III. Profile Description

Ap	0-15 cm	Very dark grayish brown (10YR3/2) moist and brown (10YR5/3) dry, sandy clay laom; strong medium subangular blocky; slightly sticky, slightly hard (11) moist, no mottle; many fine roots; abrupt smooth boundary; pH 4.9 (Sample No. P46-1)
IIB1	15-35 cm	Yellowish brown (10YR5/4) moist and brownish yellow (10YR6/6) dry, clay; moderate medium subangular blocky; very sticky, very hard (19); few pale brown mottles; few fine roots; clear smooth boundary; pH 5.7 (Sample No. P46-2)
IIB2	35-95+cm	Yellowish brown (10YR5/6) moist and strong brown (7.5YR5/6) dry, clay; weak coarse subangular blocky with slickensides; very sticky, extremely hard (24) moist;many reddish brown (5YR5/6) and dark reddish brown (2.5YR3/4) mottles; no root; groundwater came up to 83 cm from the surface; pH 5.8 (Sample No. P46-3)

No visible reaction with chemical reagents throughout profile.

PROFILE No. P50

I. Information on the Site

a. Profile No. : P50

b. Soil Name : Inceptisol, Dystropept tipico, familia arenosa a franca, disica, isohipertérmica;
Simbolo: ECa

c. Date of Examination : December 5, 1985

d. Location : El Catey de Sanchez. 200 m north of the national road. Approximately 6.5 Km east of junction at Cruce de Rincón, Provincia de Sanchez.

e. Elevation : 17 m

f. Land Form and Slope : Undulating piedmont slope (3 - 5%), gradually downward to southwest about 50 m from pit. A few small marshes are located.

g. Vegetation and Land-use: Coconuts and grasses with many young Guayaba trees (Guawa) in good growth status.

II. General Information on the Soil

a. Parent Material : Coarse allubial deposits on weathered limestone layer.

b. Drainage : Well drained

c. Depth of Groundwater : Unknown but certainly more than 1 m

d. Presence of Surface Stones, Others
: None at site

e. Evidence of Erosion : Slight sheet erosion in heavy rainfall season .

III. Profile Description

A1	0-9 cm	Very dark brown (10YR2/2) moist and dark yellowish brown (10YR3/4) dry, loamy sand; moderate fine subangular blocky; not sticky and slightly hard (10) moist; no mottle; common fine roots; abrupt smooth boundary; pH 4.70 (Sample No. P50-1).
A2	9-33 cm	Very similar to above horizon but hard (18) moist and common medium roots; clear smooth boundary; pH 4.28 (Sample No. P50-2)
A3	33-60 cm	Dark yellowish brown (10YR3/2) moist and yellowish brown (10YR4/4) dry, sandy loam; weak medium angular blocky; not sticky and very hard (20) moist; no mottle; few fine and medium roots; very slight oxidized manganese reaction; gradual smooth boundary; pH 4.41 (Sample No. P50-3)
B1	60-122 cm	Yellowish brown (10YR4/4) moist and yellowish brown (10YR5/6.5) dry, sandy loam; weak coarse subangular blocky; not sticky and hard (17) moist; no mottle; almost no root; abrupt smooth boundary; pH 5.02 (Sample No. P50-4)
IIC	122-150+cm	Yellowish brown (10YR5/8) mist, sandy clay loam; massive; very sticky and extremely hard (23) moist; many reddish brown (5YR4/6) mottles; no root (Not sampled).

No detectable reaction was observed with reagents except for weak manganese reaction in third horizon.

TABLE D.4.1 IDENTIFICATION OF SOIL SERIES BY SOIL PROFILE EXAMINATION (1)

Pit No.	Series		Identified	Pit No.	Series		Identified
P 1	Re		NA	P26	LCo	→	ERi
2	AS		AS	27	Be		Be
3	Pa		Pa	28	LCo	→	LGa
4	EAg		EAg	29	LCr	→	ERi
5	Bo		Bo	30	EAg		EAg
6	LBY		LBY	31	Bo		Bo
7	RM		RM	32	Na	→	Mo
8	RM		RM	33	PN	→	LCo
9	LGa	→	ERi	34	RM		EG
10	Be	→	Mo	35	CV		PN
11	Na	→	LGa	36	NA		NA
12	LCOl		LCol	37	Pe		Pe
13	MCc		MCc	38	LYa		LYa
14	MOch		Moch	39	LCo	→	Mch
15	MCt		MCt	40	PAr		PAr
16	MU		MU	41	-		LM*
17	MCT	→	MU	42	-		AB*
18	-		LM*	43	-		ECa*
19	Be	→	ERi	44	Pa	→	ECa*
20	LBj		LBj	45	LYa		LYa
21	CA		CA	46	-		ECa*
22	Ya		Ya	47	Re	→	LBj
23	CA		CA				
24	AsD		CV				
25	LB		LB				

Note: Series name (map symbol) of pit site was quoted from Soil Map of SEA/FAO (1976).

* Newly established.

TABLE D.4.2 IDENTIFICATION OF SOIL SERIES BY SOIL PROFILE EXAMINATION (II)

Pit No.	Series		Identified	Pit No.	Series		Identified
P48	Pa	→	ECa	73	-		LM*
49	Pa	→	ECa	74	-		LM*
50*	-		ECA	75	Mo-Moch		Mo
51	-		LM*	76	LGa		LGa
52	-		Yab*	77	RNi		RNi
53	-		LM*	78	NA		NA
54	Pa		Pa	79	Re		Re
55	Be	→	Na	80	RM	→	Pa
56	-		Yab*	81	CV	→	EG
57	LBj	→	Be	82	JR	→	LGa
58	-		LM*	83	RM	→	Na
59	Be	→	ERi	84	LBj	→	LGa
60	LBj	→	LGa	85	RM2	→	EG
61	JR	→	EG	86	AsD		EG
62	-		LM*	87	EAg	→	MS
63	-		Yab*	88	EAg	→	MS
64	CA	→	LCo	89	-		AB*
65	AsD		LCo	90	MOch	→	PN
66	AsD		CA	91	Mu		Mu
67	LCo		LCo	92	BCh	→	BoG
68	LCol		LCol	93	BoG		BoG
69	LCo		LCo	94	Be		Be
70	LCo		LCo				
71	LCo	→	EG				
72	LCo		LCo				

Note: Series name (map symbol) of pit site was quoted from Soil Map of SEA/FAO (1976).

* Newly established.

TABLE D.4.3 CLASSIFICATION TAXONOMY AND LAND SUITABILITY OF SOILS (1)

I. Soil Series

No.	Order	Suborder	Great-Subgroup	Series	Symbol	Land Suitability for Upland Crops	Rice
1	Vertisol	Udert	Cromudert acuéntico	Payabo	Pa	4A1	A1
2			" "	Yaiba	Ya	2W	A1
3			" ácuico	Cuaba Abajo	CA	4A1	A1
4			" "	El Guayabo	EG	4A1/2w	A1
5	Inceptisol	Acuept	Halacuept aérico	Boca del Medio	BoM	5	A4ws
6			" histico	Boca Chiquita	BCh	4S/5	A5ws
7			" vértico	Boca Grande	BoG	3ws	A6
8			Tropacuept aérico	Ciénaga Vieja	CV	2w	A1
9			" histico	Agua Santa	AS	4S/5	A3ws
10			" "	Milla Uno	MU	5	A3ws
11		Tropept	Eutropept típico	Yabacoa	Yab	4P/6	A6
12			" "	Los Yayales	LYa	3ws	A4ts
13			" fluvacuénico	Los Coles	LCO	2w	A1
14			" "	" "	LCO1	3w	A2w
15			" "	Punta Arena	PAr	3ws	A4ts
16			" fluvéntico	Río Nigua	RNi	1	A1
17			Dystropept tipico	La Majagua	LM	4P/5	A6
18			" "	Agua Buena	AB	4P/5	A6
19			" "	El Catey	ECa	3ts/2s	A3ts/6

TABLE D.4.3 CLASSIFICATION TAXONOMY AND LAND SUITABILITY OF SOILS (2)

No.	Order	Suborder	Great-Subgroup	Series	Symbol	Land Suitability for Upland Crops	Rice
20	Molisol	Acuol	Argiacuol histico	Molinillos	Mo	4A2/4P	A2w
21			" vértico	El Rincón	ERi	4A1/3w	A1/2w
22			Haplacuol histico	Palmar Nuevo	PN	4A2/4P	A3ws
23		Udol	Argiudol ácuico	La Garza	LGa	4A1/2	A1/2w
24			" "	Nigua Abajo	NA	2w	A1
25			" vético	La Bija	LBj	2w	A1
26			Hapludol ácuico	Machete	Mch	2w	A1
27			" fluvacuéntico	Los Carreres	LCr	3w	A2w
28			" fluvéntico	Juana Rodriguez	JR	1	A1
29			" típico	Rincón de Molinillos	RM	1	A1
30			" "	" "	RM-2	2w	A1
31	Alfisol	Acualf	Albacualf vértico	Paraguay	Pr	4A1	A1
32			Tropaculaf aérico	La Guamita	LGu	3w	A4ws
33			" vértico	Reforma	Rf-1	4A1	A1
34			" ácuico	La Barca	LB	2w	A1
35			Tropudalf típico	Arevano	Av	2w	A1
36			" vértico	Reventazón	Re	3w	A1
37	Histosol	Fibrist	Tropofibrist térrico	Pescadeno	Pe	4S/5	A5ws
38			" típico	Milla Cuarto	MCt	4S/5	A6
39		Hemist	Tropohemist fíbrico	Bojolos	Bo	4S/5	A6
40			" "	Mangle de Sánches	MSa	4S/5	A6

TABLE D.4.3 CLASSIFICATION TAXONOMY AND LAND SUITABILITY OF SOILS (3)

No.	Order	Suborder	Great-Subgroup	Series	Symbol	Land Suitability for Upland Crops	Rice
41	Histosol	Hemist	Tropohemist fibrico	Milla Ocho	MOch	4S/5	A6
42			" "	Milla Siete	MS	4S/5	A6
43			" " (hidrico)	Milla Tres	MT	4S/5	A6
44			" térrico	Bebedero	Be	4S/5	A3/4ws
45			" típico	El Aguacate	EAg	4S/5	A6
46			" "	Milla Cinco	MCc	4S/5	A6
47			" sáprico	La Balsa de Yuna	LBY	4S/5	A5ws
48		Saprist	Troposaprist térrico	Nagua	Na	4S/5	A4ws

II. Soil Associations Identified and Described

No.	Great-Subgroup		Symbol		
1	Bahia Escocesa	Tropacuept y Tropohemist	As BE	3	A3ws
2	" "	Halacuept, Sulfacuept y Acuept	As Bo Es	5	A4ws
3	Duarte	Eutropepts, Tropacuepts Tropohemists	As D	3-4A-5	A2w

TABLE D.4.3 CLASSIFICATION TAXONOMY AND LAND SUITABILITY OF SOILS (4)

III. Soil Associations Not Described

No.	Great-Subgroup			
4	Bebedero & Milla Cuatro	As Be-MCt	4S/5	A5ws
5	Bojolos + Milla Tres	As Bo-MT	4S/5	A6
6	Boca Chiquita + Mangles de Sánchez + Paraguay	As BCh-MSa-Pr	5-4S/5-4Al	A6
7	La Guamita + Agua Santa + Payaba	As LGu-AS-Pa	3w-4S/5-4Al	A3ws
8	Machete + AGua Santa	As Mch-AS	2w-4S/5	A3ws
9	Molinillos + Milla Ocho	As Mo-MOch	4A3/4P-4S/5	A3ws
10	Milla Ocho + El Aguacate + Milla Tres	As MOch-EAg-MT	4S/5	A6
11	Milla Tres + Bojolos + Milla Siete	As MT-Bo-MS	4S/5	A6
12	Milla Tres + Bebedero	As MT-Be	4S/5	A4-6
13	Milla Tres + Milla Cuatro + Bebedero	As MT-MCt-Be	4S/5	A4-6
14	Nagua + Pescadeno	As Na-Pe	4S/5	A4-5

Note: Refer to " Sistema del Servicio de Conservación de Suelos de los E.E.U.U. (1973)", and " Los Suelos del Bajo Río Yuna (1976) ".

TABLE D.4.4 LIST OF SOIL SERIES DISTRIBUTING ON TOPOGRAPHIC DIVISION

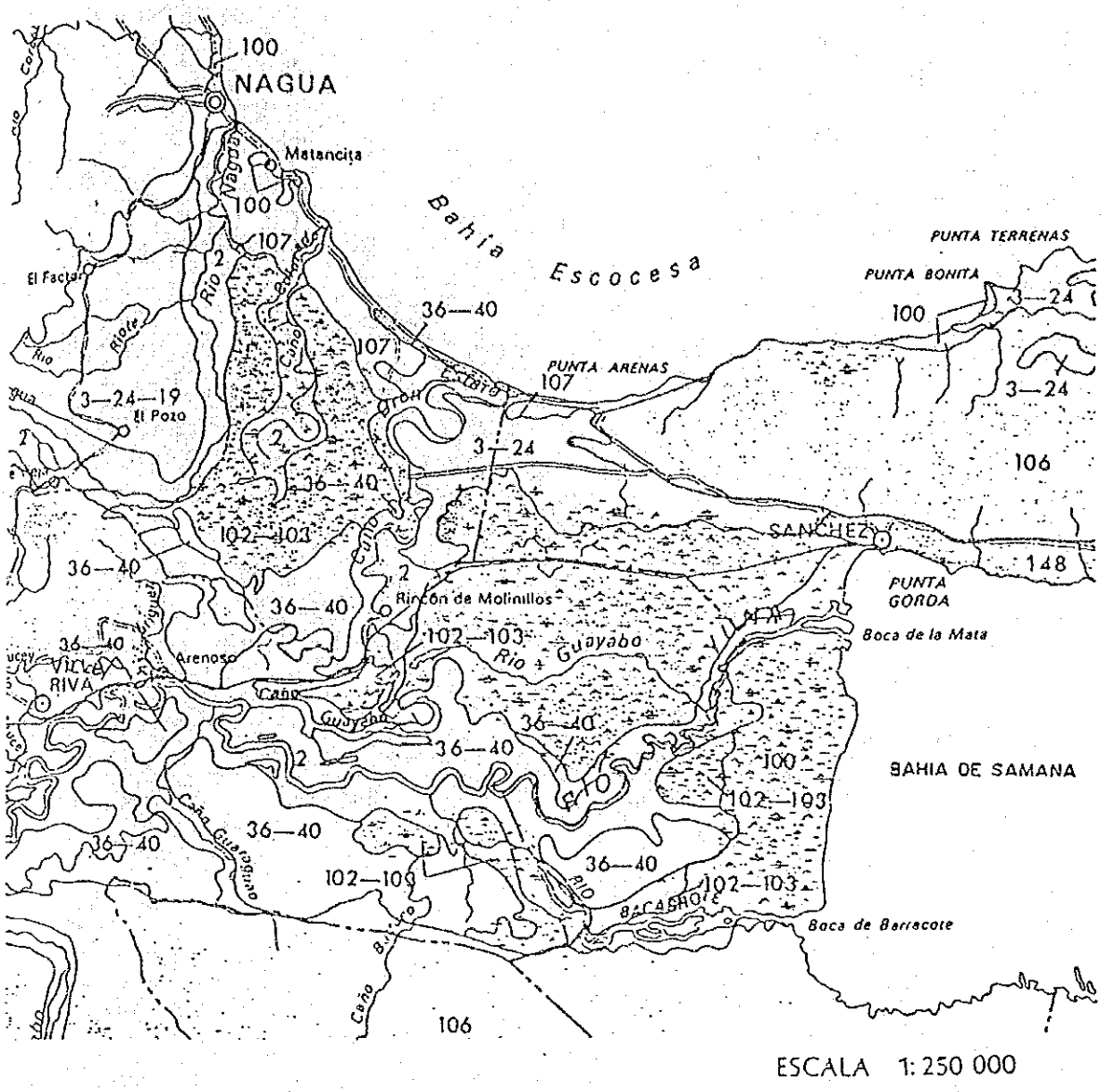
Topographic Division	Vertisol	Inceptisol	Molisol	Alfisol	Histosol	Association
I. Savanna Remnant Area of East Cibao 1) Monadnock and mountain slope area		Eutropept tipico (Yab) Dystropept tipico (LM, AB, ECa)				
2) Upper terrace area	Cromudert ácuico (CA)		Argiudol ácuico (NA)			
II. Alluvial Plain and Delta Ara of Rio Yuna	Cromudert acuéntico (Pa, Ya) ácuico (EG)	Eutropept fluvacuéntico (LCo, LCol) fluvéntico (RNi) Tropacuept aérico (CV) Halacuept aérico (BoM) vértico (BoG)	Hapludol fluvéntico (JR) fluvacuéntico (LCr) típico (RM, "2) Argiudol vértico (LBj) ácuico (LGa) Argiacuol vertico (ERi)	Tropudalf vértico (Re) típico (Av) ácuico (LB) Albacualf vértico (Pr) Tropacualf vértico (Rfl)		As BE: Tropacuept, Tropohemist As BoEs: Halacuept Sulfacuept, Acuept As D: Eutropept, Tropacuept, Tropohemist
III. Marsh and Peat Area		Tropacuept histico (AS, MU) Halacuept histico (BCh)	Argiacuol histico (Mo) Haplacuol histico (PN)		Tropofibrist térrico (Pe) típico (MCt) Tropohemist fibrico (Bo, MSa, MOch, MS, MT) térrico (Be) típico (EAg, MCc) Saprico (LBY) Troposaprist térrico (Na)	Be-MCt, Bo-MT, Mo-MOch, MOch-EA MT, MT-Bo-MS, MT Be, MT-MCt-Be, Na-Pe, BCh-MSa-P
IV. Recent Coastal Terrace Area		Eutropept fluvacúentico (PAr) típico (LYa)	Hapludol ácuico (Mch)	Tropacualf aérico (LGu)		As Bo Es: Halacuept, Sulfacuept, Acuept Mch-AS, LGu-AS-Pa

Note: Refer to "Los Suelos del Bajo Rio Yuna (1976).

TABLE D.4.5 HECTARAGE OF SOIL SERIES AND ASSOCIATIONS

(ha)

Soil Order: Soil Series	Area (ha)	Soil Order: Soil Series	Area (ha)	Soil Association	Area (ha)
Vertisol:	1,690	NA	310	Described:	750
Pa	280	LBj	335	As BE	105
Ya	50	Mch	65	As BoEg	30
CA	860	LCr	95	As D	615
EG	500	JR	210		
		RM	710	Not Described:	2,900
Inceptisol:	5,240	RM-2	320	As Be-MCt	150
BoM	250			As Bo-Mt	255
BCh	25	Alfisol:	550	As BCh-MSa-Pr	120
BoG	85	Pr	-	As LGu-AS-Pa	570
CV	245	LCu	35	As Mch-AS	50
AS	470	Rf-1	40	As Mo-MOch	125
MU	155	LB	120	As MOch-EAg-MT	860
Yab	480	Av	125	As MT-Bo-MS	330
LYa	25	Re	230	As MT-Be	65
LCo	980			As MT-MCt-Be	355
LCol	715	Histosol:	10,030	As Na-Pe	20
PAr	65	Pe	725		
RNi	65	MCt	1,260	Lagoons	60
LM	885	Bo	500		
AB	390	MSa	400	Total Area	24,100
ECa	630	MOch	1,490		
		MS	65		
Molisol:	2,880	MT	650		
Mo	55	Be	2,520		
ERi	230	EAg	1,930	Note: Areas of around 600 ha consisting of road, canal and residential quarter are included in adjacent soil series, respectively	
PN	205	MCc	225		
LGa	345	LBY	180		
		Na	85		



SUELOS DE SABANA

a) ARENOSOS, CON PERMEABILIDAD LENTA

3-24 — Asociacion *Pimentel-Fantino*

3-24-19 — Asociacion *Pimentel-Fantino-Cotui*

SUELOS ARCILLOSOS NO CALCAREOS

36-40 — Asociación *Villa Riva-Barraco*

109 — Suelos no calcáreos de valles intramontanos

SUELOS DE ORIGEN CALCAREO

a) CON TOPOGRAFÍA LLANA A ONDULADA

1. Sobre Calizas Blandas

148 — Asociación *Truffin*

b) CON TOPOGRAFÍA ALOMADA A MUY ALOMADA

2. Sobre Calizas, Areniscas y Conglomerados

9-11-1-6 — Asociación *Santa Clara-Marilópez-Duarte-Jabobán*

SUELOS ALUVIALES RECIENTES

2 — Suelos Aluviales recientes

CIENAGAS

100-101 — Ciénagas Costera e Interior

PLAYA COSTERA Y DUNAS

107-108 — Playa costera y Dunas

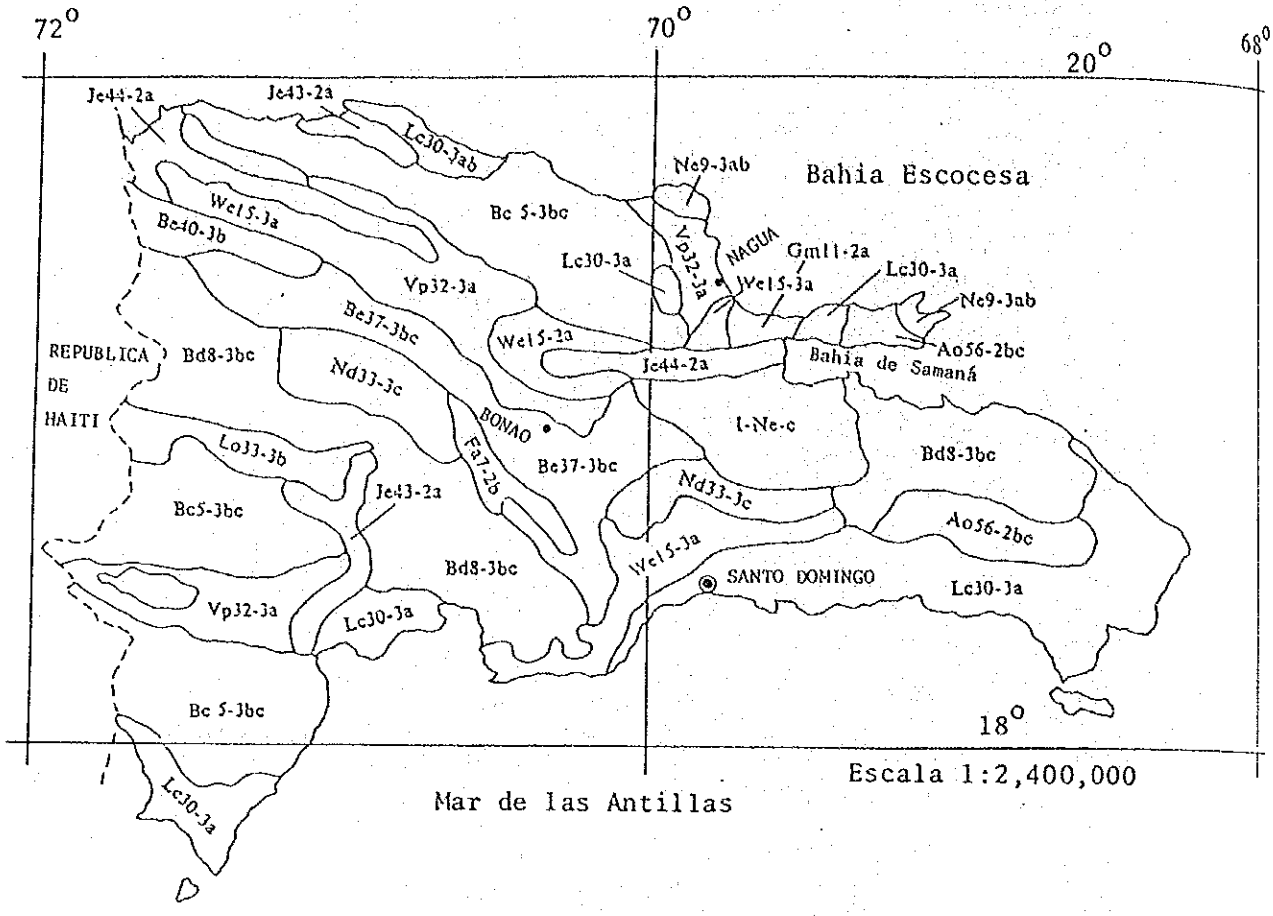
SUELOS ORGANICOS

102-103 — Turba y Turba Mineralizada

TERRENOS CARSICOS

106 — Asociación *Los Haitises*

FIG. D.4.1 SOIL ASSOCIATIONS GROUPED BY PRINCIPAL SOIL CHARACTERISTICS AROUND THE STUDY AREA (1969)



SOIL UNITS	Map symbol	Associated soils	Inclusions	Phase	SOIL UNITS	Map symbol	Associated soils	Inclusions	Phase
Eutric Fluvisols	Je43-2a	Gh Lv Vp	Tv Vc		Orthic Luvisols	Lo33-3b	Be Bk Lc	E	
	Je44-2a	Gh Je Vp	Jt We		Chromic Luvisols	Lc30-3a	Bv E	Vp	Lithic
						Lc30-3ab	Bv E	Vp	
Mollic Gleysols	Gm11-2a	Re Vp	Oe						
LITHOSOLS	I-Ne-c				Eutric Planosols	We15-2a	Ge Lf Lp	Gm	
Eutric Nitosols						We15-3a	Ge Lf Lp	Gm	
Pellic Vertisols	Vp32-3a	Lv Re	Je Lf		Orthic Acrisols	Ao56-2bc	Bd I	Gh Je	
Eutric Cambisols	Be37-3bc	E I Ne	Bd Je	Lithic	Eutric Nitosols	Ne9-3ab	Bv Lc		Lithic
	Be40-3b	Bv E	I		Dystric Nitosols	Nd33-3c	Bd I		Lithic
Dystric Cambisols	Bd8-3bc	Be I Nd	Je	Lithic					
Chromic Cambisols	Bc5-3bc	E I No	Jo	Lithic	Acric Ferralsols	Fa7-2b	Bd Fr Nd	No	

FIG. D.4.2 SOIL UNITS AROUND THE STUDY AREA, COMPILED BY FAO/UNESCO (1972)

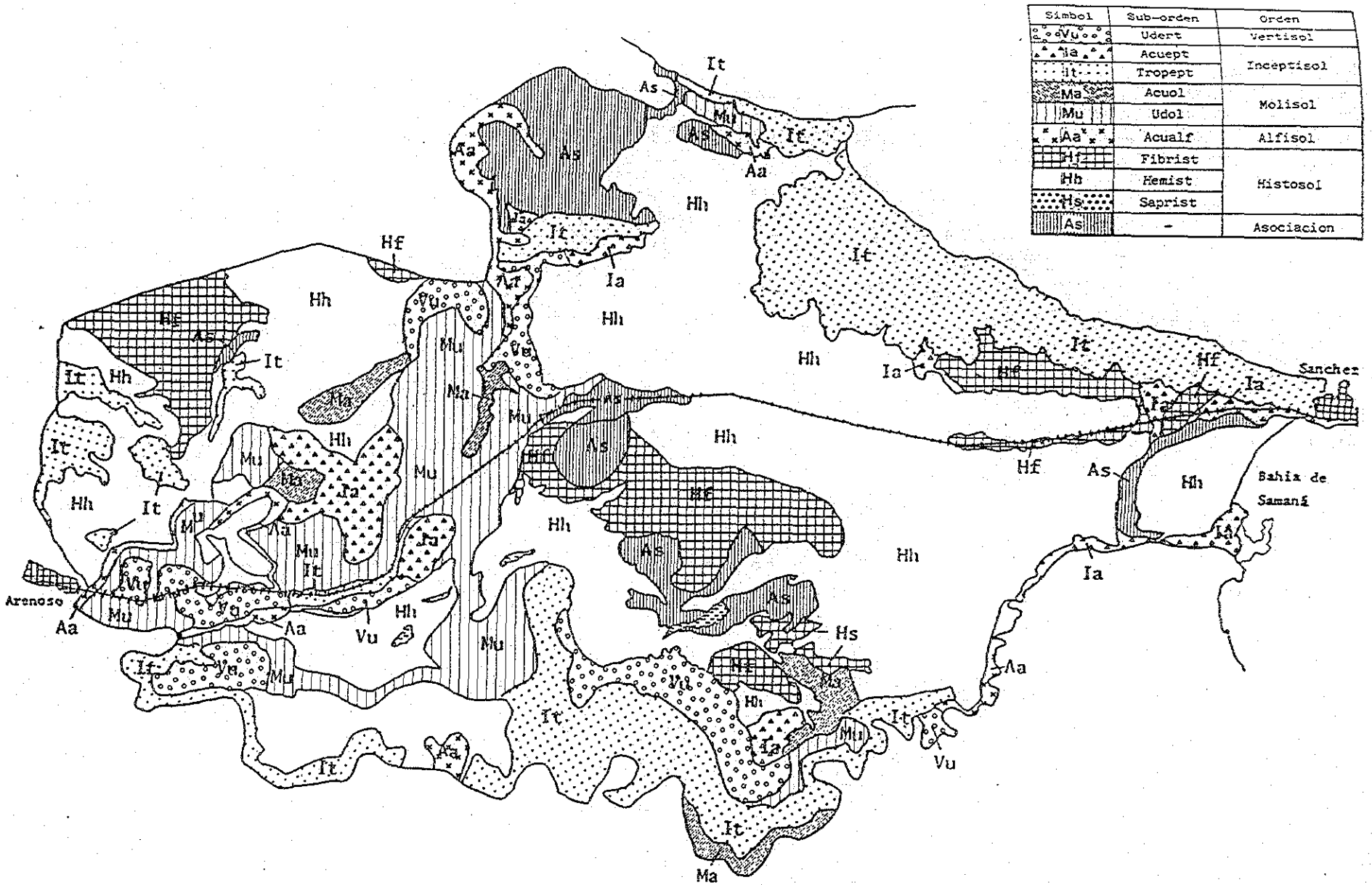


FIG. D.4.3 SOIL ORDER AND SUBORDER MAP

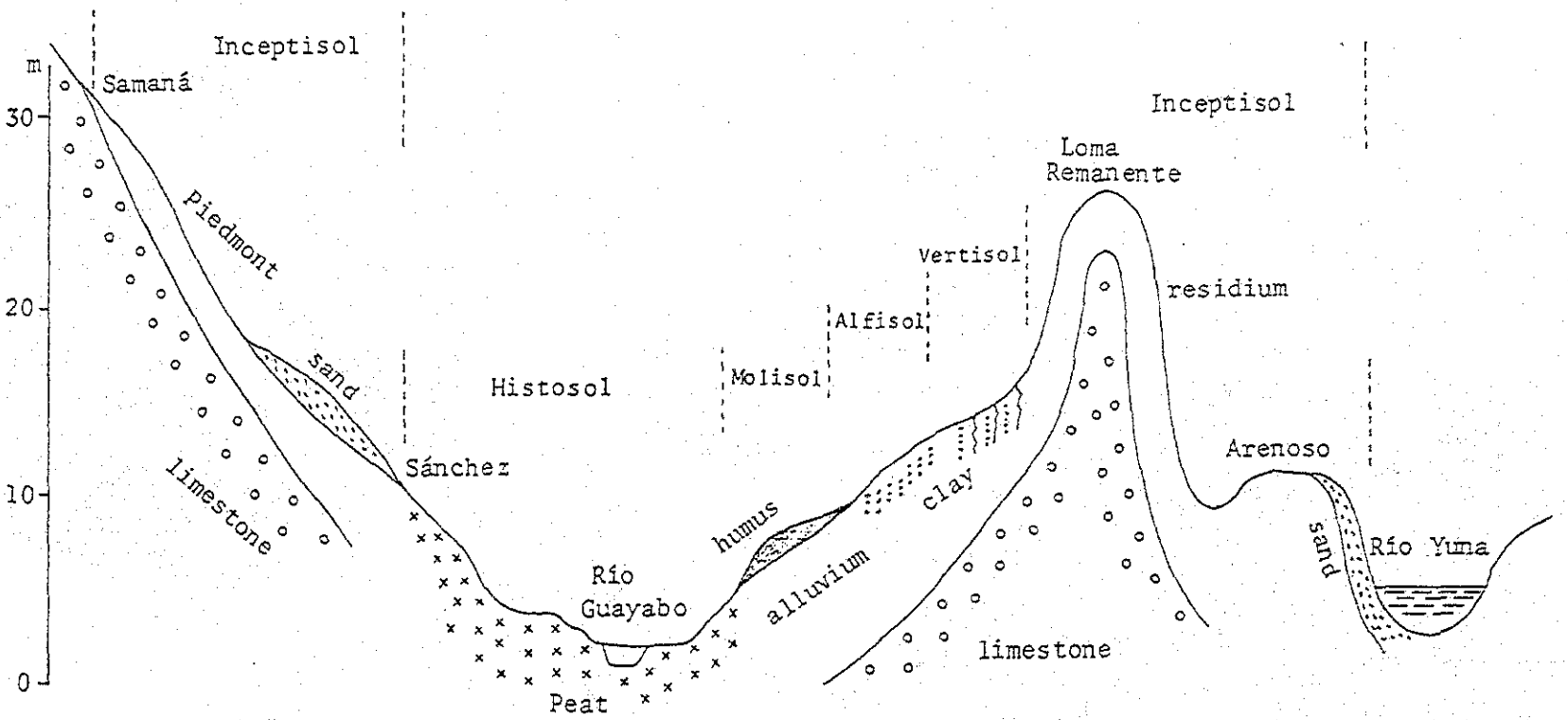


FIG. D.4.4 SCHEMATIC DIAGRAM OF SOIL FORMATION OCCURRING IN THE STUDY AREA

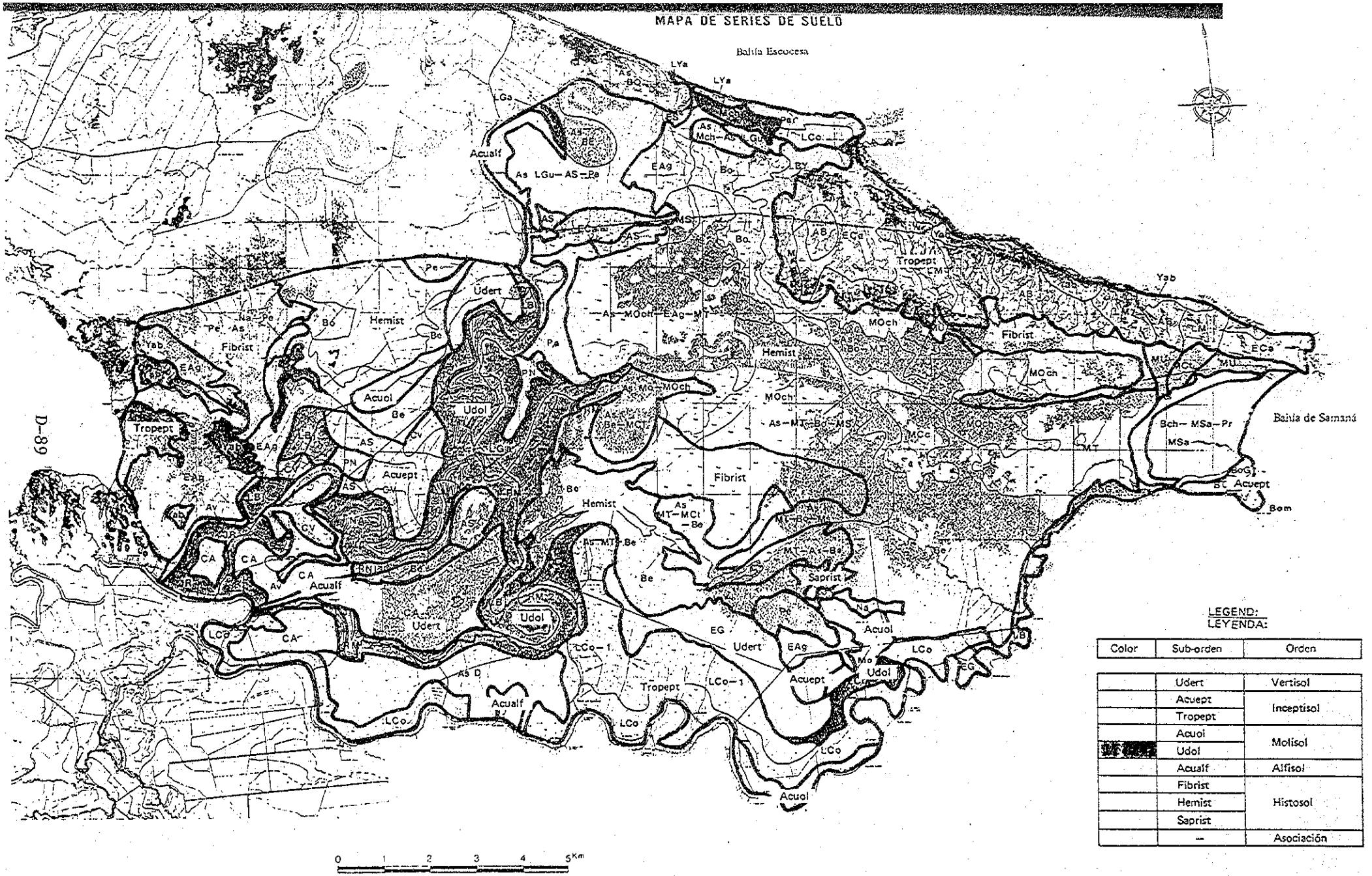

MAPA DE SERIES DE SUELO
Bahía Escocesa
Bahía de Samaná
LEGEND:
LEYENDA:
Color
Sub-orden
Orden
Udert
Vertisol
Acuept
Tropept
Inceptisol
Acuol
Udol
Molisol
Acualf
Alfisol
Fibrist
Hemist
Saprist
Histosol
–
Asociación
0 1 2 3 4 5Km

FIG. D.4.6 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,dry
(7.5YS/2),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. Organic Matter Content:

2 - 5 % •
5 -10 % • •
10 -30 % • • •
———— >30% • • • •

Peat:

fibric	Oi	|||||||
hemic	Oe	═══
sapric	Oa	|||||||
decayed timbers and roots		

5. Mottles:

few	×
common	× ×
many	× × ×
abundant	× × × ×

6. Concretions:

iron	◉
manganese	◑

7. Slickensides:

weak	//
moderate	// //
strong	// // //

8. Frictions, Cracks:

few	∫
common	∫ ∫
frequent	∫ ∫ ∫

9. $CaCO_3$ Content:

0.5 - 2 %	△
2 -10 %	△ △
>10 %	△ △ △

10. Gravel Content:

few	o
common	o o
frequent	o o o

11. Horizon Boundary:

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

12. Groundwater Level: ▽

13. Gley Layer: ═══

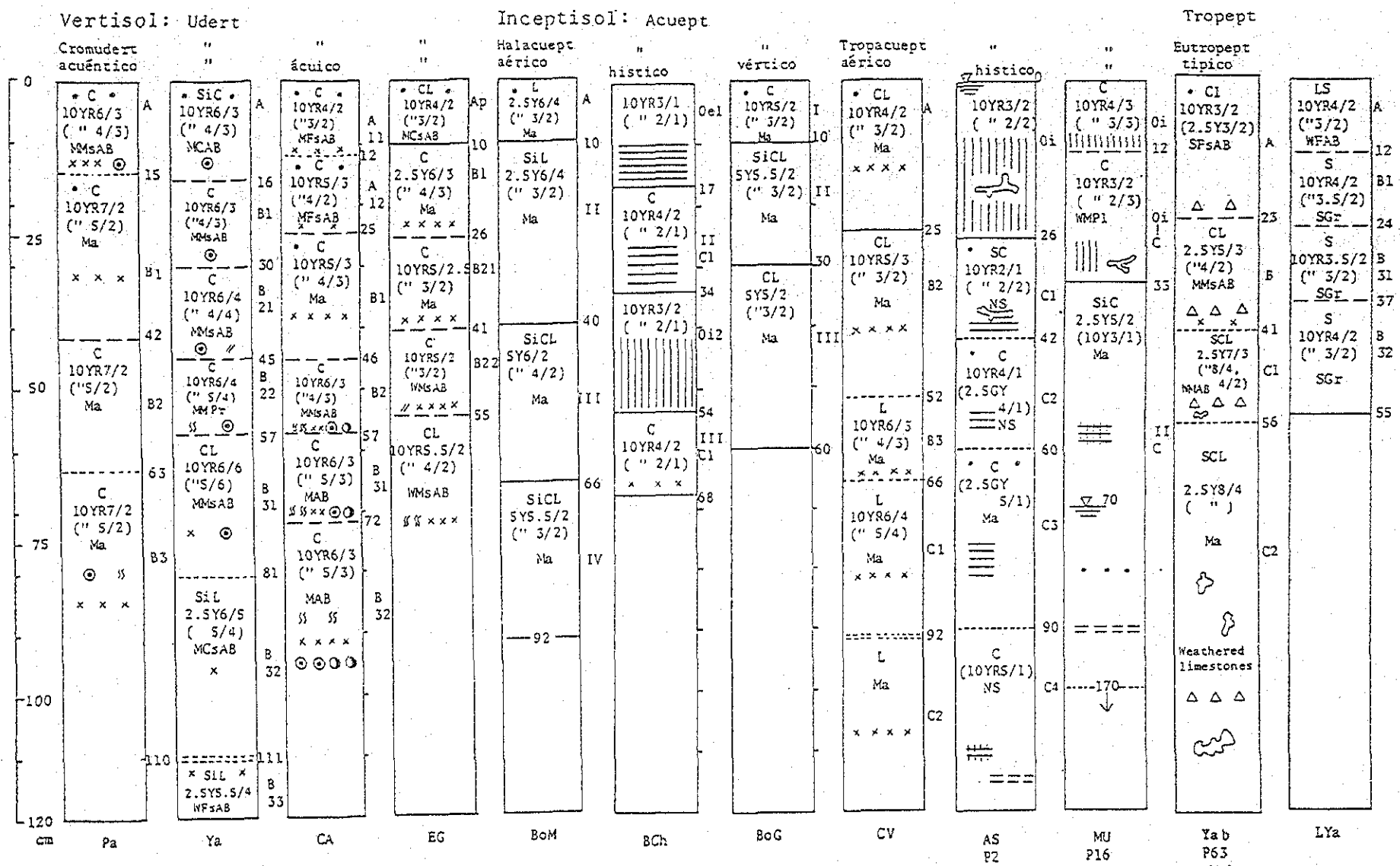


FIG. D.4.6 COLUMNAR DIAGRAMS OF SOIL PROFILE OF SOIL SERIES IN EACH SOIL ORDER (1)

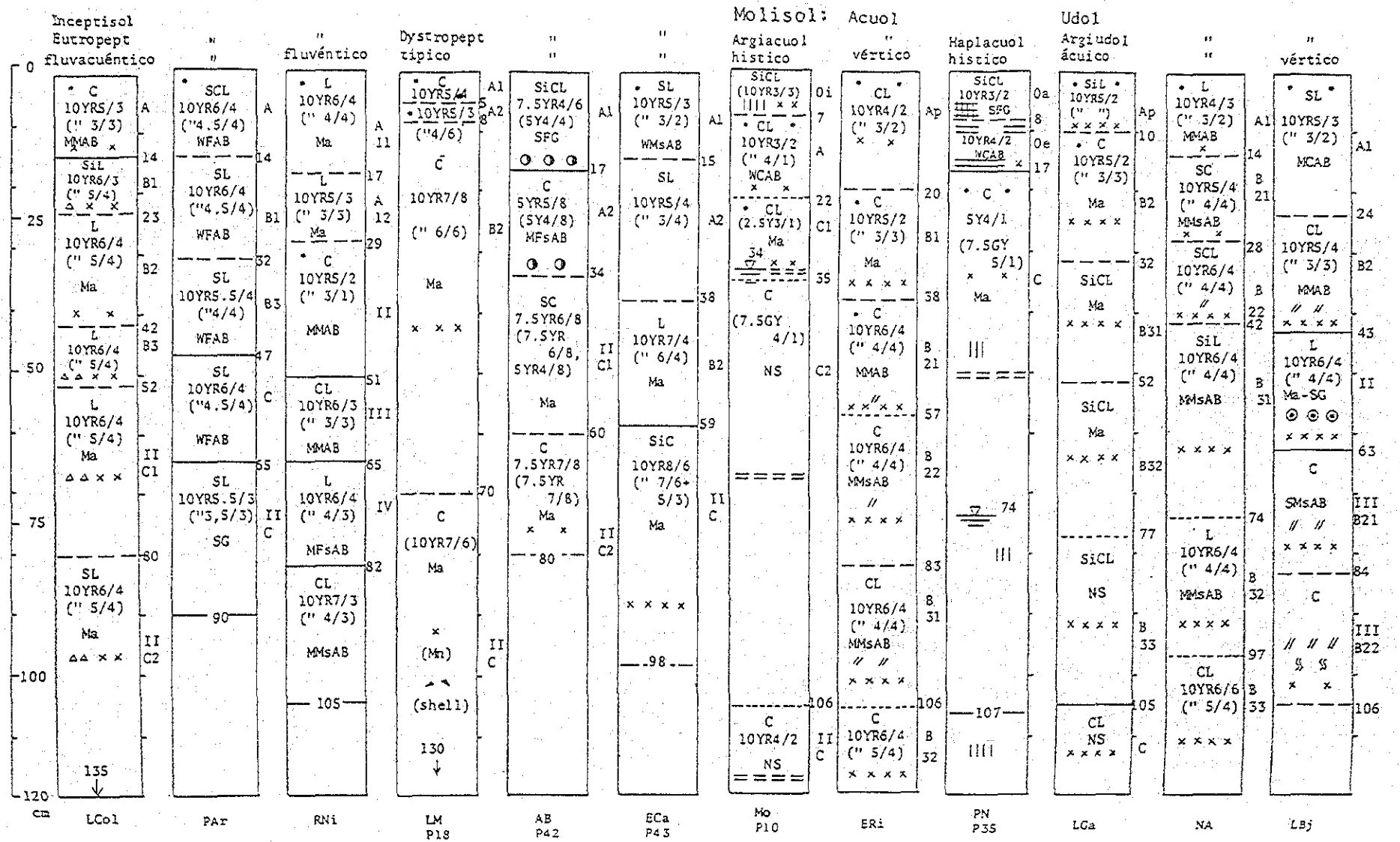


FIG. D.4.6 COLUMNAR DIAGRAMS OF SOIL PROFILE OF SOIL SERIES IN EACH SOIL ORDER (2)

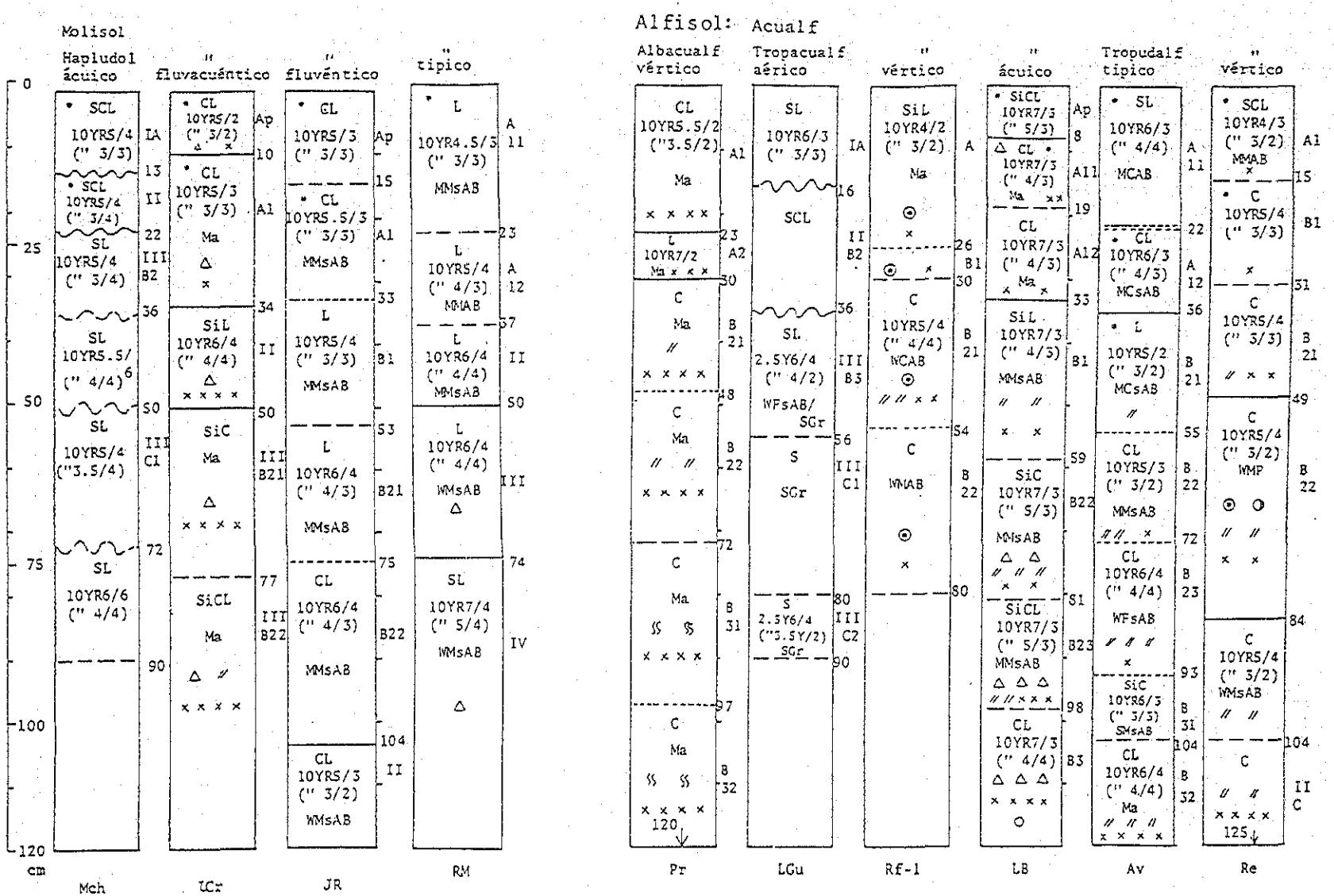


FIG. D.4.6 COLUMNAR DIAGRAMS OF SOIL PROFILE OF SOIL SERIES IN EACH SOIL ORDER (3)

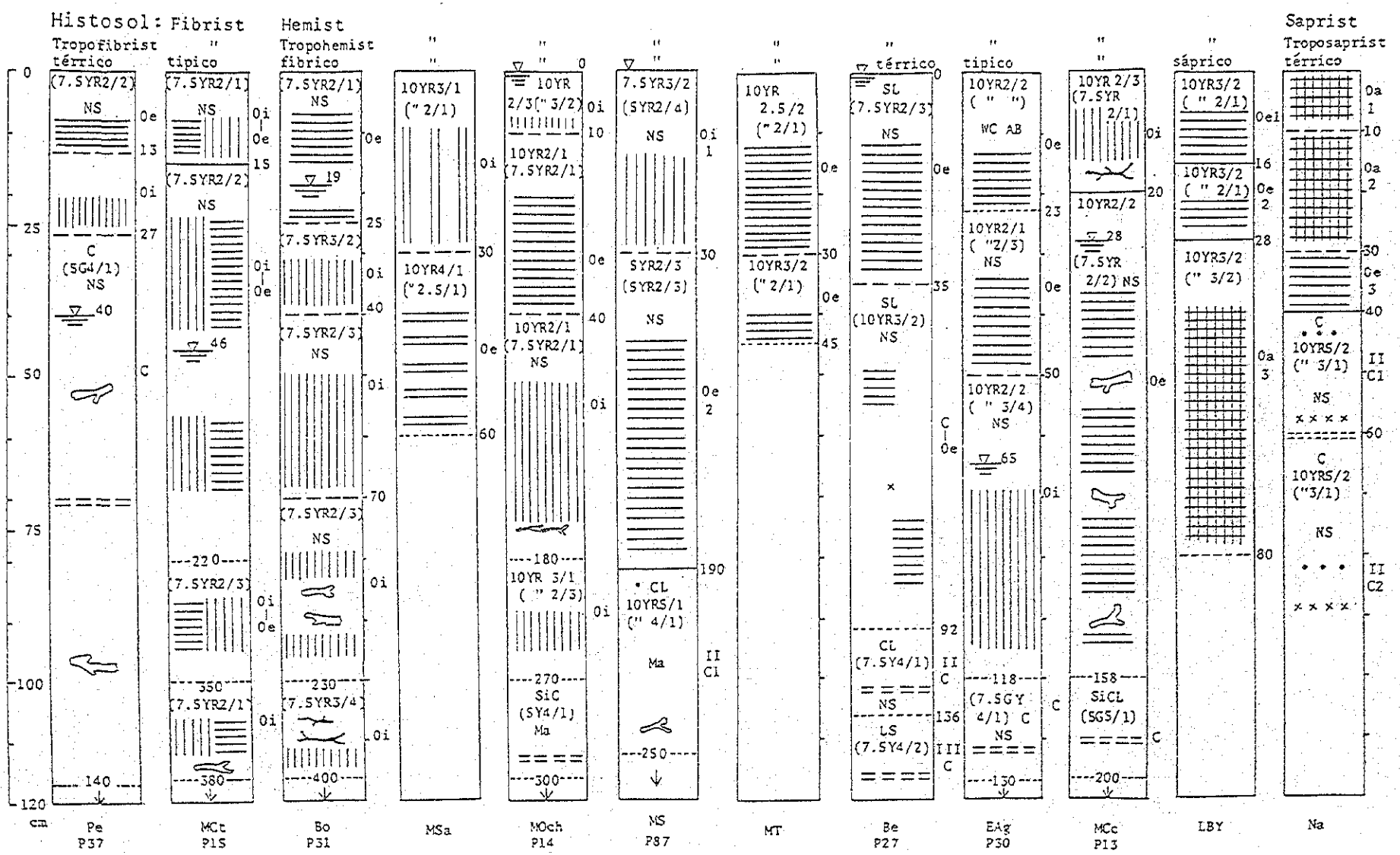


FIG. D.4.6 COLUMNAR DIAGRAMS OF SOIL PROFILE OF SOIL SERIES IN EACH SOIL ORDER (4)

5. Soil Characteristics

In this chapter, general soil characteristics are described mainly on the dominant soil orders from the viewpoints of soil fertility and land use.

5.1 Inceptisol

Inceptisol lies scattered almost all over the study area from mountainous area to sea coast. Its diagnostic horizons vary widely from cambic to histic depending on the topographic circumstances.

Except for coastal terrace and undulating area, soils are in general clayey and neutral in reaction with low EC value and high base saturation. These are devoted to rice fields realizing a greater part of rice production in the area. Rice plants of local variety have been grown even on histic (AS, MU) and saline (BoM, BoG) series in spite of very low produce. Slightly high salinity of soil has been recognized with MU and BoG series, giving EC value of 2 to 3 mmhos with 1:2 ratio extract. Acid sulphate soil (Thionic Fluvisol or Sulfaquept) popularly appearing on coastal area has not been reported in the study area.

As aforementioned, soils of hilly areas (LM, AB and ECa) are acidic in reaction with very low bases, resulting in a low fertility. The areas are planted to coconut palms, but will need soil amelioration when developed to upland crop fields.

5.2 Molisol

Molisol also shows a broad distribution and is quite distinctly planted to cacao plants and plantains. Of course some series such as Mo, PN and LGa are used to grow rice or coconut palms.

Most of them have been formed on delta and levee areas of Yuna River, being endowed with appropriate organic matter and good structure. To develop for rice production, the lands should be irrigated by pumping because of a slightly higher elevation than the low land areas of Inceptisol.

5.3 Histosol

This histic soil order occupies more than half of the study area, since peat varies to assume fibric, hemic and sapric depending on the decomposition grade of vegetable materials. Including histic series of the other soil orders, Fig. D.5.1 illustrates variation in horizon sequence with which soil series are classified. Among them, MOch and MS give the same sequence but differ from each other in acidity, the latter being more acidic as low as pH 4.

These soils have been developed on lagoonal area without influence of sea water. Vegetable materials of peat are mostly composed of fibrous grassy tissues and scarcely thick roots and woody timbers which are considered parts of mangrove plants.

Because of excess in organic matter, strong acidity and lack of exchangeable bases, soils of Histosol are ranked at the lowest in fertility and suitability for crop production. Nevertheless, not a few extent of the soil series such as Pe, Be and Na, whose depth of peat layer does not exceed 50 cm, are now cultivated to rice.

As for the other soil orders, Vertisol occurs on lowlying alluvial plains. The profile is characterized with surface cracks and gleization caused by montmorillonite clay of swelling nature. Vertisol is planted only to rice. Alfisol has also a small extent along river levees. It is mostly used to grow rice or plantain.

5.4 Water Quality

Measurement of pH and EC of water is an expedient to know its quality. Water samples collected during the soil survey are numbered as follows in terms of water source:

Ground Water (pit)	39	River Water	5
Canal Water	14	Well Water	1
Drain Water	3	Surface Water (Stagnant)	5
TOTAL	67		

The analytical data are shown in Tables D.3.5 and D.3.6.

(1) Groundwater

Groundwater taken from the soil pit tends to show similar pH and EC values as those of the soil horizons. Samples taken from histosol were very low in pH as around 4-5, while those from Tropacuept (AS, MU) and Eutropept (LYa) were high in EC as 1.2 - 3.2 mmhos. Since salinity damage usually occurs when EC value exceeds 4 mmhos, it will not be probable in the study area so far as irrigation facilities are installed, excluding coastal saline areas.

(2) Canal and Drain Water

No problem is found with the determinations except for those of samples taken near the month of Caño Gran Estero, where sea water intrudes with the tide.

Drain water from the peat areas, however, gives a slightly low pH assuming dark brown in color probably derived from immatured humus. It is advisable to avoid re-use of such drain water for irrigation. Because soluble organic acids and phenolic substances of peat humus have been reported harmful to plant growth. Water of the Guayabo River should be regarded as drain water.

(3) River Water

Within the determinations, water of the Yuna River is slightly alkaline and low in EC as 0.2 mmho. Its quality for irrigation use is satisfactory with ideal content of base elements, Ca and Mg, based on the water analysis data shown in ANNEX E.

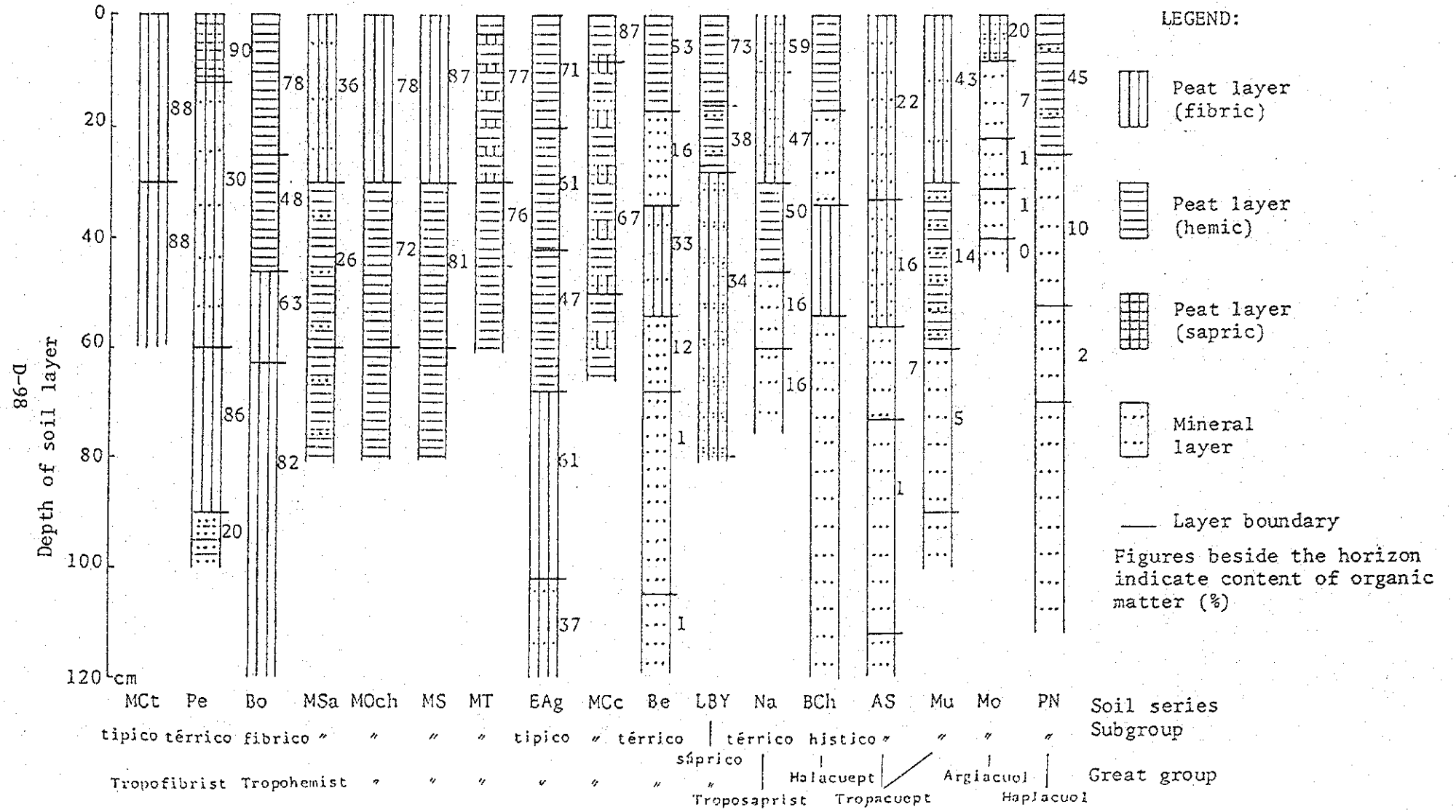


FIG. D.5.1 HORIZON SEQUENCE OF HISTOSOL AND OTHER HISTIC SERIES

6. Land Classification

Land classification requires examination and appraisal of the physical and chemical characteristics of the land, which include soil properties and qualities of the topographic and drainage features. In the Dominican Republic, USDA method for land suitability has been widely used as well as soil classification method.

6.1 Results of Former Soil Survey

First land evaluation at the former soil survey (1967) had patterned after the procedures employed at the Bureau of Reclamation, USBR (1953). Fig. D.6.1 shows the results of land classification for productive capability.

In the study area, a small area along the Yuna River and Cano Gran Estero was ranked at Class III, the last class of cultivable lands. Class IV land is marginally suitable and Class V land is not cultivable but limitedly suitable for rice. These classes are seen in delta and piedomont areas. As a result, a greater extent of the area was rated as VI to VIII Classes. These lands were recommended to be left as wild pasture and forest or resort area.

The results are fundamentally not different from those of the recent survey except for non-existence of Classes I and II lands. This might be based on the occasional flood damages at the time of survey before Hatillo Dam was constructed.

6.2 Land Suitability for Upland Crops and Others

The soil survey conducted by SEA/FAO including the study area (1976) applied also the USDA method (1967) for land classification. Main specifications for soil and land conditions under irrigation system are cited in Tables D.6.1 and D.6.2. In this method, lands suitable for upland crops are divided into three classes from 1 to 3; those suitable for rice and pasture are dealt with as 4A and 4P, respectively; and lands ranked at below 4S are not recommended for arable use.

Class 5 indicates problem lands which cannot be used at present but need to be further investigated. Class 6 corresponds to Class VIII in the method mentioned above. Subclasses are set up for 1 - 3 by attaching limitation symbols, w, s, and t which express hazard of drainage, soil and topography, respectively. Symbol 's' is mostly due to the presence of peat layer.

With these specifications, land class of each soil series was compositely evaluated as was listed in the right column of Table D.4.3. The lands of the same class are grouped and mapped in Fig. D.6.2. The map simply illustrates that lowlying poorly-drained lands are suitable for rice and sloping piedmont areas for pasture, but majority of Histosol and other peaty soil series are classified into 4S/5. As summarized in Table D.6.3, extent suitable for rice is only 10% of the whole area while that of 4S/5 is more than 60%. The results seem not so useful as to realize enlargement of the arable area especially in expectation of enhanced rice production under the development program.

6.3 Land Suitability for Rice Cultivation

In view of its primary concern to reclaim the peat lands prevailing in the project area, more detailed appraisal of land capability for rice has been studied in this report.

Specifications of Table D.6.4 have been made to adapt to paddy field development by focusing on how extensive the peat lands could be reclaimed.

In comparison with the foregoing two tables, specifications are not so strict in available depth, pH of soil and drainability, but need finer texture, more exchangeable bases and less gradient of land.

The most important item, however, is how to rate the organic soils different in appearance and thickness of peat layer.

Limitations caused by the presence of peat are considered in both physical and nutritional character; the former is subsidence of the land due to the decomposition and shrinkage of peat, and the latter is nitrogen surplus, phosphorus deficiency and unbalance in the other nutrients after developing the land. The shallower and the thicker appears the peat layer, the more severe becomes its deteriorative effect irrespective of tropical or temperate zone. In the research results obtained in the tropics, specifications for peat layer are defined in the last item of Table D.6.4. Land suitability is not expected when the peat layer appears shallow and is thick beyond the limit of 60 cm.

In this classification, lands are rated into 6 classes, and those lower than Class 5 means unsuitable for rice cultivation. Since each class may include not a little deviations in peat appearance, Fig. D.6.3 illustrates probable soil profiles schematically, where corresponding soil series are given. With these specifications, each soil series was newly classified as listed in the right column of Table D.4.3.

Fig. D.6.4 has been thus drawn on land suitability for rice under irrigation system. As compared with Fig. D.6.2, the area possibly to be developed to rice field has much increased though classes are generally low excluding present upland area and no method is found to upgrade the central part of peat areas (A6). The extent of each class is also summarized in Table D.6.3. Extent not suitable for rice decreased to 48% of the whole area because several soil series of peat origin (4S/5) were upgraded to marginal suitability class (A4). As is well known, fundamental measures to improve peat land are drainage and mineral soil dressing. Without such a large investment, profitable output would not be realized in the peat areas of A5 and A6.

TABLE D.6.1 LAND CLASSIFICATION SPECIFICATIONS FOR IRRIGATION OF UPLAND CROPS (I)

Characteristics of Soil or Land	Class 1	Class 2	Class 3	Class 4A	Class 4P	Class 4S	Class 5
Land suitability	Arable land with no limitation	Arable land with some limitations	Arable land with serious limitations	Land suitable to lowland rice	Land suitable to pasture only	Land of organic soil for special cultivation	Land to be further investigated
Soil texture, 0-30cm	SL - SiC	LS - permeable C	LS - C	SiL, SiCL - C	Gravelly L - C	(Organic)	(Organic or mineral)
Subsoil	SL - permeable C	LS - C	LS - C	Sil, SiCL - C	*	(Organic or mineral)	(Organic or mineral)
Available soil (until sand or gravel)	>100 cm	60 - 100 cm	40 - 60 cm	>75 cm	>25 cm	>30 cm	*
Soil acidity or alkalinity: pH of saturated paste	5.5 - 8.2	5.0 - 8.5	4.5 - 8.5	5.0 - 8.5	4.5 - 8.5	4.5 - 8.2	Strongly acidic until clayey layer
exchangeable sodium (PSI, %)	<5% throughout the profile	<15% throughout the profile	<15% over the upper 30 cm soil	<15% throughout the profile	<15% over the upper 20 cm soil	<15% throughout the profile	--
Soil salinity: electrical conductivity of saturation extract (mmhos/cm, 25°C)	<4ms throughout the profile	<4ms when permeable, <8 ms when less permeable	<8ms when drainable but less permeable, <16ms when drainable and permeable	<4-8ms with first class irrigation water, <8-16ms with second or third class water	<8ms with good water periodically, <16ms with poor quality water	<4ms throughout the profile	--
Base saturation (%)	>50% throughout the profile	-	-	>35% throughout the profile.	**	**	**
Cation exchange capacity (upper 30 cm)	>10 me per 100 g soil	>5me per 100 g soil	>3me per 100 g soil	>5-20ms per 100 g soil	>3me per 100 g soil	**	**

TABLE D.6.2 LAND CLASSIFICATION SPECIFICATIONS FOR IRRIGATION OF UPLAND CROPS (II)

Characteristics of Soil or Land	Class 1	Class 2	Class 3	Class 4A	Class 4P	Class 4S	Class 5
Natural drainage of the land:							
Uncontrolled inundation	Not present	Not present	Exceptionally present	Not present	From time to time	Moderately frequent	Frequent
Depth of groundwater level	>200 cm	>150 cm	>100 cm	<100 - 150 cm	>50 cm	>20 cm	-
Class of natural drainage	Moderately well - well	Imperfect - somewhat excessive	Between poor and somewhat excessive	Very poor - moderately well	Very poor - excessive	Very poor - imperfect	Very poor excessive
Requirement for artificial drainage	No, <50 m of surface drainage per ha	Somewhat,<200m of surface drainage per ha	Required, <500m of sub-surface drainage per ha	No, but required when the area is irrigated	More or less required to remedy inundation	Significantly required including the area	Very significantly required including the area
Slope and relief:							
Slope	<2%	<5%	<5 - 8%	<2 - 5%	0 - 20%	-	-
Relief and microrelief	Flat - almost flat	Almost flat - slightly undulating	Undulating	Flat - slightly undulating	Flat - undulating or concave	Flat - concave	Flat - concave
Productive capacity:							
Cultivation adaptability	Suitable for annual cropping	Some limitations for annual cropping	Slightly serious limitations for annual	Only for rice or some selected crops	Only for grasses	Special crops only for organic soil	Depending on improvement of facilities
Production anticipated under good management	High with fertilization and protection	High - moderately high with best techniques	Moderate - moderately high.	High - moderate with fertilization and techniques	High - moderate with best techniques	Moderately high with recommended techniques	Depending on effect of improvement.

NOTE: Cited from the report "De Suelos del Bajo Rio Yuna (1976)".
* --- No need to describe. ** --- Not applicable - Any values are included.

TABLE D.6.3 AREA OF LANDS CLASSIFIED FOR CROP SUITABILITY

1) Upland Crops and Others (USDA Method)

Class	Subclass (Limitation)*	Suitability	Area (ha)	Percentage (%)
1	-	Very suitable	980	4.1
2	w	Suitable	2,590	10.7
2	s	"	150	0.6
3	w	Marginally suitable	1,810	7.5
3	ws	"	280	1.2
3	ts	"	450	1.9
4A1	-	Very suitable for rice	2,070	8.6
4A2-3	-	Suitable - m. suitable for rice	160	0.7
4A2/4P	-	Suitable for rice/ pasture	260	1.1
4P	-	Suitable for pasture	1,180	4.9
4S/5	-	Not suitable/5	13,180	54.7
5	-	To be further surveyed	810	3.3
6	-	Non arable use	180	0.7
Total			24,100	100

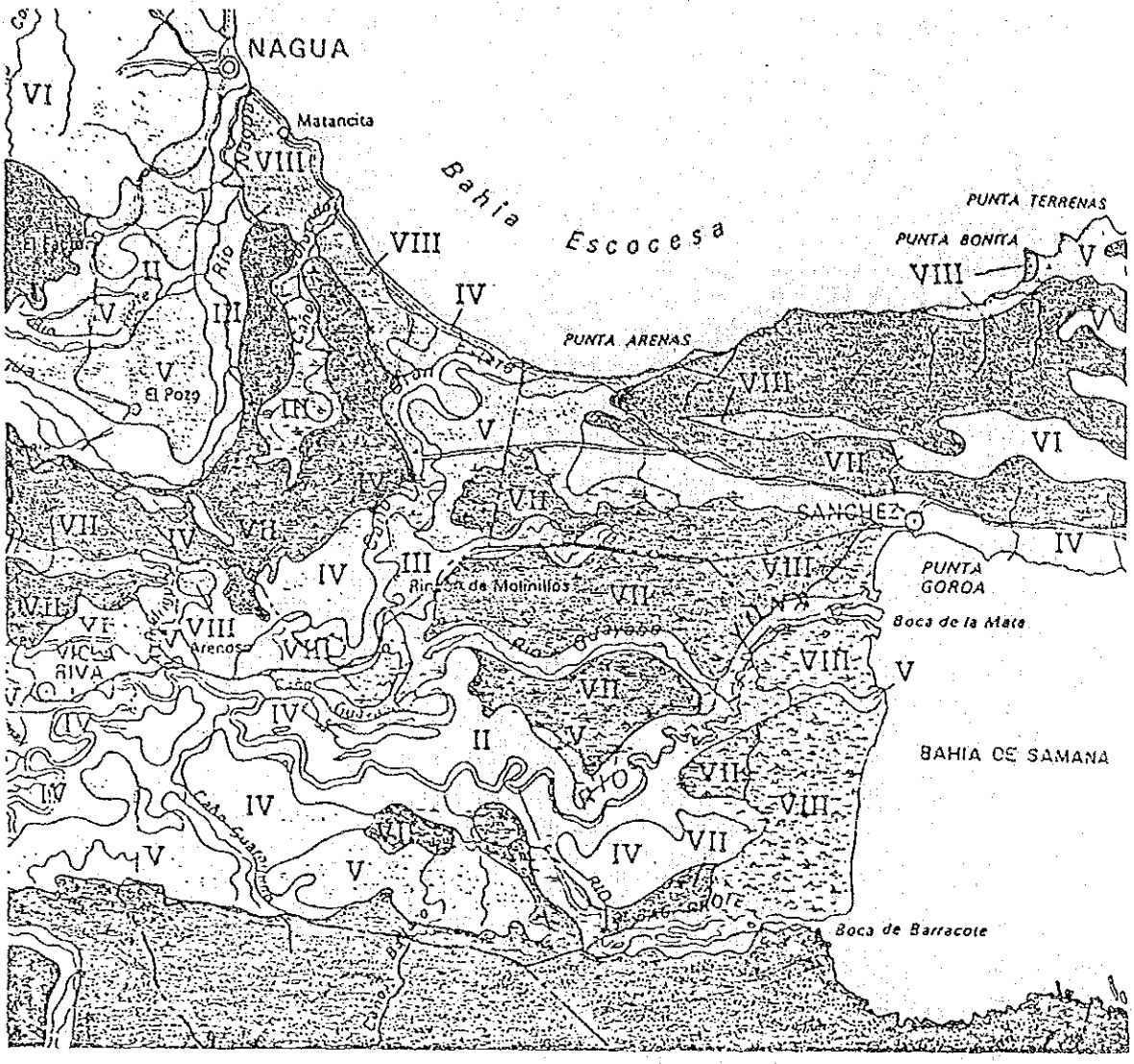
2) Rice (Project Method)

1	-	Very suitable	5,870	24.4
2	w	Suitable	1,640	6.8
3	ws	Moderately suitable	1,930	8.0
3	ts	" "	370	1.6
4	ws	Marginally suitable	2,440	10.1
4	ts	" "	90	0.4
5	ws	Not suitable	1,520	6.3
5	ts	" "	180	0.7
6	-	Non arable use	10,060	41.7
Total			24,100	100

* Limitation: w - drainage; s - soil; t - topography

Characteristics of Soil or Land	Class A1	Class A2	Class A3	Class A4	Class A5	Class A6
Land suitability	No limitation	Some limitation	Serious limitations	Marginally suitable	Not suitable	For non-arable use
1. Soil texture						
Upper 30 cm	SiL - C	SiL - permeable	SiCl - C	SiL - SL	SL - S (gravel)	*
Subsoil	SiL - permeable C	SL - C	SL - C	SL - gravel	SL - S (gravel)	*
2. Available soil (until sand or gravel)	>75 cm	75 - 50 cm	50 - 25 cm	<25 cm	<25 cm	<25 cm
3. Soil acidity or alkalinity						
pH (1:2.5)	5.0 - 8.0	5.0 - 8.0	5.0 - 8.2	<5.0 ->8.5	<4.0 - >8.5	*
Exchangeable sodium (PSI, %)	<5% throughout the profile	<10% throughout the profile	<15% throughout the profile	>10% throughout throughout the profile	>15% throughout the profile	-
4. Soil salinity						
Electrical conductivity of saturation	<4 mmhos throughout the profile	<4 mmhos throughout the profile	<4 - 8 mmhos throughout the profile	>8 - 16 mmhos throughout the profile	>16 mmhos throughout the profile	**
5. Base saturation	>50%	50 - 35%	<35%	<35%	*	*
6. Cation exchange capacity (Upper 30 cm)	>20 me per 100 g soil	20 - 10 me per 100 g soil	<10 me per 100 g soil	10 - 5 me per 100 g soil	<5 me per 100 g 100 g soil	**
7. Slope and relief	<2%, flat	<2%, flat	2-5%, slight undulating	>5 - 8%, undulating	>8%, undulating - rolling	-
8. Organic layer (peat)						
Organic matter content	<30%	<30 - 50%	>50% (peat)	>50% (peat)	>50% (peat)	-
Depth of appearance	<30 - 60	>30 cm	<30 cm	<30 cm	<30 cm	<30 cm
Thickness of layers	<30 - 60 cm	30 - 60 cm	<30 cm	30 - 60 cm	60 - 90 cm	>90 cm

NOTE: * No need to describe. ** Not applicable - Any values are included.



Scale 1: 250 000

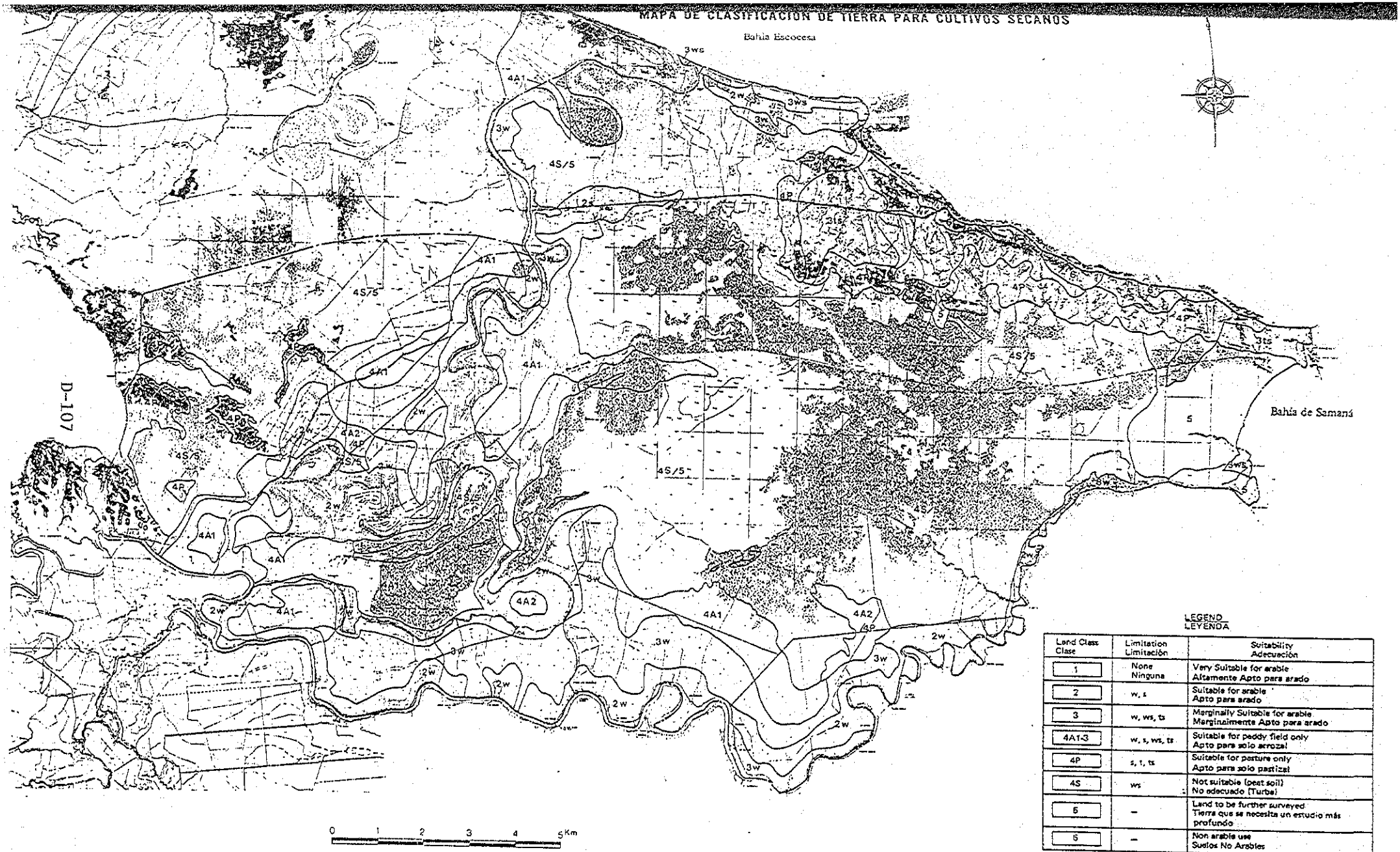
LEGEND:

Class	Productive Capability
I	TERRENOS CULTIVABLES, APTOS PARA EL RIEGO, CON TOPOGRAFIA LLANA Y SIN FACTORES LIMITANTES DE IMPORTANCIA. PRODUCTIVIDAD ALTA CON BUEN NIVEL DE MANEJO.
II	TERRENOS CULTIVABLES, APTOS PARA EL RIEGO, CON TOPOGRAFIA LLANA, ONDULADA O SUAVEMENTE ALOMADA Y FACTORES LIMITANTES NO SEVEROS. PRODUCTIVIDAD ALTA CON PRACTICAS MODERADAMENTE INTENSIVAS DE MANEJO.
III	TERRENOS CULTIVABLES, APTOS PARA EL RIEGO, SOLAMENTE CON CULTIVOS MUY RENTABLES, CON TOPOGRAFIA LLANA, ONDULADA O SUAVEMENTE ALOMADA Y CON FACTORES LIMITANTES DE ALGUNA SEVERIDAD. PRODUCTIVIDAD MEDIANA CON PRACTICAS INTENSIVAS DE MANEJO Y CON MARCADAS LIMITACIONES EN LOS CULTIVOS POSIBLES.
IV	TERRENOS LIMITADAMENTE CULTIVABLES, NO APTOS PARA EL RIEGO SALVO EN CONDICIONES ESPECIALES Y CON CULTIVOS MUY RENTABLES; APTOS PRINCIPALMENTE PARA CULTIVOS PERENNES Y PASTOS; CON TOPOGRAFIA LLANA A ALOMADA Y FACTORES LIMITANTES SEVEROS. PRODUCTIVIDAD BAJA A MEDIANA.

Class	Productive Capability
V	TERRENOS NO CULTIVABLES, SALVO PARA ARROZ EN AREAS LIMITADAS; PRINCIPALMENTE APTOS PARA PASTOS, CON FACTORES LIMITANTES MUY SEVEROS PARA EL CULTIVO; PRODUCTIVIDAD MEDIANA PARA PASTOS MEJORADOS Y ARROZ, CON PRACTICAS INTENSIVAS DE MANEJO.
VI	TERRENOS NO CULTIVABLES, SALVO PARA CULTIVOS PERENNES Y DE MONTAÑA, PRINCIPALMENTE APTOS PARA FINES FORESTALES Y PARA PASTOS; CON FACTORES LIMITANTES MUY SEVEROS, PARTICULARMENTE DE TOPOGRAFIA, PROFUNDIDAD Y ROCOSIDAD.
VII	TERRENOS NO CULTIVABLES, APTOS SOLAMENTE PARA FINES DE EXPLOTACION FORESTAL.
VIII	TERRENOS NO APTOS PARA EL CULTIVO, APTOS SOLAMENTE PARA PARQUES NACIONALES, ZONAS DE RECREO Y VIDA SILVESTRE Y PARA PROTECCION DE CUENCAS HIDROGRAFICAS.

FIG. D.6.1 LAND CAPABILITY CLASSES FOR CROP PRODUCTION (1969)

MAPA DE CLASIFICACION DE TIERRA PARA CULTIVOS SECANOS



LEGEND
LEYENDA

Land Class Clase	Limitation Limitación	Suitability Adecuación
1	None Ninguna	Very Suitable for arable Altamente Apto para arado
2	w, s	Suitable for arable Apto para arado
3	w, ws, ts	Marginally Suitable for arable Marginalmente Apto para arado
4A1-3	w, s, ws, ts	Suitable for paddy field only Apto para solo arroza!
4P	s, t, ts	Suitable for pasture only Apto para solo pastizal
4S	ws	Not suitable (peat soil) No adecuado (Turba)
5	–	Land to be further surveyed Tierra que se necesita un estudio más profundo
6	–	Non arable use Suelos No Arables

Note: Limitation symbols indicate the presence of the following deficiencies: w = drainage; s = soil; t = topography

Note: Las letras significan la presencia de las siguientes limitaciones: w = drenaje, s = suelos, t = topografía

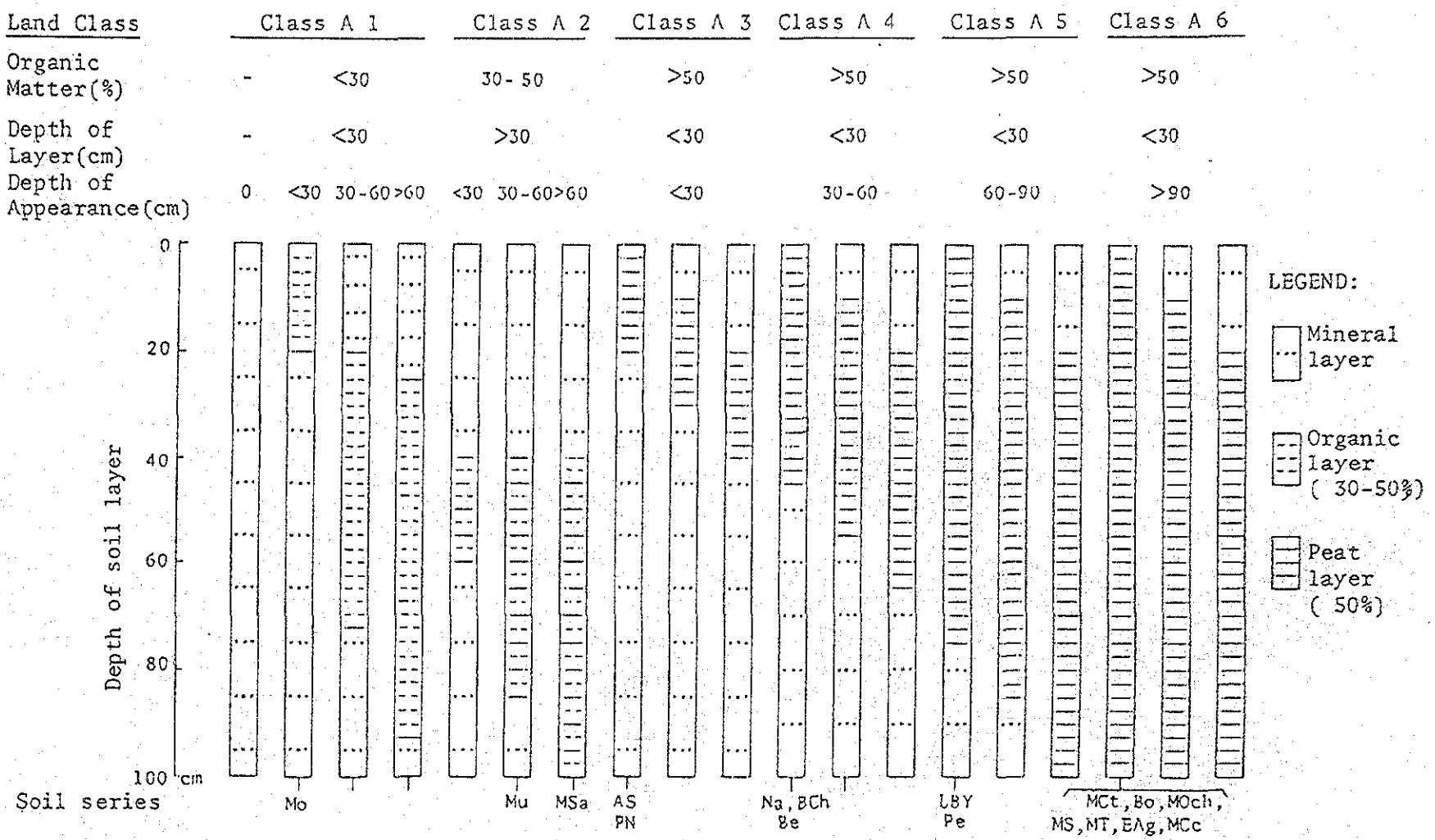
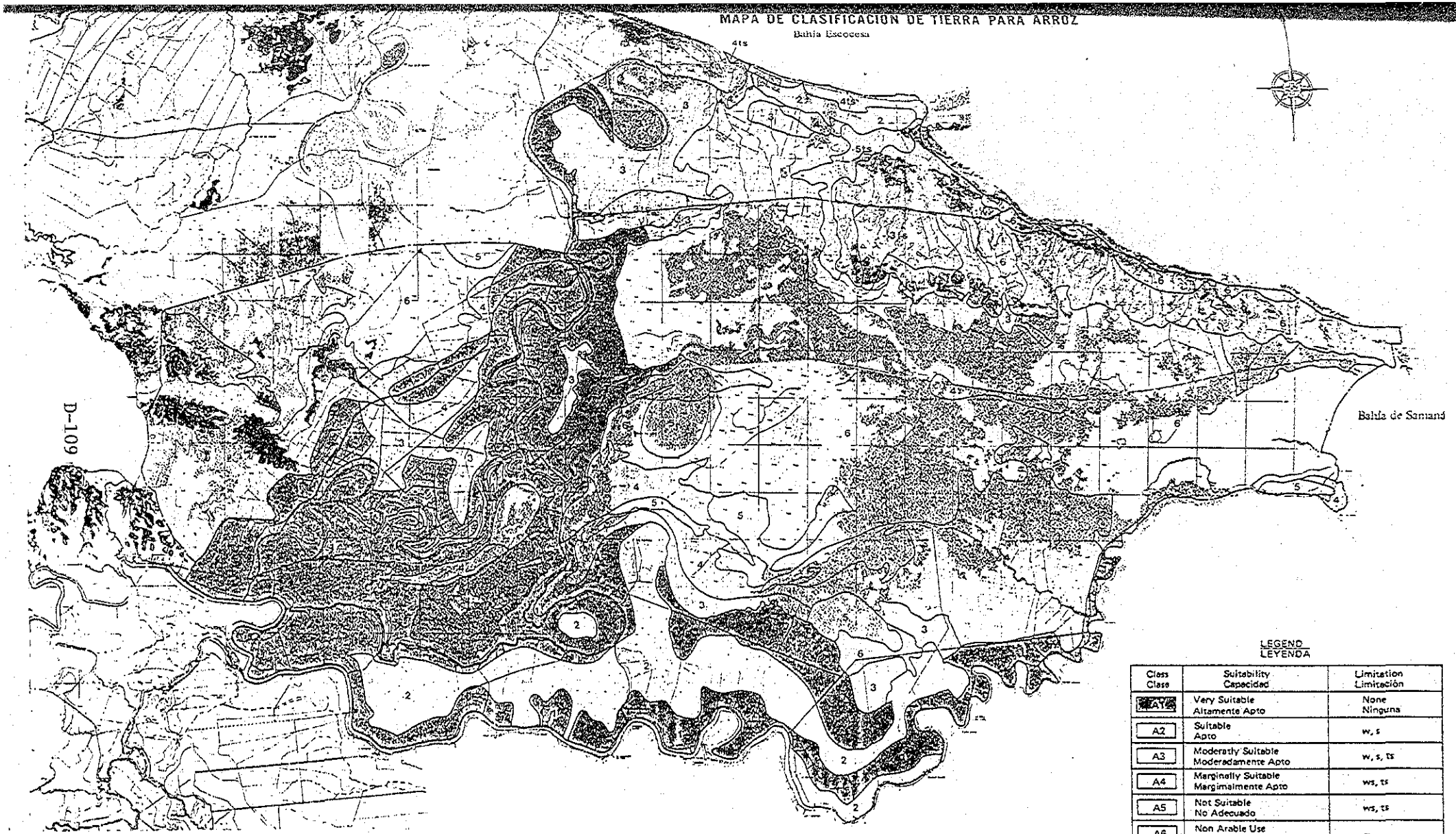


FIG. D.6.3 SCHEMATIC DIAGRAM OF ORGANIC SOIL PROFILES AS EVALUATED OF LAND CLASSES FOR RICE CULTIVATION

MAPA DE CLASIFICACION DE TIERRA PARA ARROZ



LEGEND
LEYENDA

Class Clase	Suitability Capacidad	Limitation Limitación
A1	Very Suitable Altamente Apto	None Ninguna
A2	Suitable Apto	w, s
A3	Moderatly Suitable Moderadamente Apto	w, s, ts
A4	Marginally Suitable Marginalmente Apto	ws, ts
A5	Not Suitable No Adecuado	ws, ts
A6	Non Arable Use Suelos No Arables	—

Note: Limitation symbols indicate the presence of the following deficiencies: w = drainage; s = soil, t = topography

Nota: Las letras significan la presencia de las siguientes limitaciones: w = drenaje, s = suelos, t = topografía

7. Soil Problems and Recommendations

The study area is largely divided into three groups in view of the present development program. The first is a group of the lands expected to be comprised of irrigation and drainage system. The second is a group of the developable lands but not irrigable because of topographic hazards. This group is the lands to be abandoned or left for the future development program as a result of the land classification. These lands have been classified in 4S/5-5 or A5-6 in the foregoing chapter. Fig. D.7.1 illustrates the distribution of the three groups. This chapter describes on the soil problems and recommendations for these groups separately.

7.1 Problem Soils in the Development Program

7.1.1 Distribution of Problem Soils

In Table D.6.3, out of 6,260 ha ranked at suitable lands for upland crops, 5,280 ha or 84 percent have limitations such as drainage (w), soil (s) and topography (t), singly or combiningly. While for rice cultivation, out of suitable area of 12,340 ha, 6,470 ha or 52 percent owe for similar limitations. These are in the status more or less to be subjected to reclamation treatments upon developed into arable lands under the new irrigation and drainage system.

The development program is composed of engineering work and soil amelioration, and must be followed by scrupulous operation and maintenance of facilities together with good management of the fields. The more severe limitations, the more inputs are needed.

7.1.2 Soil Amelioration and Fertilization

(1) Upland Crops

As for upland crops, most of the alluvial soils occurring on plain, delta and levee can be improved by lowering the groundwater level below more than one meter. Because of finer texture, permeability must be increased by deep plowing and corporation of compost.

To decrease gleization in subsoil with increase in structural development is also important in case of Vertisol and the other vertic soil series as well. While on the piedmont areas whose development is not programmed this time, soils are acidic and extremely deficient in bases and occasionally very compact in substratum. The lands are dominantly used as pasture or palm forest at present. They are recommended to be plowed deeply with liming especially when developed to upland fields.

Nitrogen is the first element to be applied, followed by phosphorus; potassium may be the last but cannot be neglected to get higher yield.

(2) Rice

Area of rice cultivation will be expanded to the marginally suitable areas where lands are ranked at A4.

No further problem might be raised on the lands appraised at A1 - A3 so far as similar measures as mentioned above are taken.

Problems of A4 lands generally come from hazards of soil and drainage due to the excessive accumulation of organic matter (peat) and the shallow water table. Soils are acidic with less mineral materials in rhizosphere, resulting in a poor nutritious condition which will make the crop growth worse. As described in Chapter 5, peat C/N ratio of which ranges 20 to 40 releases nitrogen dominantly through its decomposition when the land is drained. Since available phosphorus of peat is very low in content as well as exchangeable potassium which has been reported as low as 0.1 - 0.3 me per 100 g of soil, these two are the key nutrients of fertilizer for increasing rice yield.

Therefore, for the time being after land reclamation it is more safe to limit nitrogen fertilizer as little as possible but to increase phosphate fertilizer than usual. Sometimes potassium fertilizer as combined with phosphate can realize a very good

performance of rice by overcoming nutritional disorder and microbial disease of the plants when grown on the peat land. The common diseases are blast and helmintho-sporium leaf spot.

Another apprehension is about lack of minor elements such as zinc, manganese and copper, which have often been reported on peat soil as a cause of nutritional disorder of the crops. Zinc deficiency is more probable because organic acids and bicarbonates may accumulate in concentrations as high as to inhibit zinc uptake by rice after submergence of the field.

In peat lands it should be avoided to drain the field excessively from the reason that it is apt to induce a rapid decomposition of organic matter and shrinkage of peak layer resulting in subsidence of the land. Therefore, it is necessary to keep the groundwater level at around 50 cm from the surface. For this purpose, system of open and closed ditch will be required.

For other crops such as Yautia, detailed cultural methods were described in the SEA/FAO Report (1976).

7.1.3 Investigation under Model Farm System

As mentioned hitherto, it would be not easy to enhance crop production on the peat areas soon after the land development. The first reason is difficulty in management of soil and water and the second is lack of information on fertilization and plant protection.

A model farm system would be very effective to establish adequate management and cultivation techniques. Experiments on rice variety, fertilizer use and water management can be conducted in the farm, presenting useful data. For study of minor elements, soil and plant samples must be collected to subject chemical analysis in the laboratory.

7.2 Future Aspect for Undeveloped Area

Over Aguacate and Guayabo undeveloped area which will be compiled under the present study extends to about 9,000 ha or 37 percent of the entire study area. It consists of marshy peat area and saline coastal area; the former is covered with wild grasses and swamp forests and the latter with thriving mangrove forests.

In fact these areas have been partially utilized for production of paddy and fire wood or charcoal for a long time.

To assess the future development, however, a broad discussion would be required not only for agricultural use but also for others from different standpoints of ecology and sociobiology.

7.2.1 Detailed Soil Survey on Peat Lands

Peat has been called "frozen assets" in nature. Whether it should be dissolved or not may depend on the land condition and the surrounding circumstances. To answer the question, results of the past soil surveys including the present one are not so satisfactory in so far as the peat lands are concerned. For examples, areas along the old railway appear to be not so peaty but rather clayey; those at least where land is covered with swamp forests may have clayey substratum within 2 meters from the surface. The present soil map, however, only shows distribution of peat soil series and their associations without indicating and real depth of the peat layer.

Future soil survey can be expected to provide many information enough for drawing a more detailed soil map. The best opportunity for survey will come after the development works presently undertaken. Because it will take some time to decrease water table in these area after a main drainage canal is constructed down-side of the developed areas.

The survey may be easily conducted at this period under favour of better access not only for peat soils but also for flora and animals from the viewpoint of environmental conservation.

7.2.2 Possibility for Reclaiming Peat Lands

After the detailed soil survey, the lands can be reappraised by means of the same procedure as described above. Lands where peat layer is thinner than 60 cm would be developed to crop fields of such as rice or pipiota. Even the other lands could be utilized as wild pasture so far as livestocks have access to.

Prospects of further agricultural developmet would be formidably difficult due to the following reasons:

1) A lot of mineral soil must be transported to make the land arable. Moreover, large drainage and pumping facilities are necessary to keep water table lower than the sea level.

2) Such soil dressing as thick as 30 cm must be repeated since it is in a vicious circle with subsidence of the peat land.

3) As a result, the project may not be payable unless the highest output is expected with special crops.

4) Most suspected in environmental disruption which will be caused by such a big change in natural conditions.

In addition, it is likely that a large amount of irrigation water will be consumed since the peat layer is extremely permeable once drained if the drained water cannot be reused for irrigation.

There are several empirical formulas to estimate subsidence of the peat lands. According to Hallakoypi's formula, subsidence in case of 4 m - deep peat density of which is loose is calculated as follows:

$$S = D(0.08t + 0.066) = 2.85(0.08 \times 4 + 0.066) = 1.1 \text{ m}$$

where, S : Subsidence (m)

D : Coefficiet for peat density; 1.0 for compact to 2.85 for loose

t : Thickness of peat (m)

Next is an estimate by Stephens' formula (1974) for annual subsidence when the water table is kept 100 cm from the surface:

$$x = (2.54y - 6.22)/37.52 = 6.6 \text{ cm}$$

where, x : Velocity of annual subsidence (cm)
y : Water table (cm)

These mean, though quite by inference, that the land will subside by 7 cm annually and finally down to 110 cm below the present surface. Anyway, the circumstances would be well understood when the development works are forced.

7.2.3 Set Up of the Nature Conservation Area

As is clear in the foregoing discussions, most of the deep peat lands together with the coastal mangrove forest areas would be preferably left undeveloped. Especially, the mangrove forests are a very important resource as a treasure house of natural animals and a strong mole to protect the coast from sea water erosion. It has become a common knowledge in the world to reserve the mangrove forests for natural conservation and a source of scientific researches.

Based on the above discussions in this chapter, it is concluded that most of the undeveloped area is not to be reclaimed but the left the same.

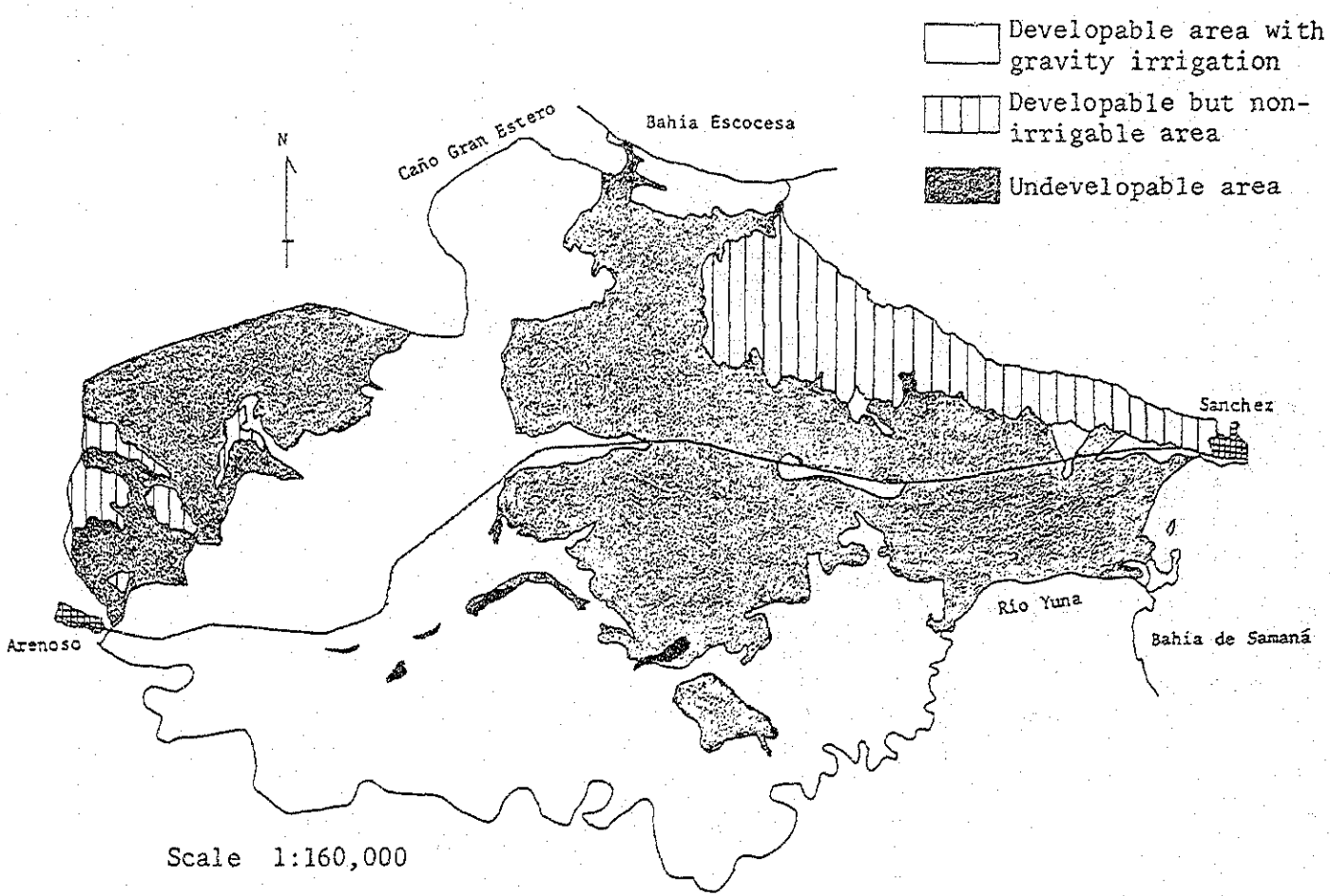


FIG. D.7.1 DEVELOPABLE AREA OF THE PROJECT AS DIVIDED BY IRRIGABILITY AND SUITABILITY

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ANNEX E: IRRIGATION AND DRAINAGE

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ANNEX E: IRRIGATION AND DRAINAGE

1. Farm Consolidation

In accordance with the existing road network and irrigation and drainage systems, the study area has been divided into 11 blocks as follows (see Fig. E.1.1).

El Aguacate	.....	7 blocks (8,400 ha)
El Guayabo	.....	4 blocks (15,700 ha)
Total		11 blocks (24,100 ha)

Due to the topographical diversity of El Aguacate and the existence of swamps in El Guayabo, farm lands in the study area are less developed than those neighboring areas as El Pozo and Limon del Yuna. The greater part of the farms is developed for the paddy field, but the lack of irrigation water and the flooding damage have left some of these fields without seeding. Comparatively well developed paddy fields are found in the following zones:

A-4 (El Aguacate)	:	Irrigation water is supplied by pumping station in the Yuna River
A-7 (El Aguacate)	:	Located higher level and near the source for the irrigation water
G-4 (El Guayabo)	:	Located beside the Yuna River

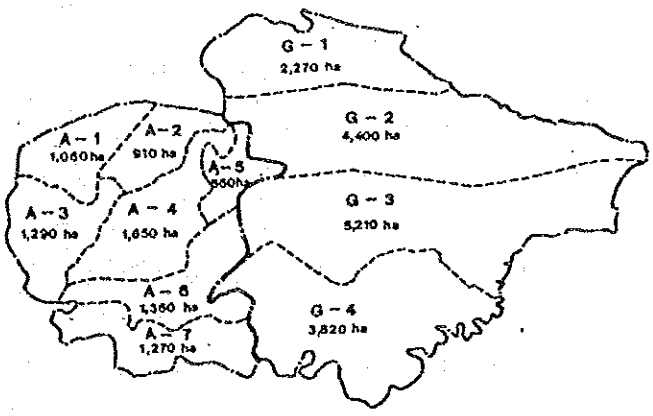


FIG. E.1.1 DIVISION OF AREA

The description on the consolidation of farms in each block is given below:

A-1. (Area: 1,060 ha, Elevation: 2.0-8.0 m)

This zone is located at the Northwest of El Aguacate bordering at North with El Pozo settlement. The most of this zone is undeveloped, due to the existence of La Ceja and swampy forests.

A-2. (Area: 910 ha, Elevation: 1.4-3.8 m)

This zone covers the Northeast portion of El Aguacate bordering at North with El Pozo settlement. The North part of this zone is occupied also by La Ceja and by swampy forests and is undeveloped. The rest of the zone is occupied by paddy fields and pastures.

A-3. (Area: 1,290 ha, Elevation: 4.3-9.6 m)

This zone covers the Western part of El Aguacate, bordering with the proposed route for the construction of the main canal of El Pozo Project. The construction of reservoir is proposed on the hill of this zone. The Caño Moreno is found within this zone, which supplied irrigation water to the paddy fields located in Eastern part of the zone. The hills are actually used for pastures.

A-4. (Area: 1,650 ha, Elevation: 1.6-1.7 m)

This zone occupies the central part of El Aguacate bordering at Northwest with the trunk road and at the South with the railroad track. Within the study area this zone is the most developed and benefitted zone by the pumping station at the Yuna River. Excepting the forest along the Caño Gran Estero the most of this zone is covered by paddy fields.

A-5. (Area: 860 ha, Elevation: 1.8-3.6 m)

This zone is located to the East of the access road connecting Cruz de Rincon with the Yuna River. The farms are irrigated by a pump installed at Caño Gran Estero.

A-6. (Area: 1,360 ha, Elevation: 2.8-8.4 m)

This zone is limited by the railroad track to the North and by the Caño Ponton to the South. The Eastern part is topographically level. In this zone lagoons such as Liandro, Madrid, Del Muerto are found without being utilized.

A-7. (Area: 1,270 ha, Elevation: 2.8-10.4 m)

This zone is located on the South of El Aguacate, bordering with the Yuna River at its end. Along the Yuna River and the access road there are developed paddy fields and the rest of the zone is utilized for pastures, cacao, coconut and residential area.

G-1. (Area: 2,270 ha, Elevation: 0.4-2.6 m)

This zone is located at North of El Guayabo, limited at south by the highway that connects Nagua and Samaná and at west by the Caño Gran Estero. Some part of this zone is being utilized for paddy fields and pastures, but the most of it is undeveloped.

G-2. (Area: 4,400 ha, Elevation: 0.4-2.8 m)

This zone is situated between the Nagua-Samaná highway to the North and the railroad track to the South. The most of the Western portion consists of swampy lands and swampy forests. To the Northeast part, mountain called "Loma la Cordillera", is found with coconut plantations and pastures.

It is supposed that there had been paddy fields at the Southeast part some years ago, but now only pastures and swampy lands are found.

G-3. (Area: 5,210 ha, Elevation: 0.4-2.8 m)

This zone is located at the central part of El Guayabo and is limited at North by the railroad track and at South by the Guayabo River. The most part of this zone consists of swampy lands and swampy forests. The developed portion is very limited.

G-4. (Area: 3,820 ha, Elevation: 1.4-7.0 m)

This zone is located at the Southern part of El Guayabo, bordering at North with the the Guayabo River and at South with the Yuna River. The level of development is the highest within El Guayabo. Parcels cultivated with rice are developed along the Yuna River, and are irrigated by pumps installed on bank of this river; however, there are undeveloped swampy lands beside Guayabo River.

Following is the summary of the study area:

Study Area	Zone	Area (ha)
I El Aguacate	A-1	1,060
	A-2	910
	A-3	1,290
	A-4	1,650
	A-5	860
	A-6	1,360
	A-7	1,270
Sub-total		8,110
II El Guayabo	G-1	2,270
	G-2	4,400
	G-3	5,210
	G-4	3,820
Sub-total		15,700
TOTAL STUDY AREA		24,100

2. Sources of Irrigation Water and Intake Facilities

2.1 Sources of Irrigation Water

Water for irrigation within the influencial zone of the study area may be obtained from one or more of the sources mentioned hereinafter. The actual situation of these sources is to be described.

(1) Yuna River

The Yuna River is the second largest river in the Dominican Republic with the longitude of 209 km and the river basin of 5,490 km^2 and it constitutes the southern boundary of the study area. In the upper stream, two dams, the Hatillo and the Rincon are constructed; the construction of the Hatillo Dam was completed in 1984 and it has been operated since then.

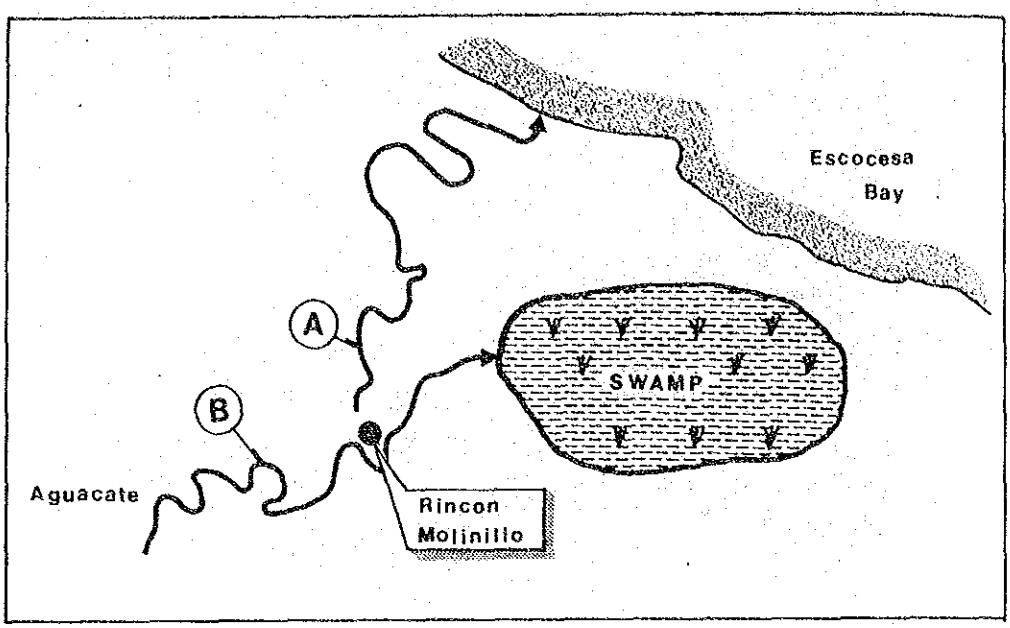
The numbers of pumps installed between Arenoso and the river-mouth are 55 on the left bank and 52 on the right bank and if all of these pumps should be operated simultaneously, the total volume of river water to be diverted would reach about 2.5 m^3/s on the left bank and 2.4 m^3/s on the right bank. The field investigation carried out on August 1, 1985 revealed that the water intake by pump operation was 0.63 m^3/s on the left bank and 1.02 m^3/s on the right bank.

The water quality on the stream of aforementioned section of the river turned out to be almost standardized with approximate values of the 8.0 for the pH and 150 ppm for the chlorine concentration.

(2) Caño Gran Estero

The Caño Gran Estero is formed by two tributaries (A, B) as illustrated below. The tributary A originates its course near the Rincon Molinillo and runs to the north up to the Escocesa Bay.

The tributary B is extended from the central part of El Aguacate agrarian reform zone to the swamp of El Guayabo. The Caño Cuba Libre is confluent with the tributary A near the river-mouth.



In normal situation, these two tributaries work separately; nevertheless, in case of flooding, some stream deviated from the tributary B flow into the tributary A.

In the upper stream, about 20 kms from the river-mouth of the tributary A, there are some zones in which riverbed is exposed and Yautia and other crops are cultivated. The riverbed was excavated to the depth of 1 m but the groundwater was not encountered. According to the verbal information from the local residents, as the development of the Aguacate zone has accelerated, the groundwater level has lowered. The tributary B is also featured by little stream which is covered with water plants. Two pumps, one on the tributary A at Rincon Molinillo and the other on the tributary B, are installed at present.

The reason why this water resource are not utilized for the irrigation purpose may be rooted:

- The high salinity of lower stream of the tributary A ranging between 500 ppm and 1,500 ppm of chlorine consentration suggests that the use of these water for agricultural purpose is limited to some crops.

- The upper stream of the tributary A, and the whole stream of the tributary B though they have no such problem as mentioned above, do not count on enough resources as to supply irrigation water in the dry season.

(3) Caño Ponton

The Caño Ponton originates its stream near the Aguacate pumping station and runs to the east as far as to the "Laguna Prieta". Like the Cano Gran Estero, water is stagnated innormal condition with thick growth of water plants to cover the whole stream. Only the small-scaled pump is installed on this river. In terms of quality, the water in this river could be used for the agricultural purpose with the pH between 6.8 and 7.3 and the chlorine concentration between 75 ppm and 105 ppm.

(4) Caño Moreno

The Caño Moreno has its course in the old trace of the Yuna River and is formed a lagoon including swamps around it. At present irrigation water is pumped by three pumps including that of IAD's property from this water resource. The water quality is ranging between 6.8 and 7.3 for the pH and 75 ppm and 105 ppm for the chlorine concentration, which present no constraints for agricultural use.

(5) Guayabo River

At present, the water route of the Guayabo River reaches up to 1.5 km upper stream of the confluence with the Yuna River; further upper stream from this point, thick water plants are growing. The both side of the river is covered by low swamp land with an approximate elevation of 1.5 m.

Some drains which are excavated from the Guayabo River to the swamp lands were not working with water stagnation at the time of the field survey. Judging from this phenomenon, the water level of the Guayabo River is considered to be equal with the groundwater level of the swampy lands. The reverse flow of the Guayabo River was observed during the investigation conducted on August 7. Our survey on this river has drawn an assumption that the Guayabo River and its surrounding swampy lands are forming a retarding basin and the flow of the Guayabo River is affected by the relation between the riverwater level of the Guayabo and the groundwater level of the swampy lands.

The total flow volume of the river is estimated to be approximately 400,000 m^3 at present and further aquifer is supposed in the surrounding swampy zone. The water quality analysis indicates in this river the pH to be 7.0 and the chlorine concentration to be 140 ppm. Water in this river is irrigated by means of two pumps installed on its bank.

(6) Lagoons and Groundwater in Swampy Zone

The following lagoons are found within the Study area:

El Aguacate: Liandro, Madrid, El Muerto, etc.
El Guayabo: Los Ostiones, Prieta, etc.

These lagoons are surrounded by swampy zone and water reserves within them are supposed to be large in volume.

The water quality os supposed to be an acid reaction due to the disintegration of peat.

(7) Small Streams in Mountain "Loma la Cordillera"

A total of eleven small streams are found in the study area originating their stream in the mountain called "Loma la Cordillera" and ending in the swampy zone of El Guayabo. Because these streams contain so little flow actually that investigation

on the flow volume has not been carried out. The topographic conditions of these streams prevent from constructing a large-scaled reservoir on their catchment. Privately used small-scaled reservoir is located at the Arroyo El Catey.

As mentioned briefly above, the source for irrigation water within the study area is largely dependent on the Yuna River, though irrigation facilities actually set up are small in scale and almost exhaused. On the other hand, rain plays an important role in the crop cultivation, which reflects unstable agricultural practice in the study area; irrigation water supplied by means of artificial facilities is used for plowing or for the complementary water in the dry season. The locations of source for the irrigation water is indicated in Fig. E.2.1.

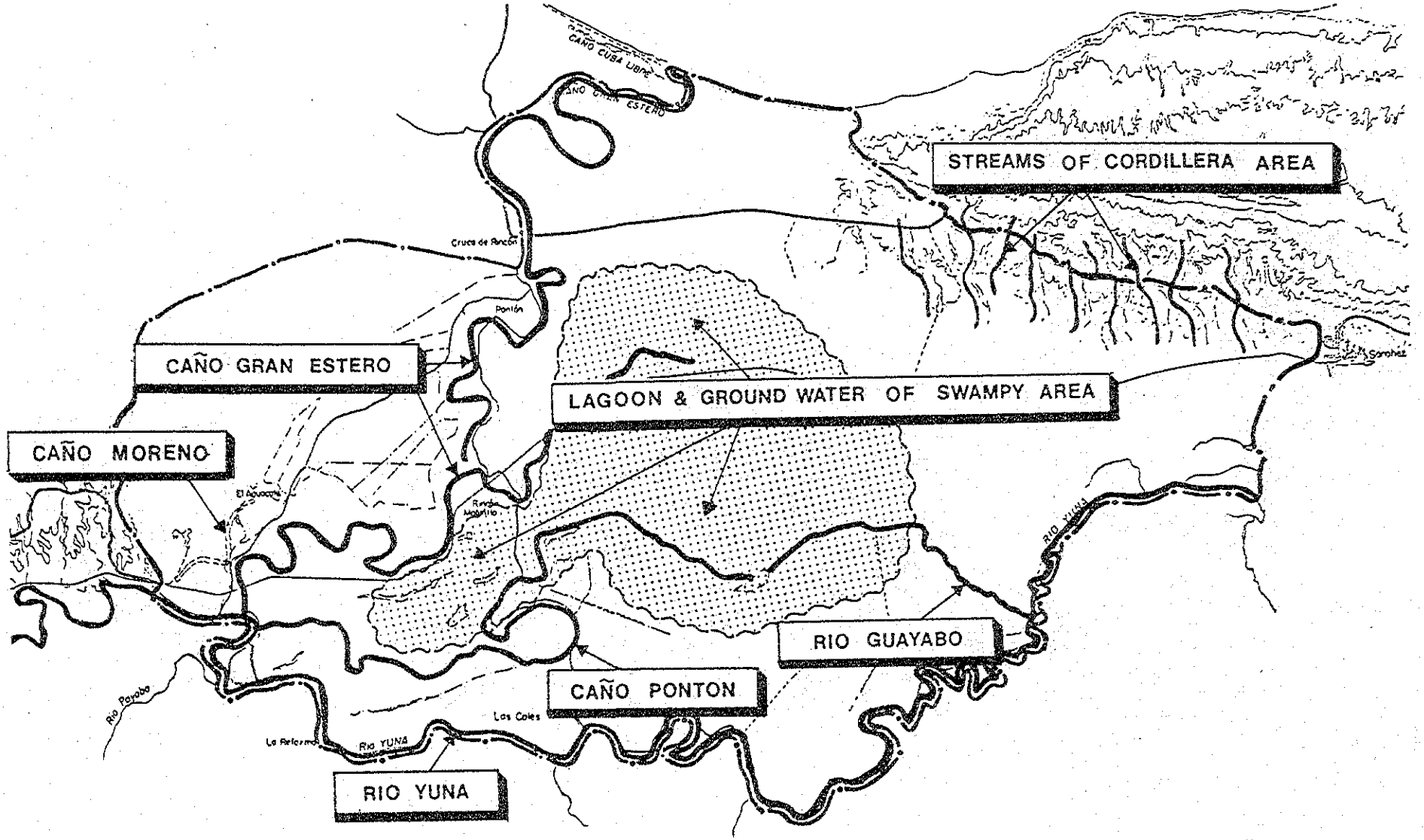


FIG. E.2.1 LOCATION OF WATER RESOURCES

TABLE E.2.1 SUMMARY OF SOURCES FOR IRRIGATION WATER

Sources	Water Reserve	Water Quality	Utilization Situation for Irrigation Purpose	Remarks
Yuna River	Abundant	Good	55 pumps (left bank) with a range between ϕ100 - ϕ300 are installed	
Caño Gran Estero	Deficient in droughty season	High acidity in lower stream	IAD's pump (ϕ300) and another one are installed	
Caño Ponton	"	Good	1 pump is installed	
Guayabo River	Enough	Good	2 pumps (ϕ100) are installed	. Water intake facilities should be constructed on poor ground . Irrigation water thru canal is to be conducted topographically reverse direction
Caño Moreno	Stagnated water	Good	IAD's pump (ϕ300) and another two pumps are installed	Water intake facilities should be constructed on poor ground
Lake, Marsh and Groundwater	Enough	Supposed to contain acidity	Not utilized	. Water intake facilities should be constructed on poor ground . Irrigation water thru canal is to be conducted topographically reverse direction
Small Streams Originating "Loma la Cordillera"	Deficient in droughty season	Information not available	One reservoir is constructed	. Higher cost is expected with the construction of reservoir . Development resources are deficient

2.2 Water Intake Facilities

Except the small-scaled reservoir installed at Arroyo El Catey, the irrigation water is totally obtained through pumps. A total of 63 pumps (55: on the Yuna River, 2: on the Caño Gran Estero, 3: on the Caño Moreno, 2: on the Guayabo River, 1: on the Caño Ponton) were confirmed their existence during the field survey. The location of these pumps is shown in Fig. E.2.2 and their capacities are as in Tables E.2.2, E.2.3 and E.2.4. The Aguacate pumping station, the largest one in the study area, is equipped with two vertical suction pumps one (ϕ: 24 inches) was installed by IAD in 1962 and the other (ϕ: 14 inches) was installed by INDRHI in 1984 to answer the urgent need. Besides having troubles very often, the outworn equipment cannot pump up water when the river flow is in low level. Aside from this station, IAD supervises three stations, one on the Caño Gran Estero and the two on the Caño Moreno. The rest of pumps installed in the study area is possessed privately.

Most of pumps except those installed in the Aguacate pumping station are engine driven, single suction, volute type with diameter less than 300 mm. The pump head of these pumps is 10 m or lower with average height between 5 and 6 m. The pumps which are in their most parts made in Japan, U.S.A., Taiwan, Czechoslovakia are met working well due to the deterioration and bad maintenance. Pumps with diameter more than 200 mm are put up a shed, but others are exposed to the air.

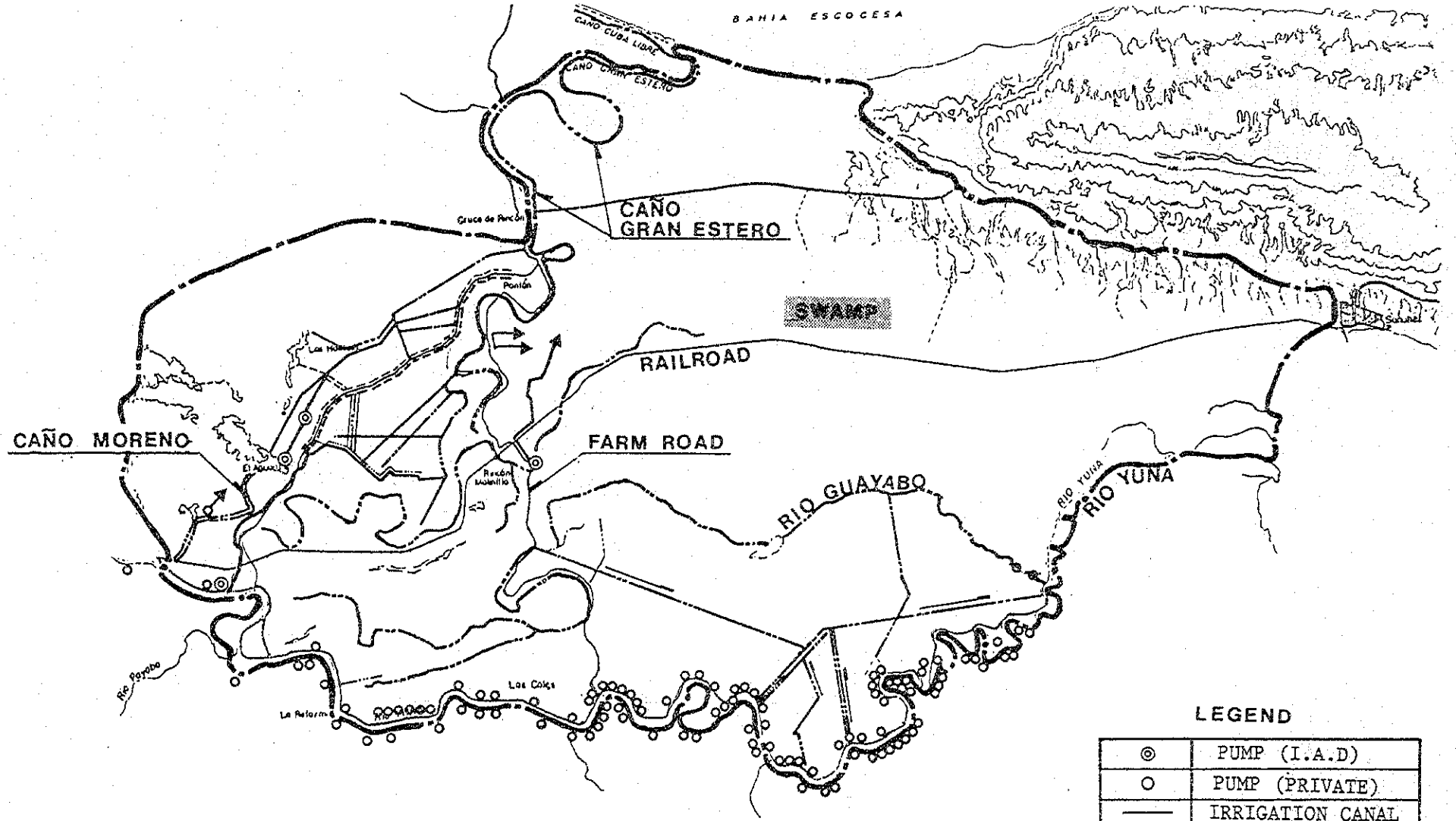


FIG. E.2.2 EXISTING CONDITION OF STUDY AREA

TABLE E.2.2 PUMPS ON THE LEFT BANK OF THE YUNA RIVER

Pumps	Diameter (mm)	Capacity (m^3/s)	Ownership	Reference
L-1	100	0.018 *	Private	
L-2A	300	0.183 *	IAD	Aguacate
L-2B	200	0.080	"	"
L-3	100	0.018	Private	
L-4	100	0.018	"	
L-5	150	0.042	"	
L-6A	100	0.018	"	
L-6B	100	0.018	"	
L-7	100	0.018	"	El Limon
L-8	150	0.042	"	
L-9	100	0.018	"	
L-10	100	0.018 *	"	
L-11	250	0.125	"	
L-12	150	0.042	"	
L-13	150	0.042	"	
L-14	150	0.042 *	"	
L-15	150	0.042 *	"	
L-16A	100	0.018 *	"	
L-16B	100	0.018 *	"	
L-17A	200	0.080 *	"	
L-17B	150	0.042	"	
L-18	200	0.089	"	
L-19	200	0.089	"	
L-20	100	0.018	"	
L-21	200	0.080	"	
L-22	100	0.018	"	
L-23	200	0.080	"	
L-24	150	0.042	"	Los Cacao
L-25A	100	0.018	"	
L-25B	150	0.042	"	
L-26	150	0.042	"	

.... cont'd

Pumps	Diameter (mm)	Capacity (m^3/s)	Ownership	Reference
L-27	150	0.042 *	Private	
L-28A	200	0.080	"	
L-28B	150	0.042	"	
L-29A	150	0.042	"	
L-29B	150	0.042	"	
L-30	150	0.042	"	
L-31	150	0.042	"	Barracote
Sub-total		1.774 (0.443)*		
L-32	100	0.018	Private	
L-33	100	0.018	"	
L-34	100	0.018	"	
L-35	100	0.018	"	
L-36	250	0.125	"	
L-37	100	0.018	"	
L-38	100	0.018	"	
L-39	100	0.018	"	
L-40	250	0.125	"	
L-41A	100	0.018	"	
L-41B	150	0.042	"	
L-42	150	0.042	"	
L-43	150	0.042	"	
L-44A	150	0.042	"	
L-44B	200	0.080	"	
L-45	150	0.042	"	
L-46	150	0.042	"	
Total		2.500 (0.625)*		

Remarks: 1. * pumps operated at the time of the field investigation.
2. The category of diameter is as follows:
ϕ 300 mm = 1, ϕ 250 mm = 3, ϕ 200 mm = 8,
ϕ 150 mm = 22, ϕ 100 mm = 21

TABLE E.2.3 PUMPS ON THE RIGHT BANK OF THE YUNA RIVER

Pumps	Diameter (mm)	Capacity (m^3/s)	Reference
R-1	-	-	
R-2	150	0.042 *	
R-3	100	0.018 *	
R-4	100	0.018	
R-5	100	0.018	
R-6	150	0.042 *	
R-7	150	0.042	
R-8	300	0.183 *	
R-9	100	0.018	
R-10	300	0.183 *	
R-11	150	0.042	
R-12	150	0.042	
R-13	200	0.080	
R-14	200	0.080	
R-15A	150	0.042	
R-15B	100	0.018 *	
R-16	100	0.018	
R-17	100	0.018	
R-18	150	0.042	
R-19	200	0.080	
R-20	150	0.042	
R-21	200	0.080	
R-22	150	0.042 *	
R-23	150	0.042	
R-24A	100	0.018	
R-24B	100	0.018 *	
Sub-total		1.268 (0.546)*	
R-25	200	0.080	
R-26A	150	0.042	
R-26B	150	0.042	
R-27	250	0.125	

..... cont'd

Pumps	Diameter (mm)	Capacity (m^3/s)	Reference
R-28	150	0.042	
R-29	100	0.018	
R-30	150	0.042	
R-31	150	0.042	
R-32A	150	0.042	
R-32B	200	0.080	
R-33	150	0.042	
R-34	150	0.042	
R-35	200	0.080	
R-36	150	0.042	
R-37	150	0.042	
R-38	100	0.018	
R-39	100	0.018	
R-40	100	0.018	
R-41	150	0.042	
R-42	100	0.018	
R-43	100	0.018	
R-44	150	0.042	
R-45	100	0.018	
R-46	100	0.018	
R-47	100	0.018	
R-48	150	0.042	
R-49	150	0.042	
Total		2.383 (1.02)*	* in operation

Remarks: 1. * pumps operated at the tie of the field investigation.

TABLE E.2.4 PUMPS WITHIN THE STUDY AREA EXCEPT THE YUNA RIVER

Pumps	Diameter (mm)	Q (m^3/s)	Ownership	Reference
CM-1	150	0.042	Private	Caño Moreno
CM-2	300	0.183	IAD	" (248)
CM-3	250	0.125	IAD	" (325)
CG-1	200	0.080	Private	Caño Gran Estero
CG-2	300	0.183	IAD	"
RG-1	100	0.018	Private	Rio Guayabo
RG-2	100	0.018	"	"
CP-1	100	0.018	Private	Caño Ponton

3. Water Quality

The irrigation water was analyzed in relation with:

- Water temperature,
- pH, and
- Electric conductivity.

The result of this analysis is presented in the Table E.3.1 and it is concluded that the prevailing irrigation water within the study area constitutes no constraint for cultivating crops except that stagnated in the lower stream of the Caño Gran Estero which contains high salinity in the range of 500 ppm and 1,500 ppm.

TABLE E.3.1 WATER QUALITY OF IRRIGATION WATER

Location	Depth	Temperature (°C)	pH (ppm)	EC (μs/cm)	Cl (ppm)
The Yuna River					
Arenoso	Surface Water	30.0	8.4	340	150
Jagua	"	28.0	8.0	305	140
Confluence	"	29.0	8.1	315	140
"	1.5 m	29.0	8.2	310	140
500m from river-mouth	Surface Water	28.0	8.2	310	140
" "	3.0 m	28.0	8.2	310	140
River-mouth	Surface Water	28.5	7.9	310	140
"	1.5 m	28.0	8.2	340	155
The Guayabo River					
Bridge	Surface Water	31.0	7.0	305	140
1,500m from the confluence	"	32.0	7.0	310	140
The Caño Gran Estero					
River-mouth	Surface Water	27.0	7.2	2,200	1,500
Cuba Libre	"	25.0	7.8	2,800	1,500
5,000m from the river-mouth	"	27.0	7.4	1,700	800
10,000m from the river-mouth	"	29.0	7.4	1,200	550
Cruz de Rincon	"	29.0	7.4	920	420
Rincon Morinillo	"	29.0	7.4	360	100
Caño Ponton					
Bridge	Surface Water	29.0	7.3	250	105
El Jobo	"	28.5	6.8	170	75
Caño Moreno					
Pumping Station	Surface Water	29.0	7.3	250	105
500m downstream from P. station	"	28.5	6.8	170	74

.... cont'd

Location	Depth	Temperature (°C)	pH (ppm)	EC (µs/cm)	Cl (ppm)
El Aguacate					
Canal	Surface Water	28.0	7.7	320	145
Canal	"	28.0	8.2	250	115
Canal	"	29.0	8.2	290	130
El Pescadero					
Drain Outlet	Surface Water	27.5	6.8	190	85
El Guayabo					
Canal	Surface Water	28.0	7.1	260	120
Test Pit	"	26.0	6.7	510	230
Caño Gran Estero	"	30.0	7.0	420	185

Note: pH: hydrogen-ion concentration
EC: electric conductivity
Cl: chlorine concentration

ANNEX F: LAND USE

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LIST OF FIGURE

ANNEX F: LAND USE

1. General Description of the Present Land Use

1.1 Present Land Use

The study area is consisted of the alluviul plains extended on the left bank basin of the Yuna River and hills at the foot of a mountain called "Loma la Cordillera". The greater portion of the Guayabo zone is left uncultivated covered by swamps and swampy forests.

The rice cultivation is mainly practiced in the natural banks along the Yuna River and the land settlement area of the Aguacate zone.

Substantial areas have been allocated to the plantation of such crops as rice, cacao, coconut and yautia; upland crops like maize are cultivated under very small plots.

Estimates of areas devated to agricultural purposes are given below:

Present Land Use (ha)

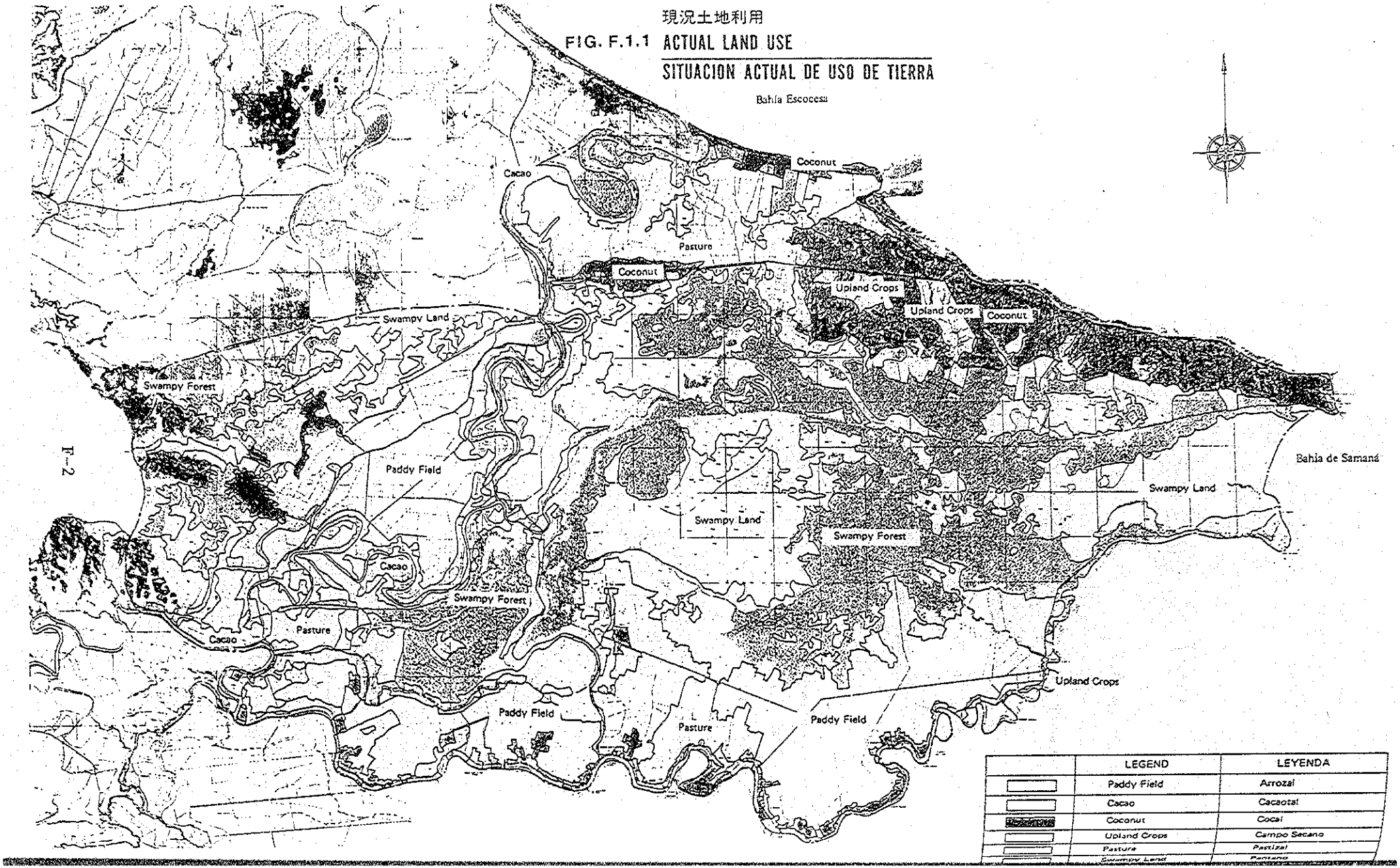
Crop	Aguacate	Guayabo	Total
Rice	2,000	2,100	4,100
Cacao	1,300	400	1,700
Coconut	-	1,400	1,400
Upland Crops	-	500	500
Rough Grazing	3,100	2,700	5,800
Swamps	1,200	3,700	4,900
Forestal Swamps	600	4,700	5,300
Alienated Land	200	200	400
Total	8,400	15,700	24,100

Note: Alienated land includes residence area, road, etc.

現況土地利用

FIG. F.1.1 ACTUAL LAND USE

SITUACION ACTUAL DE USO DE TIERRA



1.1.1 Paddy Fields

Rice is grown on the low terrace beside the Yuna River and in the settlements of the Aguacate. Paddy fields in the latter expected to be irrigated pumping from the Yuna River, but frequent troubles of pumps and lack of their capacity result in the insufficient supply of irrigation water. At present, most of the rice production is carried out depending on return flows and rain water. Flood damages are reported in these fields.

The summary of paddy field in the study area is as follows:

Paddy Field in the Study Area (ha)

	Cultivated Area	Irrigable Area	Transplanted[2] Area	Harvested[2] Area
Aguacate				
Agrarian Reform				
(Aguacate)	1,270	420	1,570	1,150
(Cienega Vieja)	320[1]	110[1]	400[1]	260[1]
Private land	410[1]	310[1]	510[1]	370[1]
Sub-total	2,000	840	2,480	1,780
Guayabo				
Agrarian Reform	1,130	850	1,110	980
Private Land	970[1]	730[1]	950[1]	840[1]
Sub-total	2,100	1,580	2,060	1,820
Total	4,100	2,420	4,540	3,600

Notes: 1) Estimated.
2) Average figure for 10 years, 1975-1984.

1.1.2 Cacao

Cacao plantation is extended in their most part in private lands located along the Caño Ponton, El Caño Gran Estero, etc.

1.1.3 Coconut

Coconut is cultivated in the Guayabo zone, the foot of the mountain, "Loma la Cordillera" and near the Escocesa Bay.

1.1.4 Upland Crops

Upland crops (cassava, maize, etc.) cultivation is confined to high terraces along the Nagua-Sanchez highway and natural banks along the Yuna River.

1.1.5 Yautia

Yautia is partially grown in swamps situated central part of the Guayabo and northern portion of the Aguacate.

2. Land Distribution according to Its Elevation

The mean elevation of the study area ranges between 2m and 3 m and the area less than 2 m occupies 42% of the total area.

The land distribution according to its elevation is as shown below:

Elevation	Area (ha)	Percentage (%)	Accumulated Area (ha)
River and Swamp	470	2.0	470
0 - 1 m	1,720	7.1	2,190
1 - 2 m	7,790	32.3	9,980
2 - 3 m	4,250	17.6	14,230
3 - 4 m	2,000	8.3	16,230
4 - 5 m	1,900	7.9	18,130
5 - 6 m	1,100	4.6	19,230
6 - 7 m	1,020	4.2	20,250
7 - 7.5 m	460	1.9	20,710
7.5 - 8 m	460	1.9	21,170
8 - 9 m	620	2.5	21,790
9 - 10 m	310	1.3	22,100
10 - 20 m	1,090	4.5	23,190
20 -	910	3.8	24,100
TOTAL	24,100	100.0	

Regarding the land tenure, the national lands are located in the area with elevation less than 4 m and the private lands in the higher area.

3. Land Tenure

Of total study area of 24,100 ha, the IAD's agrarian reform area comprising three projects of El Aguacate, El Guayabo and Cienega Vieja occupies approximately 6,700 ha. The rest of lands is composed of lands privately owned or without ownership. Farmers with holdings below 25 ha represent 94.4% of the total number of farms in the study area but only 31.7% of the farmland.

Especially, small farmers with farm size less than 1 ha occupy 43.6% of the total number of farmers. About 10,000 ha of lands (41.5% of the total) is held by only 5.6% of the total land owners.

Land Tenure by Farm Size

Farm	Area		Farm		Average Farm
	ha	%	ha	%	Size (ha)
Less than 1.0 ha	312	1.3	1,054	43.6	0.3
1.0 - 2.0 ha	352	1.5	249	10.3	1.4
2.0 - 4.0 ha	1,014	4.2	365	15.1	2.8
4.0 - 6.0 ha	909	3.8	197	8.2	4.6
6.0 - 12.0 ha	1,961	8.1	241	10.0	8.1
12.0 - 25.0 ha	2,873	11.9	175	7.2	16.4
More than 25 ha	10,003	41.5	136	5.6	73.6
IAD	6,676	27.7			
Total	24,100	100.0	2,417	100.0	100

Source: Informes de la Division de Catastro Rural.

4. Land Settlement

4.1 General

Summary of land settlements in the study area is as listed below:

Present Land Settlement (ha)

Settlements	Distributed Area	Non-distributed Area	Total Area	No. of Settler
Aguacate	1,940	3,721	5,661	487
Cienega Vieja	484	-	484	194
Guayabo	3,019	3,837	6,856	667
Total	5,443	7,558	13,001	1,348

4.2 Settlements in the Aguacate

The Aguacate land settlement project was started in 1969 and a total of 2,430 ha's land has been distributed to beneficiaries. The present land use for each settlement of Aguacate and Cienega Vieja is as given below:

Present Land Use in the Aguacate Settlements

	Aguacate	Cienega Vieja	Total
Distributed Land	1,940	490	2,430
Paddy Field	1,270	320	1,590
Cacao & Yautia	270	70	340
Rough Grazing	400	100	500

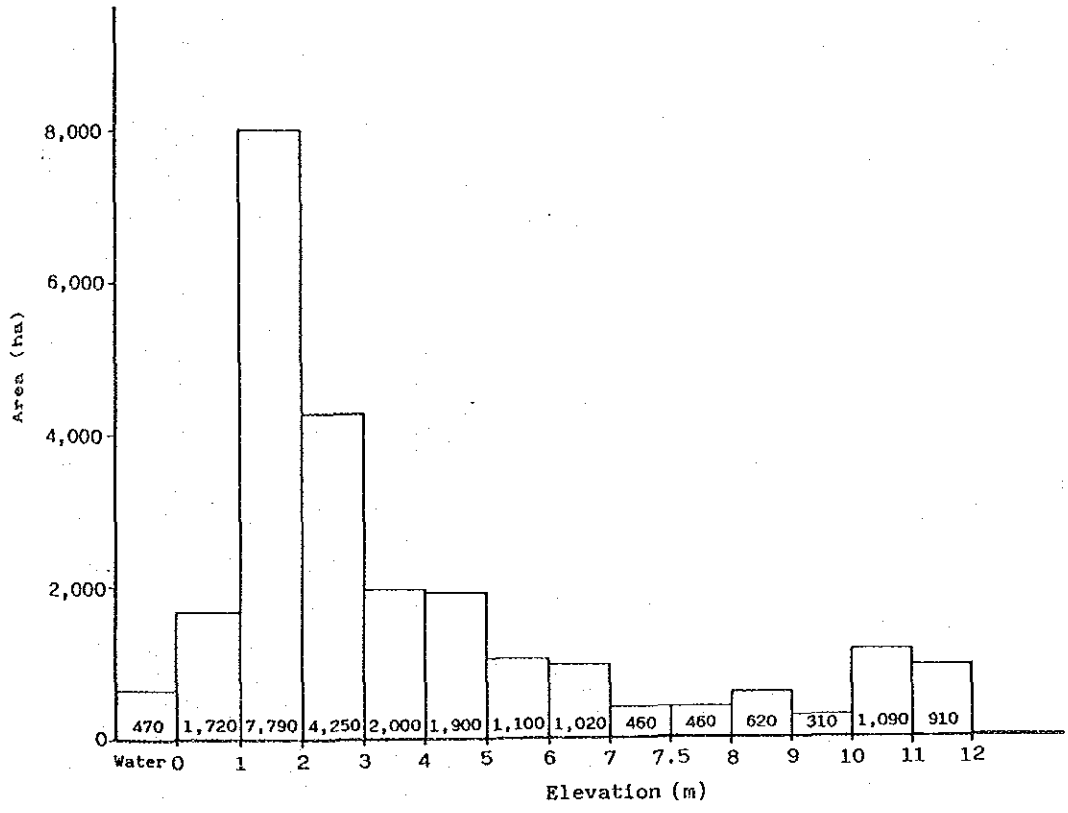
4.3 Settlement in the Guayabo

At the initial stage of the land settlement project for the Guayabo in 1976, lands of 3,019 had been allocated to 1,200 settlers, but actually only 50% of them remain in this settlement because of lack of physical and social infrastructures and adequate supporting services.

PRESENT LAND USE IN THE GUAYABO SETTLEMENTS

Distributed land	3,019
Paddy Field	1,130
Yautia	30
Rough Grazing	1,009
Abandoned Land	850

LAND DISTRIBUTION ACCORDING TO ELEVATION



ANNEX G: AGRICULTURE

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ANNEX G: AGRICULTURE

1. General

The Aguacate-Guayabo area is a part of the jurisdiction area of the SEA northeast regional office which cover four provinces. Rice cropping area in the four provinces to that in the whole country was about 30 percent in 1984. In the three concerned provinces with the study area, the share of paddy production to the national was about 24 percent as seen in Table G.1.1.

The rice production is mainly practised in the study area under the geographical conditions due to swamps and swampy areas are prevailing. As lack of irrigation system and poor drainage conditions the both productivities in terms of land and labor are relatively low. The other major crops are cacao, yautia pipiota (Cococasia esculenta Schott) and coconut. Other minor crops such as plantain, cassava, maize and beans are cultivated on a small scale, which are only for home consumption or local markets.

In the areas which are not suited to grow any of above crops, especially in the swamps and hilly area are utilized for grazing of beef cattle.

2. Crops and Cropping Pattern

Even in the swampy areas, the rice fields have been developed so far as the lands can be cropped with rice. However, the annual cropping intensity of the rice fields in the study area is estimated at only 78 percent in the IAD settlement area and 106 percent in the private land area as shown in the following table.

TABLE G.1.1 RICE PRODUCTION AND THE RESULT (1984)

Area	Planted Area			Harvested Area			Production			Unit Yield		
	Program (ha)	Actual (ha)	%	Program (ha)	Actual (ha)	%	Program (ha)	Actual (ha)	%	Program (ton/ha)	Actual (ton/ha)	%
1. National	119,930	120,750	101	122,170	118,048	96	309,548	321,861	104	2.53	2.73	108
2. Northeast Region	37,459	42,219	113	37,214	40,915	108	93,057	104,304	112	2.50	2.55	102
3. Related Province with the Project												
- Duarte	23,972	16,962	71	19,450	12,635	65	54,974	30,597	55	2.83	2.42	86
- Maria T. Sánchaz	7,459	8,849	119	8,353	8,544	102	19,409	23,244	119	2.32	2.72	117
- Samaná	1,260	522	41	432	72	17	1,083	124	11	2.51	1.72	69
Total	32,691	26,333	81	28,235	21,251	75	75,466	53,965	71	2.67	2.54	95
4. Project Relation Sub-zone Villa Riva (1985)	5,381			5,498								

Note: The data on the actual rice production in the related provinces are those by November.
Source: SEA

Rice Cropped and Harvested Area

(Unit: ha)

Item	Unit	El Aguacate		El Guayabo		Total		
		IAD	Private	IAD	Private	Total	IAD	Private
Rice field	ha	1,590 1/	410	1,130	970	4,100	2,720	1,380
Cropping intensity	%	124	124	98	98	111	113	106
Cropped area 2/	ha	1,970	510	1,110	950	4,540	3,080	1,460
Harvested area	%	72	73	88	88	79	78	83
Harvested area	%	1,410	370	980	840	3,600	2,390	1,210

Note: 1/ ... Including the Cienega Vieja settlement area.
2/ ... Estimated on the basis of the data in the Farm Management Survey (1985)

Source: See Table G.2.1

There is few rice double cropping area in the IAD Aguacate settlement area whereas it is estimated that the rice double cropping area covers about 24 percent of the total rice fields in El Aguacate. The main reason of comparatively large double cropping practiced in El Aguacate is that pump irrigation from the Yuna River may be carried out more easily than other areas. Such private rice fields is also seen in the natural levee of the Yuna River in El Guayabo. In IAD Guayabo settlement area, the annual cropping intensity is as small as 56 percent, where nearly 50 percent of rice fields have been wasted due to the irrigation and drainage conditions are extremely poor.

As the present rice double cropping calendar, the first crop is usually sown from January through February, transplanted from February through March and harvested from June through July, while the second crop is sown June through July, transplanted from July through August and harvested from November through December. In single cropping area, rice is usually sown from May through July, transplanted from June through August and harvested from October through December.

TABLE-G.2.1 RICE PRODUCTION IN IAD LAND SETTLEMENT AREA

	Total					Aguacate					Guayabo				
	Planted Area (ha)	Irrigated Area (ha)	Harvested Area (ha)	Unit Yield (ton/ha)	Production (ton)	Planted Area (ha)	Irrigated Area (ha)	Harvested Area (ha)	Unit Yield (ton/ha)	Production (ton)	Planted Area (ha)	Irrigated Area (ha)	Harvested Area (ha)	Unit Yield (ton/ha)	Production (ton)
1 1975	2,084	N.A.	1,258	2.72	3,428	2,084	N.A.	632	2.72	3,428	-	-	-	-	-
2 1976	2,064	N.A.	2,064	1.92	3,965	1,067	N.A.	1,067	1.67	1,782	998	N.A.	998	2.19	2,182
3 1977	N.A.	N.A.	N.A.	N.A.	N.A.	1,404	N.A.	1,193	1.44	1,782	N.A.	N.A.	N.A.	N.A.	N.A.
4. 1978	3,779	N.A.	2,568	1.81	4,671	1,882	N.A.	671	1.42	950	*1,294	N.A.	1,897	1.96	3,721
5. 1979	2,129	2,129	2,129	1.37	2,909	* 643	643	1,161	0.32	376	* 942	943	968	2.61	2,533
6. 1980	3,009	2,588	1,199	1.98	2,380	1,978	1,947	708	1.88	1,332	1,030	641	492	2.13	1,048
7. 1981	2,820	2,820	2,493	2.74	6,840	1,967	1,967	1,966	2.84	5,599	852	852	527	2.35	1,241
8. 1982	2,350	2,350	1,579	2.32	3,666	1,343	1,343	718	2.47	1,774	1,007	1,007	862	2.19	1,892
9. 1983	2,780	2,780	2,739	2.43	6,664	1,510	1,510	1,512	2.54	3,850	1,270	1,270	1,227	2.30	2,814
10. 1984	2,038	2,038	1,976	3.37	6,659	1,207	1,207	1,161	3.92	4,554	830	831	815	2.58	2,104
Average	2,561	2,451	2,000	2.27	4,576	1,560	1,523	1,141	2.22	2,537	1,107	928	973	2.25	2,192
Average**	2,627	2,451	2,004	2.15	4,316	1,654	1,692	1,058	2.42	2,562	1,017	942	846	2.31	1,952

Note: * These figures do not correspond to these of the harvested area.
Therefore it is assumed that these figures are equal to the harvested area.
** Excluding the yield data for the years when the maximum and minimum yields were recorded.
Source: IAD Boletin Informativo Annual (1976-1985)

The said cropping calendars vary year by year, depending upon rainfall and the availability of irrigation water. For example, the scarce rainfall upto July in 1985 has forced to delay the rice cropping considerably. Naturally, the harvesting time in the said cropping calendar differs according to varieties.

Cacao and coconut are harvested throughout the year, and yautia is also cropped all year round.

3. Production Technology and Farm Input

3.1 Rice

3.1.1 Variety

There are two types of rice varieties which are cultivated in the study area, namely (1) non-photo-sensitive improved varieties with short plant height (Juma 57, ISA 40, Tanioka etc.) (2) local varieties like Mingoro and Ingles Largo. The former group is usually planted in the area where gravitational drainage is effective and also the irrigation water is available. The latter group is tall and usually grown in the poor-drained fields where organic soils dominate. (For further details, see Tables G.3.1 and G.3.2)

The characteristics and growth period of the above-mentioned varieties are shown in ANNEX I, Table I.1. Among the improved varieties, Juma 57 results in the most stable production in the most areas, and so it has the largest area coverage. The growth period from sowing to harvesting of Fuma 57 is 150 to 160 days for the transplanting method. Therefore, it is difficult to make rice grow under optimum weather conditions in the cropping calendar of double cropping. ISA 40 has the growth period of 130 to 140 days but it is susceptible to Narrow brown leaf spot disease, which is one of the prevailing disease and has inferior rice quality. The rice quality of Tanioka is the best but sensitive to diseases. The new varieties which will solve above problems are now being developed.

3.1.2 Farming Practice and Farm Input

Following study on the farming practice and farm input is based on the result of Farm Management Survey. (Refer to Table G.3.3)

(1) Nursery

The flooded flat-bed nursery is generally applied to raise seedlings. It is often found however that the seedbeds look like those of upland nursery due to shortage of water. The average size of nursery per hectare of transplanting area is as small as 300 m^2 according to the Farm Management Survey. Few sample farmers apply seed selection and seed disinfection. The pre-germination is not be made by any sample farmers.

The average seed rate is so high as to be more than 500 g/m^2. After raising seedlings for more than 30 days, they are transplanted. The seedlings are as tall as more than 30 cm and sometimes 60 to 70 cm. The seedlings raised in this way are extremely thin and weak. These seedlings may be one of the main reason of low yield in the study area. These seedlings have poor resistance to pests and also have weak rooting capability in the main fields. When these seedlings are transplanted, late and poor tillering will arise.

Relating to the existing method to raise seedlings, the following three items could be considered as the main problems;

a) The seedbeds are usually not prepared properly under poor irrigation and extensive drainage.

b) A few quality seeds are used.

Recently, the cultivation method have been changed from transplanting to direct seeding in the considerable area where plot-wise water control in irrigation and drainage is easily practised.

The rice fields where the direct-seeding is practised, are usually developed on the natural levee. In the IAD settlement areas of El Aguacate and El Guayabo, the direct seeding is rarely applied because of the poor irrigation and drainage conditions. The seed rate is too high with low quality.

(2) Transplanting and Direct-seeding

Based on the farm management survey, the direct-seeding area is estimated at about 30 percent in El Aguacate, while in El Guayabo, at about 40 percent in both the natural levee area of the IAD land settlement and the private land. However, there are no direct seeding area in the remaining area, where rice cultivation is characterized by usage of tall and aged seedlings by transplanting due to extensive land preparation and poor foundation with organic soils.

Land preparation by four-wheel tractors on the contract basis are common in the study area. In this case, three or four passings of disc harrow are applied in the fields. Instead of tractors, several numbers of power tillers have been recently introduced by the Government for plowing works by about three passings.

Regarding with transplanting works, about 10 to 15 seedlings per hill are usually planted in spacing of 15 to 20 cm between hills, where cross-wise straight row planting is not applied. A considerable number of sample farmers answered that paddy fields are not levelled effectively.

Seedlings are usually transplanted deeply in soils for prevention of lodging due to poor rooting capability and inadequate land preparation. The land preparation for direct-seeded is made also inadequately. In this case, the seed rate is very high, whie low quality seeds are used prevalently. It seems that treatments as seed selection, seed disinfection and pre-germination are not applied. Although there are almost no unit yield difference

between the transplanted and the direct-seeded, the difficulty in weed control will cause yield decrease, if the direct-seeding is practiced continuously in the same fields.

(3) Water Control

The water control is very difficult as low intensity of irrigation and drainage canals in most of the study area, except for the limited rice fields adjacent to the Yuna River, where irrigation water is supplied by pumps and gravity drainage is effective.

In general, the paddy fields located about at one kilometers far from Yuna River are poor in drainage and it is difficult to distinguish the irrigated fields from the rainfed fields in most of the IAD Guayabo settlement area. The water control in El Aguacate settlement area is also poor since the irrigation and drainage canal is not separated in their use.

The plot-to-plot irrigation is generally practised, and such irrigation techniques as intermittent irrigation and mid-season drainage are not applied.

(4) Fertilizer Application

According to the Farm Management Survey, the applying rate of chemical fertilizers is estimated, as shown in Table G.3.4.

The highest rate of the applied fertilizers on an average is found in the private land area in El Aguacate. On the other hand, the rate in El Guayabo lowland area is as small as less than one fourth of the above rate. In considering the production conditions in El Guayabo lowland area, there are many farmers who do not apply any fertilizers.

Usually fertilizers are applied once in about 20 to 40 days after transplanting or direct-seeding.

(5) Weeding and Pest Control

All sample farmers of the Farm Management Survey apply herbicides. The manual weeding is carried out in about 30 days after transplanting or direct-seeding, and is usually followed by two additional weedings. It is considered that there are so many areas of rice fields where weeding is impossible due to the prevailing poor foundation of the fields.

Insecticides application is made by only one fourth sample farmers. Special attention should be paid to the organic soils in El Guayabo area where it is observed that rice plants have heavily suffered from diseases like helminthosoporium leaf spot. It is reported that the rice in the study area was once severely damaged by the diseases like helminthosoporium leaf spot and blast diseases.

(6) Harvesting

Immediately after cutting rice with saw typed sickles, threshing is carried out by hitting panicles in the fields. The threshed paddy is packed in sacks and are carried to roads on horseback. Then, the packed paddy is collected and transported by Instituto Nacional de Estabilizacion de Precios (INESPRE) personnel or intermediaries. The harvested paddy in this way contains considerable amount of impurity and unripened paddy with high moisture. Drying, cleaning and selection are to be made by INESPRE or intermediaries.

(7) Labor Requirement

Based on the result of Farm Management-Survey the farm labor requirement of rice cultivation is estimated as follows;

- IAD Aguacate settlement area	56.6 man-day/ha
- Private land area in the Aguacate Area	42.8 man-day/ha
- IAD Guayabo settlement area	70.9 man-day/ha

3.1.3 Productivity

(1) Study Area

The yield based on the harvested area in the study area is estimated according to the results of the Farm Management Survey and the statistical data for the IAD settlement area.

Estimated Paddy Yield on the Harvested Area Basis

Area	Yield (ton/ha)
1. El Aguacate	
- IAD settlement area	2.4
- Private land area	2.7
2. El Guayabo	
- IAD settlement area	2.3
- Private land area	2.7

Source: Refer to Table G.3.5

The yield of the both IAD settlement areas is less than that of the private land area, which may be attributed mainly to the inferior irrigation and drainage conditions.

A survey on the rice yield component was carried out to identify the defects hampering the increase of rice yield. Each one plot was selected respectively for the transplanted rice in the IAD Aguacate settlement area and the direct-seeded rice in the private land area of El Guayabo area during the limited survey period. The respective sample yields (3.6 ton/ha of the transplanted rice and 4.0 ton/ha of the direct-seeded rice) are higher than the said average yield because the sample plots have better production conditions than those of the average rice fields. However two items of problems on the yield components are pointed based on the result of the survey (Refer to Table G.3.6).

1) The number of grains per panicle is as small as 77 and 50 respectively for the samples of the transplanted and direct-seeded rice although that should be more than 120 and 170 respectively to attain yield at more than 5 ton per ha.

2) The percentage of ripened grains is also too small as 53 percent and 65 percent respectively for each sample. This figure should exceed 70 percent in any method of rice cultivation.

3) The weight of 1,000 ripened grains seems to be too small in case of the direct-seeded sample.

There are many factors to cause above yield components, but it is considered that following are most important points to improve rice cultivation.

1) To raise healthy and vigorous seedlings by means of selection and disinfection of seeds, and seeding at proper seed rate for the early rooting and vigorous tillering of seedlings.

2) To prevent usage of aged seedlings, the deep transplanting and the deep water for the early establishment of effective tillers.

3) To make the rice heading/ripening at the optimum time when enough amount of solar rotation is available.

The above-mentioned improvement of rice cultivation will be realized in the condition that any defects of irrigation and drainage system is removed and agricultural extension activities is strengthened adequately in the study area. The improvement of on-farm water management with sufficient facilities will be also required.