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VIET-NAM
Project : VIE 86 / 024

CLASSIFICATION & CORRELATION OF THE VIETNAMESE SOILS

A TECHNICAL REPORT

By :
J. SEHGAL
FAO-UNDP CONSULTANT
Oct. 30 - Dec. 5, 1989

HANOI (VIET-NAM)
November, 1989

DP-9/10 VIE 86/024
VA-3/16

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Date Sept. 6, 1990
12

DEar Dr. Brinkman,

Please refer to your letter of June 4, 1990. It is true that you didn't find answers to the questions you raised in your earlier letter as I could not receive the results of most of the analysis undertaken at the laboratories of NIAPP Hanoi, Vietnam.

As informed earlier, we used the analysis of some comparable soils from the adjoining countries as given in the FAO/UNESCO World Soil Map Publication. The analysis of one sample (brought by me) suggest that the pH increases from 3.5 (in soil : water) to 4.2 (in Soil : KCl). The soils have very low exchange capacity because of very low clay content (exceptional sample which was burried). The semi-quantitative analysis of the clay and silt fractions suggests Kaolinite to be the dominant clay mineral comprising 90-95 per cent of the clay fraction. The higher pH in soil : KCl ratio of 4.2 as one may expect suggests extreme weathering stage in these soils.

However, in order to confirm the derived relationships, we need a large number of soil samples. I have a few more soil samples which we shall run for clay, CEC, pH and B.S. and revert back to you.

With regards,

Yours sincerely,

(J.L. SEHGAL)

AGL REGISTRY
26 SEP 1990

BRINKMAN 28/9

Dr. R. Brinkman,
Chief,
Soil REsources, Management & Conservation Service,
Land and Water Development Division,
Via delle Terme di Caracalla,
00100 ROME, ITALY.

Original to REG; attachments (graphs of X Ray Diffraction indicating clay min. composition to Brinkman with c of this letter to be inserted in Sehgal's report in AGL DOC.

Danielle
please insert in Sehgal's Vietnam report
Thanks RB

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1. INTRODUCTION

1.1 BACKGROUND

According to the information received from the FAO, Rome (AGOF, Aug. 89), the consultant will work in close cooperation with the Lead Consultant and the National Project Director on the following Terms of Reference (TOR):

> To establish correlation of the Vietnamese Soil Classification with FAO Classification as given in the FAO/UNESCO Soil Map of the World Revised Legend. This should be undertaken by first writing in english the soil profile descriptions and soil properties of each of the Vietnamese soil groups and classes, and then by making a direct comparison with the descriptions in the Revised Legend of the FAO Soil Groups and Units (Annx.1).

However, during initial discussions with Prof. TON THAT CHIEU, National Project Director - NPD (in whose close cooperation, the consultant was to work), it became clear that the NPD has developed a Work Plan/Programme which included:

* Nine field trips to examine soils in different provinces of North and south Vietnam;

* Offer seminars on Soil Classification Systems (FAO-UNESCO and USDA) and on application of soil survey for land-use planning both at HANOI and HO CHI MINH;

* A 2-day workshop on the following topics:

  - Taxonomy of Vietnamese soils
  - Application of FAO-UNESCO Soil Mapping Legend to the soils of Vietnam
  - Correlation of Vietnamese soils with the FAO-UNESCO Revised Soil Mapping Legend
  - Application of soil survey for land-use planning

* General discussions at NIAPP on correlation and classification of the studied soils.

* Discussions on the report.

The consultant met and consulted Mr. A.D. SPIJKERS, charg de Programme representation FAO on Nov. 2 1989 and apprised him of his mission, T.O.R. and the programme developed by the NPD (Prof. Dr. CHIEU). Mr. SPIJKERS gave good suggestions and background material (Project Document, Dr. F.J. DENT'S, report "Assessment of Problem Soils by

agro-ecological zoning of Vietnam", and Mr. RIDEWAY's report on "Soil Classification and Land Evaluation"). He suggested to follow the programme developed by the NPD as it seems quite logical to study the soils in the field for their classification and correlation. He however felt that the mission is of short duration against the programme developed and the TOR indicated.

The consultant also met the UNDP Deputy Representative (Mr. Winston Temple) on Sat. Nov. 4, 1989 and discussed about his mission to Vietnam in the project (VIE/86/024 - Agricultural Planning and Projection) and about his first field trips impressions about soils, land-use and cropping pattern. According to Mr. Temple, the visit is of short duration to do justice for the soil classification needs of the country.

The consultant's visit (Nov. 4) to the Agricultural University No. 1 was useful for interacting with the staff and P.G. students at the University and seeing variety of Vietnamese soils displayed through soil monoliths. The interaction revealed that the students are taught USSR and US systems of soil classification. The faculty members looked forward to discuss FAO-UNESCO system in the planned workshop for comprehension and application to Vietnamese soils. The visit to Institute of Soils and Fertilizers (on Nov. 25, 1989) helped to understand their soil mapping work and see the laboratory facilities. The Consultant also met the Director of National Institute of Agricultural Planning and Projections - NIAPP (Dr. TRAN AN PHONG), Deputy Directors, NIAPP (Mr. BULQUANG TOAN and Dr. VU-NANG DUNG), Chief Soil Survey Division (Ms PHAM-THI-BINH) and other staff members of the NIAPP.

The project VIE/86/024 "Reinforcement de Institute pour la planification et les Projections Agricoles" is a multi-level planning project supporting NIAPP - one of the sixteen institutes within the Ministry of Agriculture and Food Industries. The Institute for soils and Fertilizers (ISF) is closely related to NIAPP in terms of its mandate.

1.2 FIELD STUDIES

The consultant worked in close cooperation with the NPD (Prof. CHIEU) and the NIAPP Soil Survey Staff. The soils of Vietnam were studied and described through field trips spread over 16 days examining about 20 different soils and sites. The available data on soil properties from the NPD and other sources were collected for classifying soils. Where such data were not available, expert estimates based on morphology, climate, vegetation and discussions with the NIAPP staff and using correlation developed on comparable soils were made for classifying soils in FAO-UNESCO Revised

Soil Mapping Legend (now termed as system) and in US Soil Taxonomy (as per request of NPD). In the mean time, the collected soil samples were subjected to basic soil analysis.

An 8-day visit was also undertaken to NIAPP sub-institute at HO-CHI-MINH (south Vietnam) and typical soils of the South were studied, classified and correlated according to FAO-UNESCO and US Soil Classification Systems. A brief programme of the consultant (as proposed by the NPD) is given in Table 1 (for details see Annex. 2).

Table 1: Brief itinerary of consultant (Dr. J. Sehgal)

Oct. 30 to Nov. 1, 1989	Travel to Hanoi
Nov. 2	At Hanoi; briefing meeting with FAO, UNDP and NIAPP staff
Nov. 3 - 7	Field trips to different regions of North Vietnam.
Nov. 8 - 9	Discussions with NIAPP staff regarding morphology and classification of studied soil profiles
Nov. 10 - 18	Field trip Visit to HO CHI MINH and field excursions to different areas in South Vietnam
Nov. 20 - 25	Desk work for reviewing the field work, finalisation of soil correlation and classification work. Rewriting of soil profile descriptions and discussions with local staff
Nov. 26 - 28	Workshops and offering seminars
Nov. 29 to Dec. 2, 1989	Desk work for writing of report
Dec. 4 - 5	Meetings with Prof. Gallan Chan as per FAO's directions and finalisation of the mission report
December 6, 1989	Departure from Hanoi for Nagpur (India).

During the course of field trips and discussions with the Soil Survey Staff of the NIAPP, the consultant observed that they are all devoted to the cause and are willing to work and learn. This inspired him to work and share his experience both in the field and office. The consultant offered seminars on soil classification systems so that the

Vietnamese scientist can use the system of FAO-UNESCO and independently.

The constraint of not using a common language (English) was realized but was overcome through an interpreter and/or through the use of French language with the NPD. The time spent in slow communication was overcome by spending extra time during the field trips and in office.

1.3 ACKNOWLEDGEMENTS

The consultant would like to convey his grateful thanks to the following in accomplishing his mission to Vietnam:

- FAO HQs (especially Prof. Brinkman and Dr. M.F. Purnell) for supplying FAO publications concerning SE ASIA.
- FAO and UNDP staff (especially FAO and UNDP - Reps. and their Deputies - Mr. Spijkers and Mr. Temple) and Mr. Le Huu Cat Dien, Programme Officer and Ms. White and Papita for their willing support.
- NIAPP Director (Dr. Phong), NIAPP Sub-Institute Director (Dr. TRIEU) and their Vice Directors (DR. YU NANG DUNG) and Dr. Bui Quang Toan, NIAPP, and their staff (listed in Annex 3) for their cooperation and assistance in many ways.
- Mr. TRAN KHAI, Vice Chairman of the SRV, State Planning Committee for expressing his satisfaction on the seminars offered.
- In particular, Prof. Dr. Ton That Chieu, National Project Director - NPD (VIE/86/024) who has always been enthusiastic and willing to share information and discuss classification of the studied soils. Without his support, it would have been difficult to achieve success in this mission.
- The Soil Survey Staff (headed by Dr. (Mrs) Binh at HANOI and Mr. Khanh at HO CHI MINH who have been always willing to assist in all possible ways. Their eagerness to learn fascinated the consultant to share his experience with all.
- The interpreters (Mr.Nam and Mrs Loan) for their assistance in bridging the communication gap through simultaneous translation.
- Mr. Hoang Trung Lap for his assistance in statistical analysis.

2. GEOGRAPHICAL SETTINGS

2.1 LOCATION (Fig. 1)

Vietnam is a long and narrow-shaped country extending North-South from nearly 9^{o} to 24^{o} latitude. The country is bounded by sea in the East and China in the North and Laos and Kampuchea in the West. It has a total area of 329,600 sq.km., with the resumption of the old borders with Kampuchia.

2.2 PHYSIOGRAPHY (Fig. 2)

Physiographically Vietnam can be divided into 3 broad zones, viz.

*	Lowlands	: 0 - 99	m above MSL
*	Hilly land	: 100 - 499	m above MSL
*	Mountains	: > 500	m above MSL

The National Institute of Agricultural Planning and Projections (NIAPP) has delineated five ecological zones within the three physiographic zones as:

*	Coastal Plains	Lowlands
*	Inland Plains	
*	Hills	Hilly land
*	Low Mountains	
*	High Mountains	Mountains

The lowlands, comprising relatively small area of Vietnam, constitute two major and agriculturally important areas, viz the Red River Delta (in the North) and the Mekong Delta (in the South) which are connected by a narrow and discontinuous coastal strip. The Highlands (Hilly) are mostly located in the North and forms boundary with Laos. The Highlands are hilly which conform to the NIAPP's zones of Hills (<200 m elevation) and Low Mountains (upto 500 m elevation)

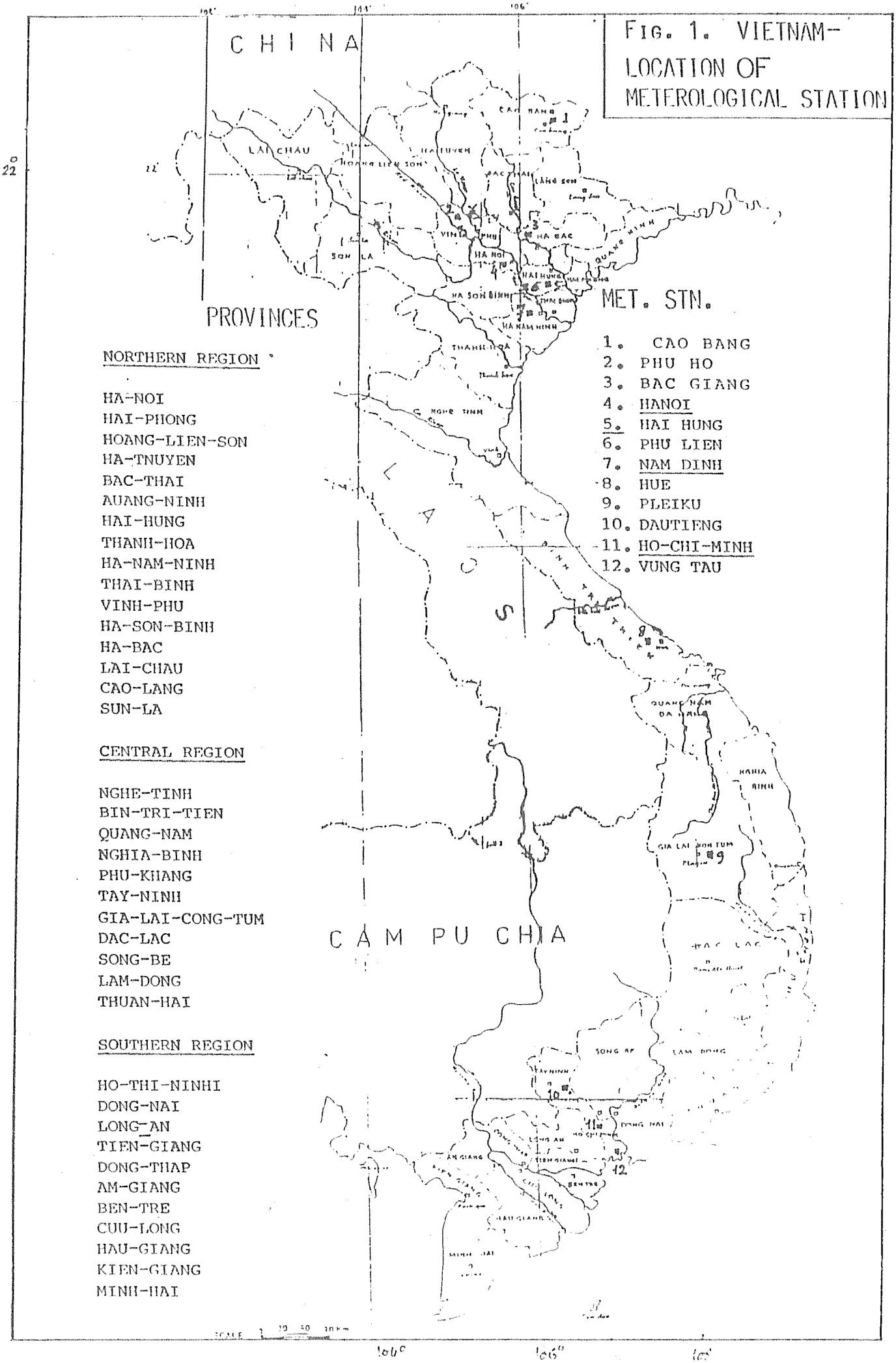
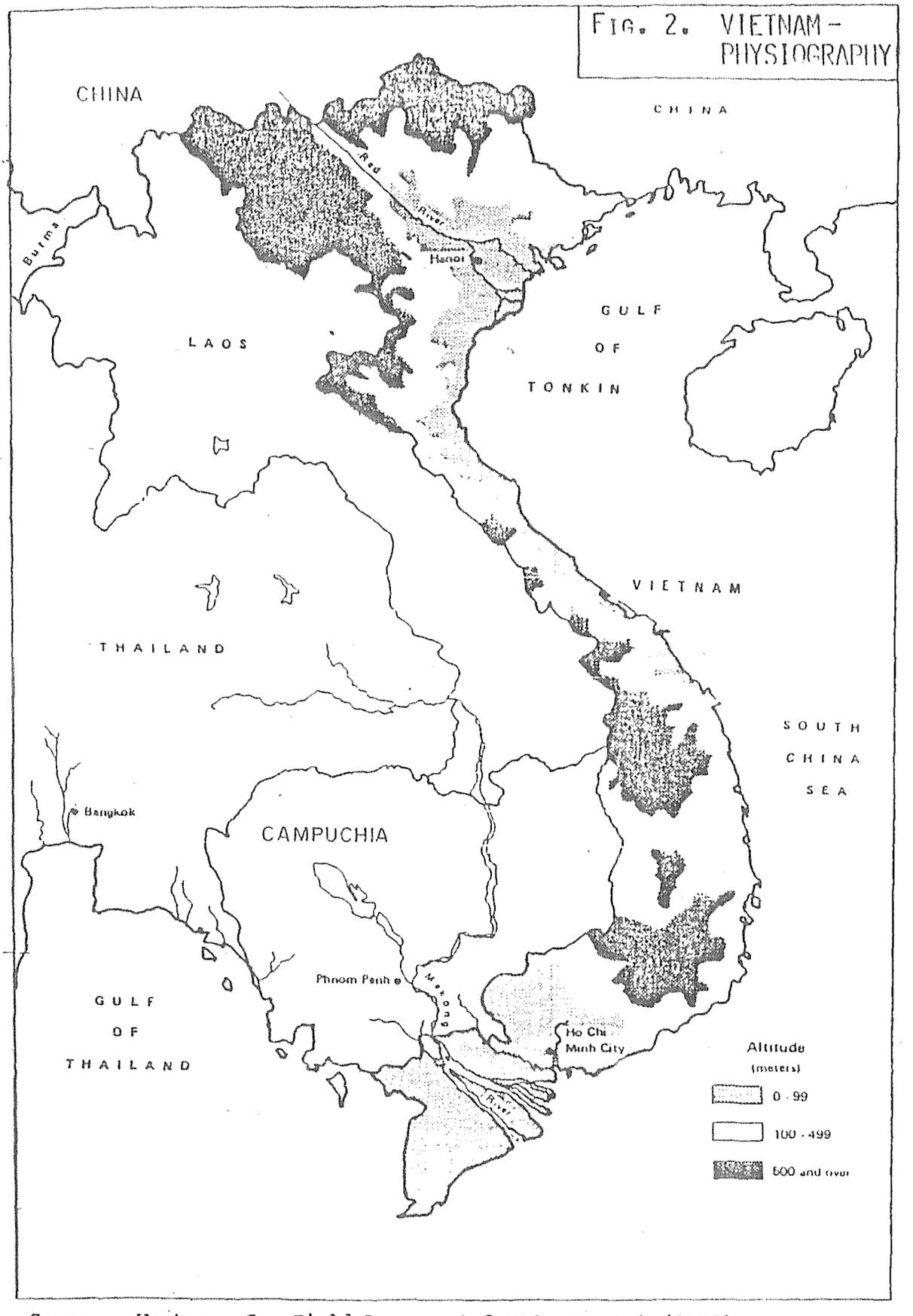


FIG. 1. VIETNAM- LOCATION OF METEROLOGICAL STATION



Source : Western, S. Field Documcment 9 FAO, Bangkok (1986)

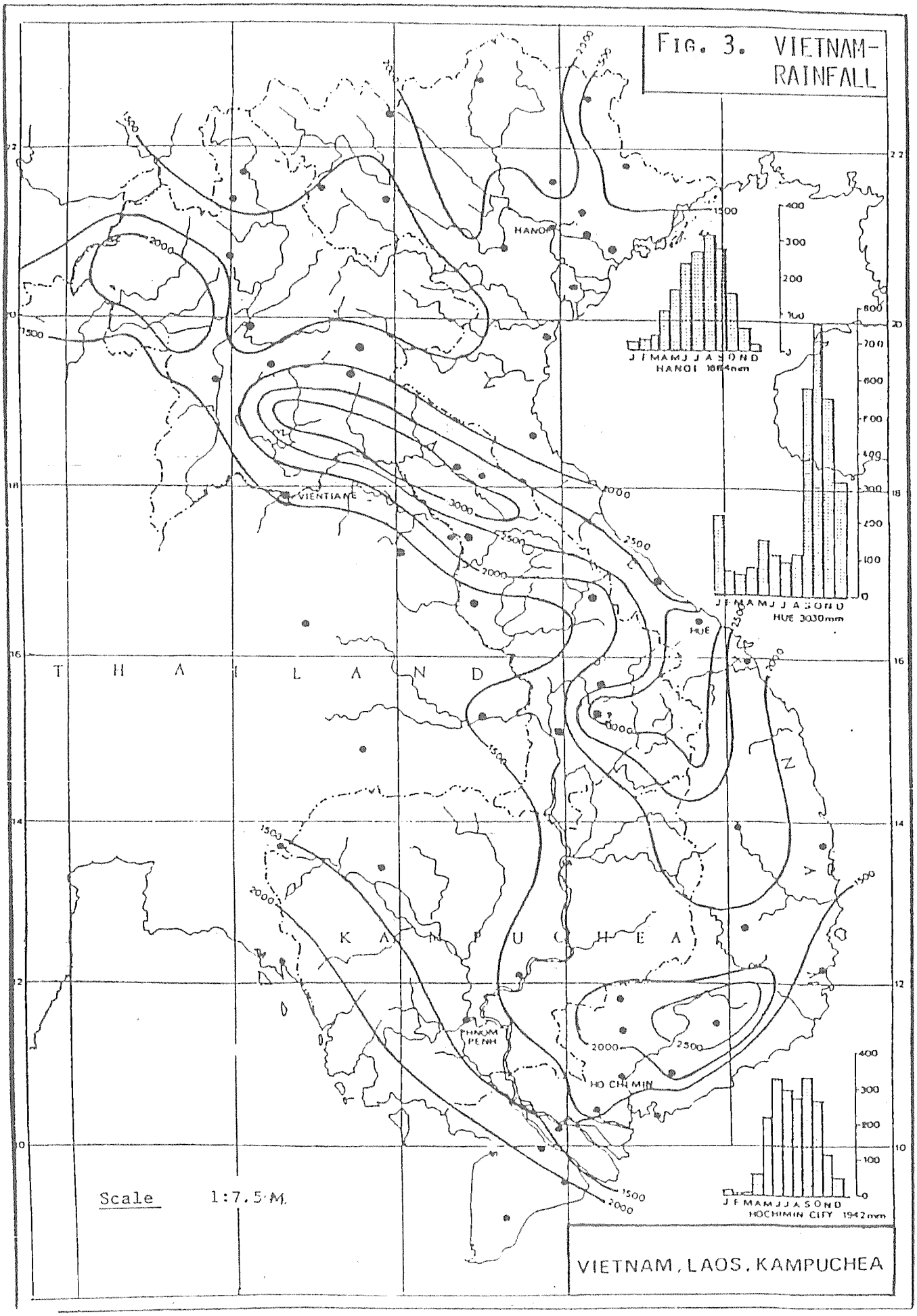
2.3 CLIMATE

The area has a tropical monsoon climate which is strongly influenced by the country's shape and topography. Table 2 outlines climatic data in respect of major stations. The data show that the annual rainfall varies from less than 1500 to over 3000 mm (Fig. 3). The mean annual temperature varies from 21 to 29° C. The mean summer and winter temperature differ by less than 5° C only up to North latitude of 15° suggesting iso climatic conditions; beyond 15 N non-iso conditions prevail.

The detailed monthly water balance data for some important stations is presented in Table 3 and Fig 4.

Table 2: Climatic elements at some important stations in Vietnam

Station	Province	Location		Annual rainf.	Mean An.Tem.	Mean Sum.Tem.	Mean Win.Temp.
		Latitude	Longitude	(mm)	(°C)	(°C)	(°C)
1. CAO BANG	: CAO BANG	22°39'N	: 106°14'E	: 1374	21.4		
2. PHU HO	: VINH PHU	21°29'N	: 104°13'E	: 1862	26.3		
3. BAC GIANG	: HA BAC	21°17'N	: 106°12'E	: 1476	23.3		
4. HANOI	: HANOI	21°01'N	: 105°48'E	: 1664	23.5	28.7	17.1
5. HAI HUNG	: HAI HUNG	20°56'N	: 106°18'E	: 1611	23.4		
6. PHU LIEN	: HAI PHONG	20°48'N	: 106°36'E	: 1802	22.8		
7. NAM DINH	: HA NAM NINH	20°26'N	: 106°09'E	: 1825	23.4	28.7	17.1
8. HUE	: BINH TRI THIEN	16°24'N	: 107°41'E	: 3031	25.3	29.4	20.5
9. PLEIKU	: GIA LIA	13°59'N	: 108°00'E	: 2280	21.4	22.0	19.4
10. DAU TIENG	: SONG BE	11°20'N	: 106°20'E	: 2102	27.0		
11. HO CHI MINH	: HO CHI MINH	10°49'N	: 106°40'E	: 1943	27.2	27.6	26.1
12. VUNG TAU	: VUNG TAU	10°20'N	: 107°05'E	: 1352	26.3		



ce : WEstern, S (1986)

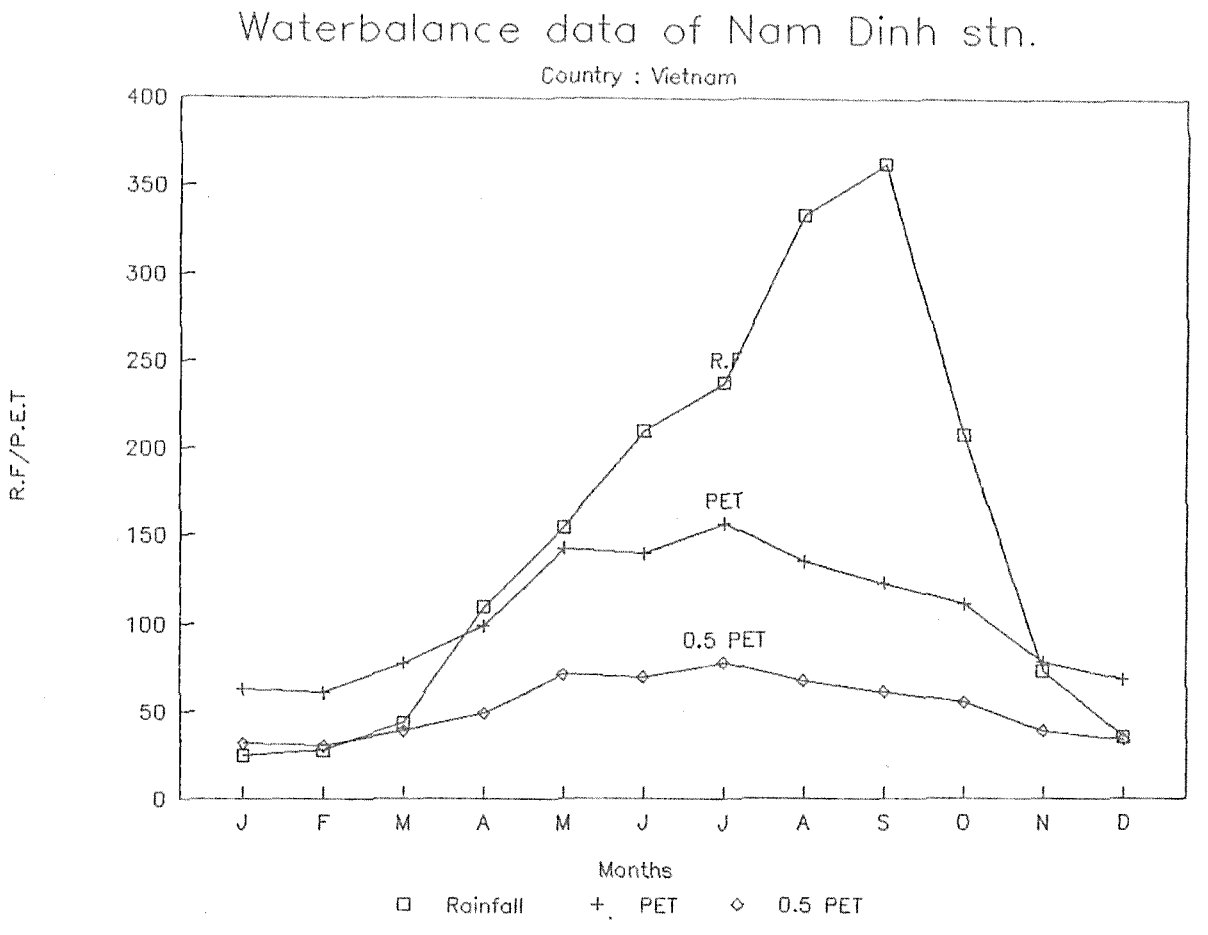
Table 3 : Monthly water balance data

Station : Nam Dinh (North Vietnam)

month Clim.element	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean annual
Rainfall(mm)	25	28	44	110	155	210	238	334	363	208	74	36	1825
Average temp. (^{o}C)	16.3	16.8	19.7	23.4	27.3	20.5	29.2	28.4	27.3	24.7	21.2	18.3	23.4
R.H.(%)	89	87	90	89	84	84	82	85	85	79	82	79	
Sunshine(%)	23	14	13	26	50	45	54	44	50	50	45	37	
Pot.Evapo-transpiration (mm)	63	61	78	99	143	140	157	136	124	112	79	69	105.8

Station : Ho chi Minh (South Vietnam)

month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mea annu
Rainfall(mm)	1.4	1.4	1.1	5.2	21.9	32.2	29.3	27.1	33.0	26.7	11.2	4.8	194
Temperature (^{o}C)	25.7	26.7	27.9	29.0	27.2	27.7	27.4	27.8	27.1	26.9	26.5	26.0	27.
Pot.Evapo-transpiration (mm)	107	128	145	148	125	115	105	118	108	103	100	98	108.



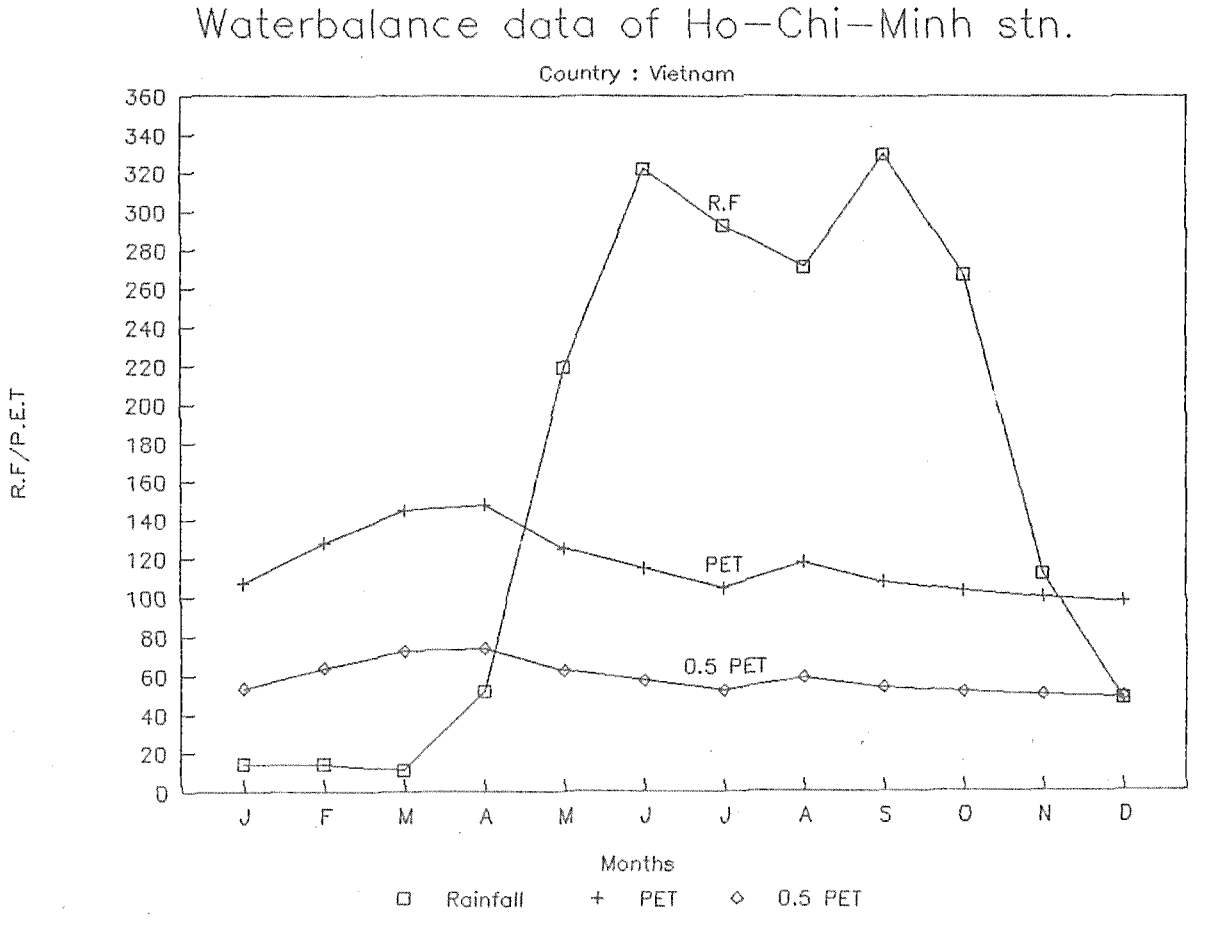


Fig. 4. Water balance data of some stations in Vietnam
(For location, See Fig. 1)

2.4 LAND USE

The natural vegetation in extinct in most of Vietnam, except in the mountain and hilly parts of the HA NAM NINH province, where evergreen broad-leaved forest dominates and a fraction of the area is occupied by deciduous winter forest. The destruction of forests could be due to increased human population pressure for more and more need for agricultural land for cultivation.

The major crops grown in Vietnam are paddy (2 to 3 crops per year) followed by in the former case, a subsidiary crop of groundnut, potato, sweet-potato, maize, etc. The land use in the North (because of mild winter) is dominated by two paddy crops in summer and spring and sandwiched by a subsidiary crop of maize, potato, sweet-potato or groundnut during the winter season. In the South, in view of the typical tropical environments, three crops of paddy or two crops of paddy and one subsidiary crop are cultivated. The area under different land uses in the country is given in Table 4.

Table 4 Actual land use and growing period of seasonal crops in Vietnam

LAND USE	Acreage (1,000ha)	% of natural superficies
Natural superficies	33,036	100
1. Forest	9,642	29
2. Agricultural area	6,914	21
+ Perrenial crop	5,527	16.7
- Rice	4,242	12.8
- Vegetable	16	0.05
- Reed	16	0.05
- Subsidiary crop + industry crop	1,253	3.8
+ Perrenial crop	860	2.6
- Industrial crops	664	2.0
- Fruit crops	196	0.6
+ Grass land	323	0.98
+ Water surface	173	0.52

Seasonal crops

A. In the North

Winter crop	Spring crop	Wet seasonal crop
15/9 - 31/1	1/2 - 30/6	1/7 - 30/11 15/6 - 15/9

B. In the South

Winter-spring	Summer-Autumn	Wet season
1/10 - 31/3	30/4 - 15/8	1/8 - 30/1

3. SOIL MAPPING & CLASSIFICATION STATUS

3.1 PRE-1975 EFFORTS

The USSR Academy of science compiled a generalised soil map of Vietnam (North of 17° N) at 1:3,000,000 scale. Although the map, legend and report are no longer available at NIAPP, it is understood that the legend contained six main soil formations as:

1 - Ferrsialitic and acid soils (upland areas)
2 - Acid soils with mobile light humus (with a short dry period)
3 - Weakly acid and neutral soils (dried areas along the coast with a dry season)
4 - Saline (and alkaline) soils (coastal and deltas)
5 - Mountain soils
6 - Alluvial soils (rivers and deltas)

Moorman (1961)* compiled a soil map of Vietnam south of 17° N on 1:1 m scale based on:

- reconnaissance soil survey of major part of South Vietnam
- a general interpretation of the air photos
- semi-detailed and detailed soil surveys in various regions, and
- interpretation of existing soil, geological and topographical maps.

The soil units/associations are the Great Soil Groups. These are characterised by the dominant parent rocks, the topography and characteristics of the soils. In all 25 mapping units were identified, which could be grouped in 8 major soils as under:

Map Units	Major Soils
1 - 5	Alluvial soils (undifferentiated, saline, acid, very acid and brown)
6 - 7	Regosols (on sand dunes and old red sand)
8 - 10	Non-calcic Brown soils (shallow, on acid rock or old alluvium)
11 - 18	Podzolic soils (sandy, red-yellow, gray, low humid on old alluvium and complex)
19 - 24	Latosols (Reddish brown, Red and Yellow, Earthy red, Reddish brown and Shallow)
25	Peat and Muck soils

3.2 POST-1975 EFFORTS

The NIAPP and ISF (1978) jointly brought out a soil map on 1:1 m scale by unifying the two existing soil maps with additional observations (both in field and laboratory). The same was publised (on 1:500,000 scale) in 1983 (Fig. 5). The NIAPP has also been producing soil maps of different provinces, districts, state farms and villages on scales ranging from 1:100,000 to 1:5,000 scales.

The Vietnamese legend is largely based on the Russian System, that is Genetic, based on zonality concept, taking, in addition, into consideration parent material, and topography. It has two categories: Major soil groups and soil classes; the number of groups and classes vary depending on the scale of mapping. The same groups and classes appear at different scales; however their number increases as the scale is enlarged (from 1:1 m to 1:5,000) as under:

Mapping scale	For	Soil Groups	Soil classes
Small (1:1,000,000 to 1:500,000)	Country	13	31 (including negligible Alkaline soils
Medium (1:250,000 to 1:50,000)	Provinces Districts	14	75
Large (1:25,000 to 1:5,000)	Districts; Villages	15	86

An example of the small-scale map legend reduced from 1:1 m soil map is evident in Fig. 5 and is briefed in Table 5.

Table 5 : Soil Groups of Vietnam and the area under major soils

SOIL GROUPS & CLASSES	MAP SYMBOL	AREA REPRESENTATION	
		1000 ha	%
1	2	3	4
I. SANDY SOILS		502	1.5
1. White and Yellow sand dune soils	Cc		
2. Red Sand dune Soils	Cd		
3. Sandy Marine Soils			
II. SALINE SOILS		991	3.0
4. Mangrove Saline Soils	Mm		
5. Saline Soils	M		
6. Alkaline Saline Soils	Mk		
III. ACID SULPHATE SOILS		2140	6.5
7. Strongly Acid Sulphate Soils	Sn		
8. Medium & Weakly Acid Sulphate Soils	S		
IV. SWAMP SOILS & PEATS		72	0.2
9. Swamp Soils	J		
10. Peat Soils	T		
V. ALLUVIAL SOILS		2936	8.9
11. Alluvial Soils of Red R.	Ph		
12. Alluvial Soils of Mekong R	Pc		
13. Alluvial Soils of Other Rivers	P		
VI. GREY DEGRADED SOILS		2813	8.5
14. Grey Degraded Soils on old alluvium	X		
15. Gley Degraded Grey Soils on old alluvium	Xg		
16. Grey Degraded Soils on acid igneous rocks and on sandstones	Xa		
VII. BROWN GREY SOILS		35	0.1
17. Brown-grey Soils (semi-arid zone)	Xx		

1	2	3	4
VIII. BLACK TROPICAL SOILS		238	0.7
18. Black Tropical Soils	R		
IX. FERRALLITIC SOILS		15,816	47.9
19. Purple-brown soils on basic & neutral igneous soils	Fkt		
20. Red-brown soils on basic & neutral igenous rocks	Fk		
21. Yellow-brown soils on basic & neutral igenous rocks	Fkx		
22. Brown-red soils on limestones	Fy		
23. Yellow-red soils on claystones & metamorphic rocks	Fs		
24. Yellow-red soils on acid igneous rocks	Fa		
25. Light-yellow soils on sandstones	Fq		
26. Brown-yellow soils on old alluvium	Fb		
X. RED-YELLOW HUMIC SOILS IN MOUNTAINS		3,257	9.9
in : Northern mountains - 700/900 to 2000 m in : Southern mountains - 1000 to 2000 m			
27. Red-yellow Humic soils in mountains	Fh		
28. Humic soils in high mountains	H		
XI. PODZOLIC SOILS			
29. Podzolic soils	O		
XII. ERODED SKELETIC SOILS		505	1.5
30. Eroded skeletal soils	E		
Unmapped Soils/Data Not Available			(about 10%)

The morphological descriptions and analytical data (horizon wise) have been given in each of the soil survey report produced. These provide valuable data-base for land-use planning. But the preliminary observations suggest that the profile descriptions and the analytical data do need checking and control as the information contained therein serve limited purpose to classify and correlate the soils in any internationally accepted system of soil classification, such as FAO-UNESCO, US Soil Taxonomy, which demand precise information (both from field and laboratory).

3.2.2 FAO-UNESCO Soil Map

The FAO and UNESCO (1976) has compiled a soil map of the world on 1:5 million scale wherein sheet IX covers S.E. Asia, including Vietnam. The soil map of Vietnam (as per FAO-UNESCO Legend) is given in Fig. 6. The mapping units consist of a soil unit or an association of soil units. The texture and slope are shown as suffixes to the main unit; the former is indicated for the dominant soil unit, while the latter (slope) reflects the topography in which the soil association occurs. The presence of indurated layers, depth, stoniness and salinity are shown by different shades (not shown in Fig. 6). Each soil unit is composed of dominant and sub-dominant or associated soil units, the latter covering at least 20 percent of the delineated area; other soils covering less than 20 percent of the area are included as inclusions. The Map Units are shown by a symbol representing the dominant soil, followed by a figure (60 or 73) correlating with the descriptive legend, followed by the textural and slope class symbol (2a, 1b, 1/2 ab). The extent and distribution of various soil units (see Fig. 6) (representing major soil groups) occurring in Vietnam are given in Table 6. The data, summarising the extent of dominant and sub-dominant soils of Vietnam, suggest that Acrisols (A) occupy the largest area (± 48%) followed by the Gleysols, occupying 13.3%, and the Cambisols (B) and Fluvisols (J) covering 7.8% and 7.6% of the total land area respectively. The Ferralsols (F) and Luvisols (L) represent 4.5 percent and 2.4 percent area, respectively. It also shows that the Lithic phase, suggesting a soil depth of less than 50 cm and Lithosols (I), which by definition, are very shallow soils (< 10 cm) taken together, cover almost one-third of Vietnamese soils.

Analysing the two soil maps (Figs 5 and 6) and the data given in Tables 5 and 6, suggests interesting distribution pattern of major soil groups in Vietnam. According to the Vietnamese Legend, Ferrallitics soils (occupying about 50% of the area) are the dominant soils, followed by equally distributed Red-Yellow Humic, Grey Degraded and Alluvial Soils (each covering ± 10% of the area) and the Acid Sulphate Soils (± 7%).

The FAO soil map, on the other hand, suggests Acrisols to be the dominant soils (covering about 50% area), followed by Gleysols (13%), Fluvisols (8%), Cambisols (7%), Ferralsols (5%) and Luvisols (2.5%).

Table. 6 : COMPOSITION AND EXTENT OF THE SOIL MAPPING UNITS IN VIETNAM

	FLUVISOLS		GLEYSOLS				REGO SOLS	LITHO SOLS	ARENO SOLS		POD SOLS	VERTISOLS		SOLON CHAKS	SOLO NETZ	CAMBISOLS				LUVISOLS		PLANO SOLS	NITO GOLS	HISTO SOLS	ACRISOLS					FERRALSOLS				TOTAL EXTENT
	Je	Jt	Ge	Gd	Ga	Gh	Re	I	Qf	Qa	Po	Vp	Vc	Zg	Sg	Bd	Bg	Bk	Bl	Lc	Lg	Wd	Nd	Od	Ao	Af	Ah	Ap	Ag	Fo	Fr	Fh	Fa	(1 000 ha)
Af 60-1/2ab									225										450						450	900			225					2251
Af 61-1/2ab				169																						845		507	169					169
Ag 16-2a				32											32						65				65			32	97					324
Ag 17-1/2ab				21															83		83	21				83			124					415
Ao 90-2/3c lithic								1189								1189									8323		1189							11890
Ao107-2bc								504											504				1007		2014	1007								5035
Fa 14-3ab								22																		22				22			155	221
Fo102-3ab			112																							12				61		36		121
Fr 33-3ab								168				168											168							504	672			1661
Gd 29-3a	92			644	92	92																												920
Ge 55-3a saline		44	352														44																	440
Ge 56-3a	255		1274		764	255																												2547
I-Af-3c								75																		75								150
I-Lc-Bk-c								302										302		302														907
Je 72-2a	357		179		60																													595
Je 73-3a saline	272	109					54							109																				513
Jt 13-3a		1007	112																															1119
Jt 14-3a		319		53		159																												531
Lc 59-2b			24					24												118			71											233
Lc100-c lithic								122										41		245														409
Qd 21-a		18				18																		146										183
Re 83-1ab	61		61				181		121	121	60																							603
Vp 64-3a lithic			60					119				238	119																	60				596
total extent (1 000 ha)	1036	1497	2072	919	916	524	235	2525	346	121	60	407	119	109	32	1189	44	343	1037	665	148	21	1246	146	10852	2945	1189	539	616	647	672	36	155	33405
(I)	3.1	4.5	6.2	2.8	2.7	1.6	0.7	7.8	1.0	0.4	0.2	1.2	0.4	0.3	0.1	3.6	0.1	1.0	3.1	2.0	0.4	(0.1	3.7	0.4	32.5	8.8	3.6	1.6	1.8	1.9	2.0	0.1	0.5	(33.4 m.h.
	(7.6)		(13.3)				(0.7)	(7.6)	(1.4)		0.2	(1.6)		(0.3)	(0.1)	(7.8)				(2.4)		(0.1)	(3.7)	0.4	(48.3)					(4.5)				(100 %)

Source : Nguyen, S. (1986)

4. CHARACTERIZATION AND CLASSIFICATION OF SOILS

4.1 CHARACTERISATION

In view of the inherent limitations of available information on soil morphology and analytical data on different soils for the purpose of classifying and correlating them into FAO-UNESCO Revised Legend, several field excursions were made as per the Work Plan prepared by the NPD to study soils in the North and South of Vietnam for setting principles for classifying and correlating Vietnamese soils in the FAO-UNESCO Revised Legend (1988) and in US Soil Taxonomy (Soil Survey Staff, 1975).

4.1.1 Studied Pedons

In all 20 soil profiles from the north and south of Vietnam (see Fig. 7) were studied in the field and described by following the FAO Guidelines* on the subject. The morphological features and diagnostic horizons observed in the field and their application in classifying soils (both in the FAO-UNESCO and USDA systems) were discussed with the NIAPP Staff for their benefit and with the objective to make them work independently to describe and classify soils. The detailed descriptions of the studied soil profiles are given in Annexure 3.

The soil samples collected horizon-wise were subjected to analysis in the NIAPP laboratories. While some basic properties could be determined, others were derived by using correlation technique of samples with available data. The correlation between pH and base saturation, and clay and exchange capacity, using analytical data on comparable soils from the region, were worked out (Table 7). The correlations developed and used are shown in Figs. 8 to 15. The data thus derived in conjunction with the laboratory data (given in Table 8) were used to classify soils.

4.2 CLASSIFICATION (Please see page

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* FAO (1977) Guidelines for Soil Profile Descriptions. FAO, Rome Publ., p 66.

Table 7: Analytical data of some studied pedons

Map Unit	Depth (cm)	pH (1:5) Water	pH (1:5) KCl	Salts (ds/m) %	Organic matter %	Soil Particle Size Sand% >0.05 mm	Silt% 0.05-0.002 mm	Clay% <.002 mm	CEC me/100 g (soil)	CEC me/100 g (clay)	Exchangeable cation me/100g soil Ca	Mg	Na	Base Saturation %
	PEDON: 2 RED & YELLOW FERRALITIC SOILS ON GNEISS													
Fs	15-53	3.8						~40	~8		~10			
	53-90	3.7						~40	~8		~9			
	90-120	3.8						~40-50	~8.5		~10			
	PEDON:3 RED FERRALITIC SOILS ON MICA SCHIST													
Fs	20-45	5.0		N.D.	58	9	33	7.3	22.2		16	0.4	0.7	
	PEDON: 4 GLEY DEGRADED GREY SOILS ON OLD ALLUVIUM													
Bg	15-20	4.9						~25	~6.0		~45			
	20-29	4.2						~45	~8.5		~23			
	29-52	3.9						~45	~8.5		~10			
	PEDON: 5 GREY DEGRADED GLEY SOILS ON OLD ALLUVIUM													
Bp	12-28	5.2						~6	~<3		~57			
	28-50	6.0						~4	~<3		~60			
	50-78	5.2						~40	~8		~57			
	78-100	5.5						~40	~8		~60			
	PEDON: 6 GLEY ALLUVIAL SOILS ON RECENT ALLUVIUM													
Pf	12-23	5.1						~40	~8		~53			
	23-50	4.0						~40	~8		~14			
	50-100	3.7						~40	~8		~8			
	PEDON:8 ALLUVIAL GREY SOILS													
Ph_g	12-25	6.6						~45						Saturated
	25-43	6.6						~45						
	43-63	6.5						~50						
	PEDON:14 GREY SOILS ON OLD ALLUVIUM													
X	17-30	4.6	3.8			53.5	14.0	32.5	~6					
	30-53	4.8	3.9			52.8	8.0	39.2	~8					
	53-78	4.6	3.9			50.8	12.0	37.2	~7					
	78-100	4.4	3.8			52.8	6.0	41.2	~8					
	PEDON:15 DARK BROWN SOILS ON BASALT													
Ft	0-22	5.9	4.8			28.0	35.0	37.0	14.8	40.0	68	2.9	7.1	
	22-45	6.1	5.2			12.0	37.0	51.0	16.6	32.0	78	2.9	10.1	
	PEDON:16 RED BROWN FERRALITIC SOILS ON BASALT													
Fk	0-13	4.8	4.0			10.0	27.0	63.0	8.7	14.0	19.3	0.84	0.84	
	13-35	5.1	4.1			5.0	23.0	72.0	8.3	11.0	19.1	0.84	0.72	
	35-57	5.2	4.3			6.0	17.0	77.0	8.2	11.0	35.2	1.2	1.08	
	57-113	5.2	4.3			6.0	16.0	78.0	7.8	10.0	26.0	1.2	0.84	
	113-150	5.6	4.6			6.0	12.0	82.0	7.9	10.0	30.4	0.42	0.96	
	150-200	5.78	4.6			5.0	13.0	82.0	8.1	10.0	23.6	0.72	1.20	
	PEDON: 19 RED BROWN FERRALITIC SOILS ON BASALT													
Fk	0-30	5.2	4.2			14.0	16.0	70.0	7.8	11.1	0.9	0.5		18.4
	30-78	5.4	4.3			20.0	12.0	68.0	7.5	11.0	0.7	0.6		17.5
	78-120	5.5	4.5			13.0	10.0	77.0	7.6	9.0	1.2	0.2		18.6
	120-165	5.6	4.5			7.0	15.0	78.0	6.0	7.0	1.1	0.2		22.0
	165-220	5.5	4.6			10.0	12.0	78.0	5.3	6.0	0.9	0.2		22.6
	>220	5.0	4.7			10	12.0	75.0	4.8	6.0	0.5	0.1		17.4

~ around

Table 8: Statistical data regarding correlations worked out between different parameters.

B hor. of ACRISOL		B hor. of FERRALSOL	
Regression Output: CLAY & CEC		Regression Output: CLAY & CEC	
Constant	0.824434	Constant	4.855392
Std Err of Y Est	2.370395	Std Err of Y Est	1.330194
R Squared	0.465061	R Squared	0.249685
No. of Observations	13	No. of Observations	11
Degrees of Freedom	11	Degrees of Freedom	9
X Coefficient(s)	0.1984395	X Coefficient(x)	-0.02737
Std Err of Coef.	0.05715168	Std Err of Coef.	0.070878
Regression Output: BS & pH (H2O)		Regression Output: BS& pH (H2O)	
Constant	4.330894	Constant	4.483247
Std Err of Y Est	0.3752468	Std Err of Y Est	0.2444831
R Squared	0.590698	R Squared	0.624214
No. of Observations	13	No. of Observations	19
Degrees of Freedom	11	Degrees of Freedom	17
X Coefficient(s)	0.042664	X Coefficient(s)	0.014311
Std Err of Coef.	0.008978	Std Err of Coef.	0.007924
Regression Output: BS & pH (KCL)		Regression Output: BS & pH(KCL)	
Constant	3.603302	Constant	4.076460
Std Err of Y Est	0.3172059	Std Err of Y Est	0.247784
R Squared	0.427183	R Squared	0.483480
No.of Observations	33	No.of Observations	19
Degrees of Freedom	31	Degrees of Freedom	17
X Coefficient(s)	0.025376	X Coefficient(s)	0.010595
Std Err of Coef.	0.0092931	Std Err of Coef.	0.008999

Fig. 8. Relation Between Clay and CEC IN B HOR.

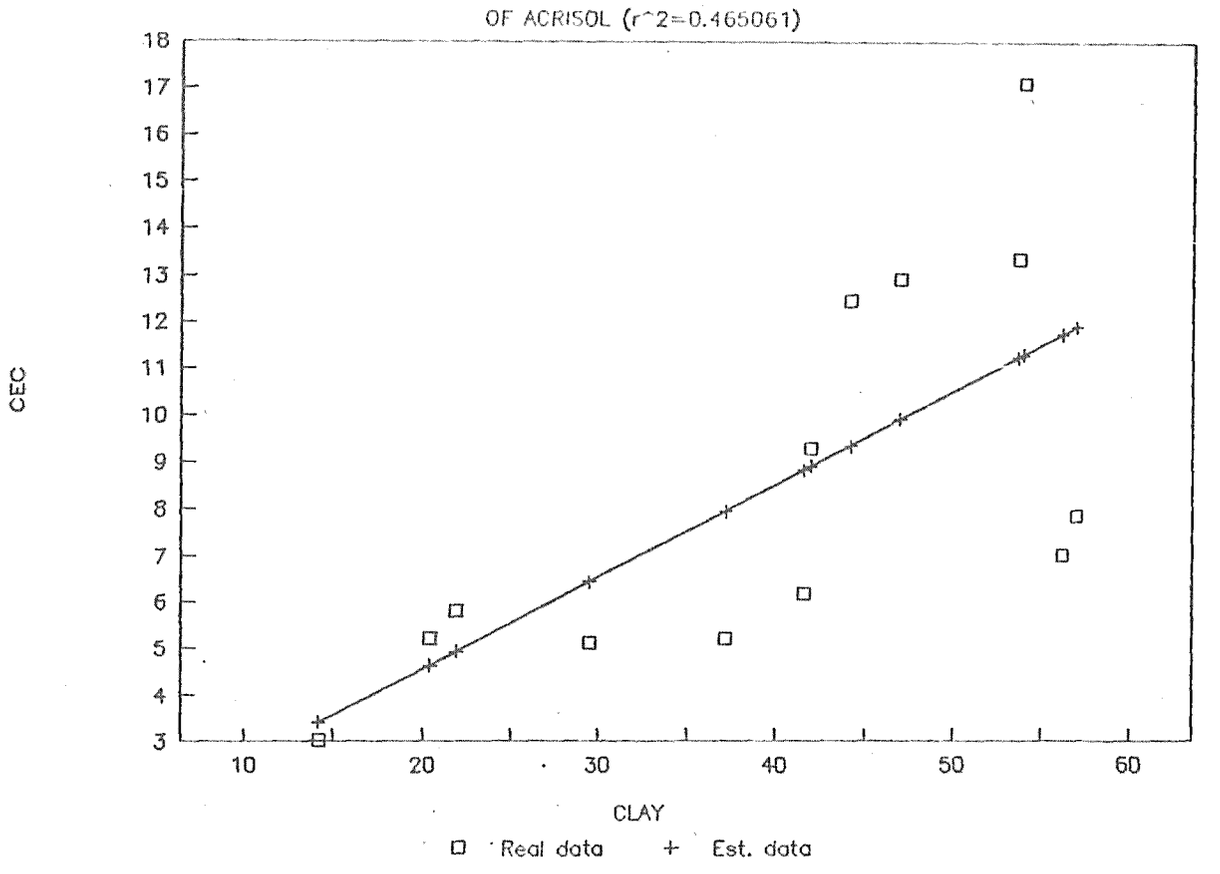


Fig. 9. Relation Between Clay and CEC IN B HOR.

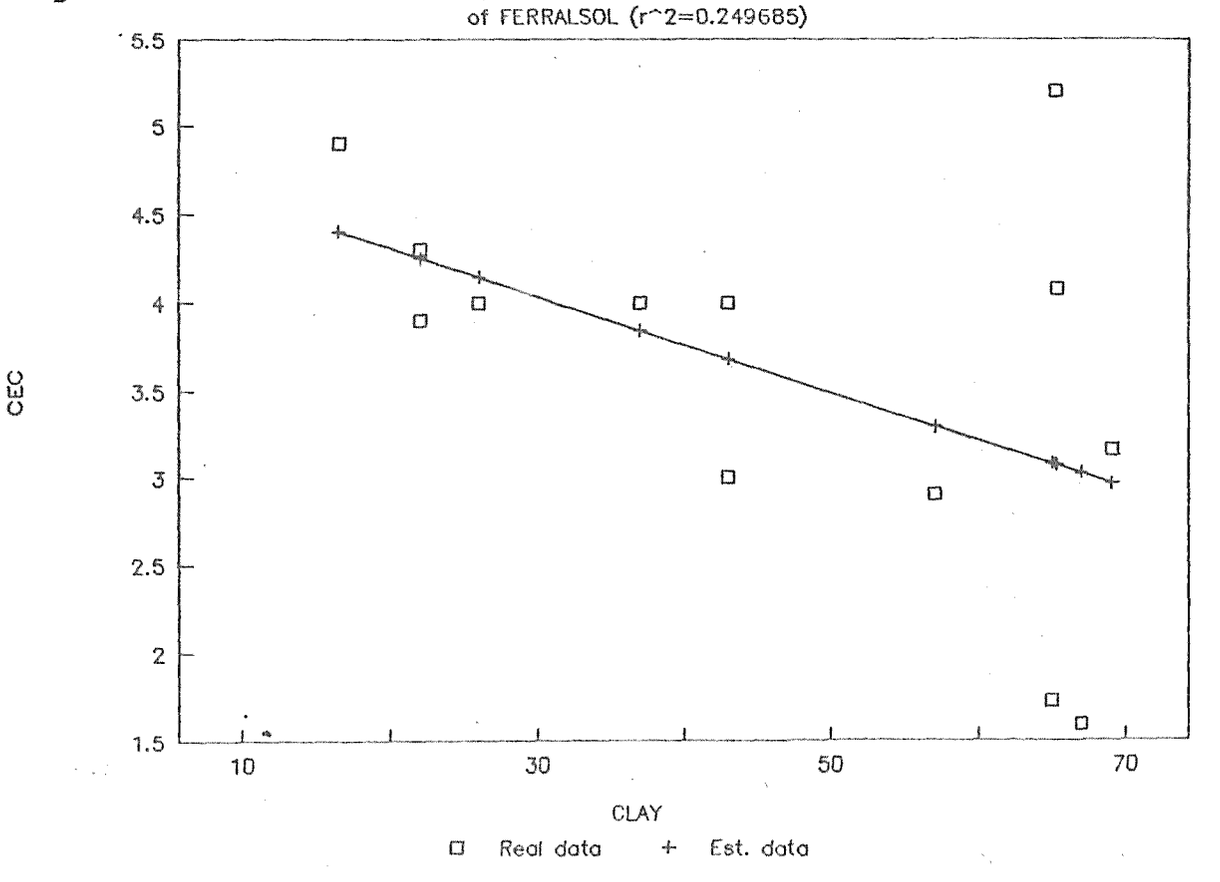


Fig. 10. RELATION BETWEEN BS & pH H2O

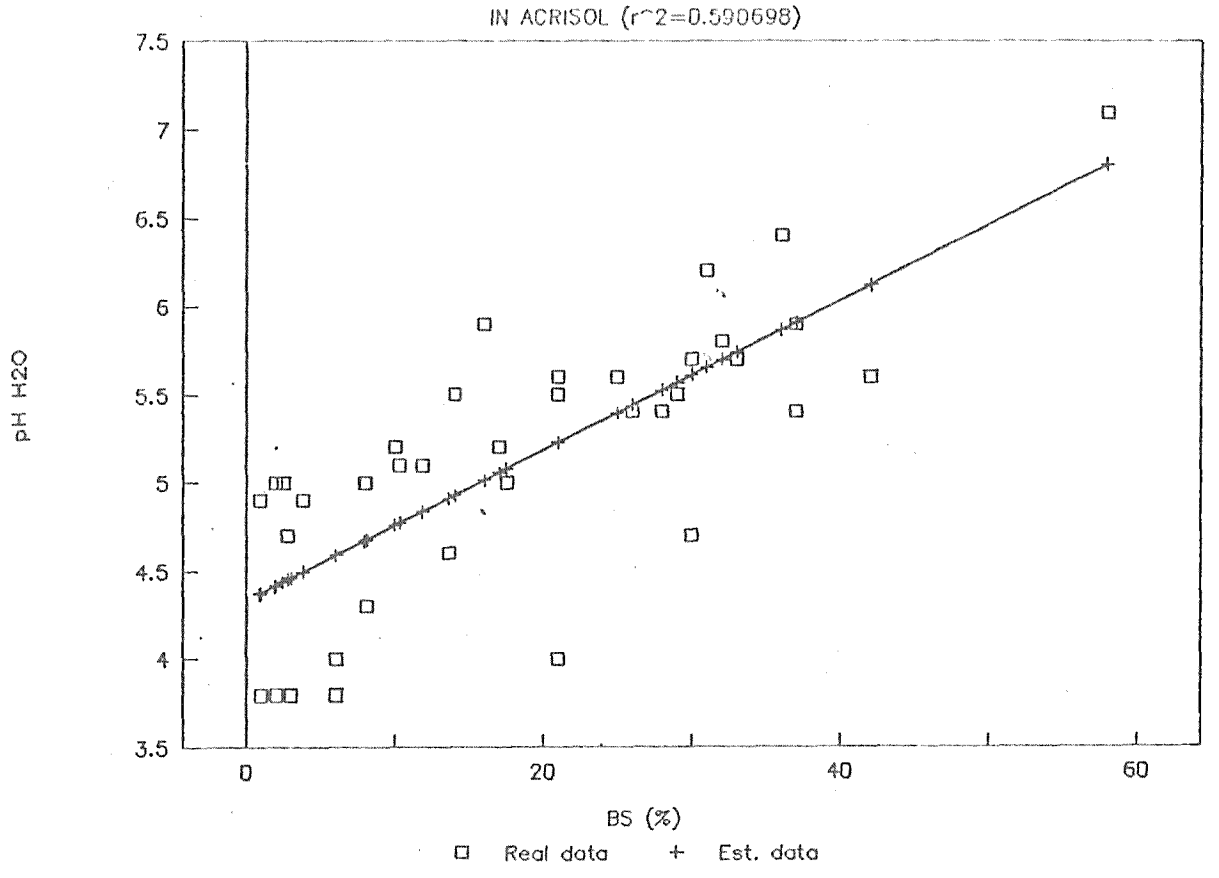


Fig. 11. RELATION BETWEEN BS & pH KCL

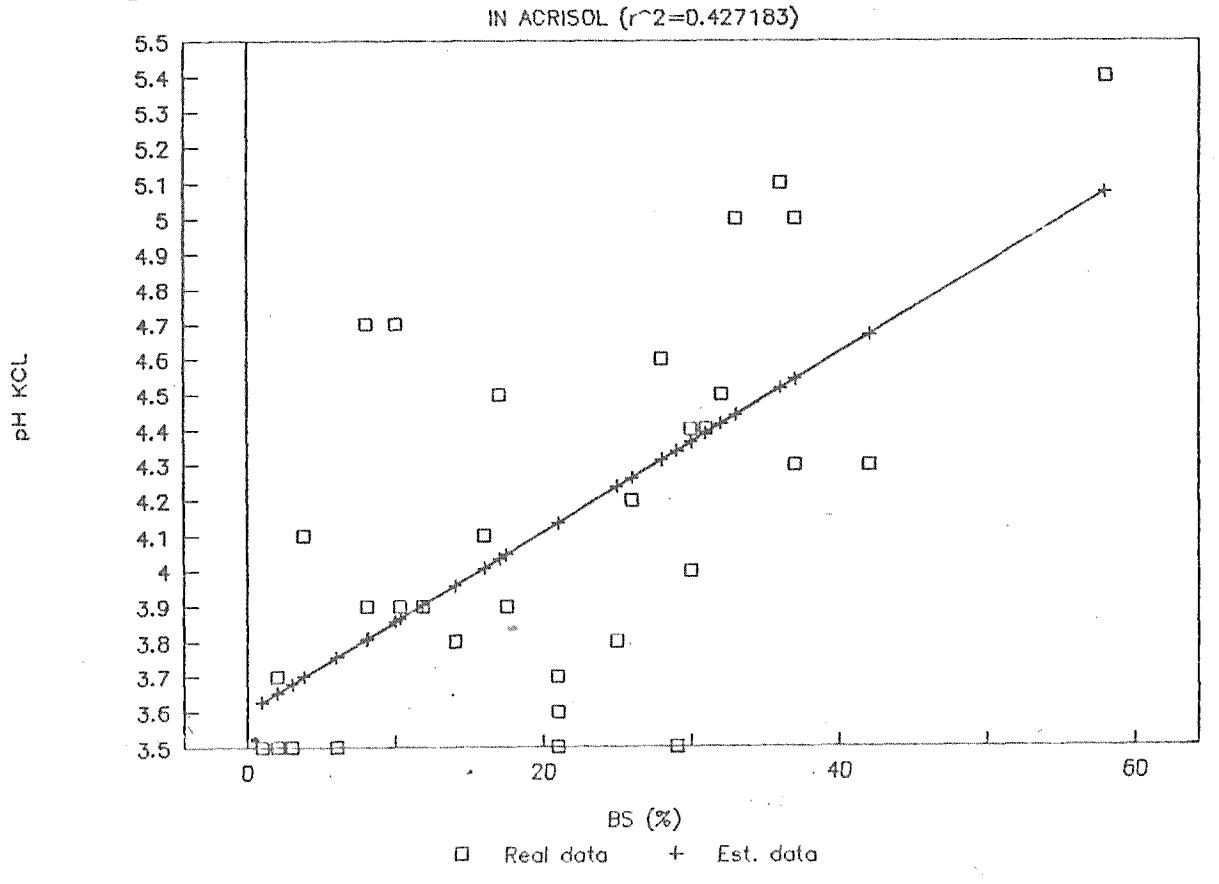


Fig. 12. RELATION BETWEEN pH (H2O) & BS

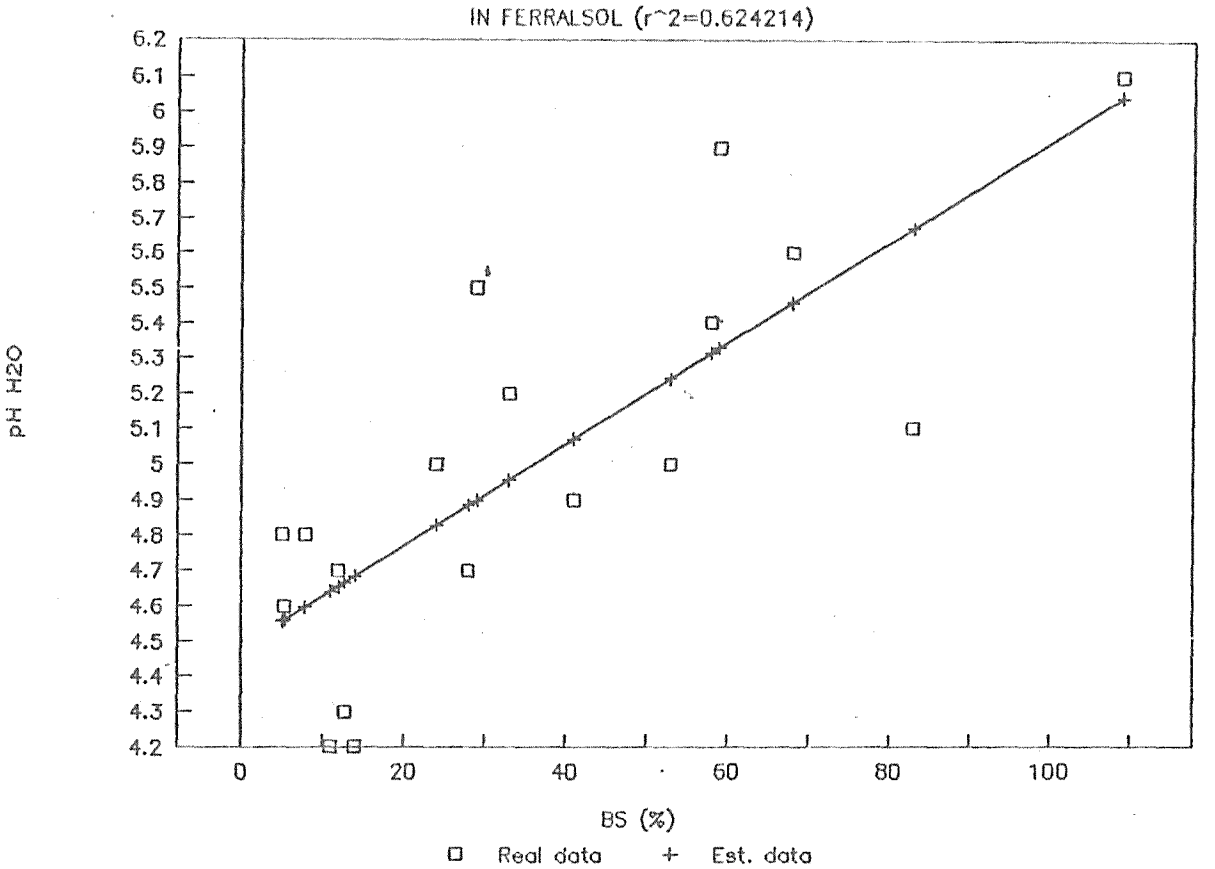


Fig. 13. RELATION BETWEEN pH (KCL) & BS

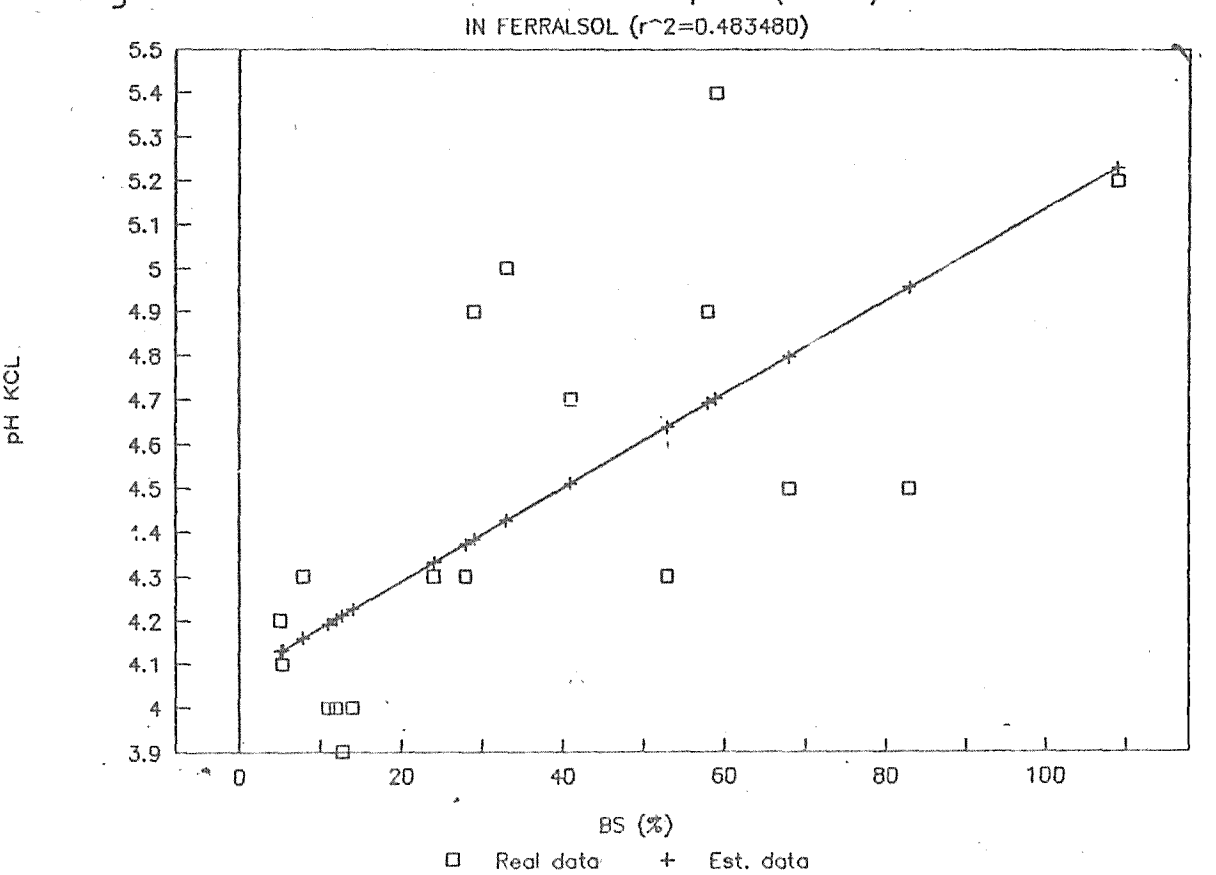


Fig. 14. RELATION BETWEEN pH (H2O) & BS

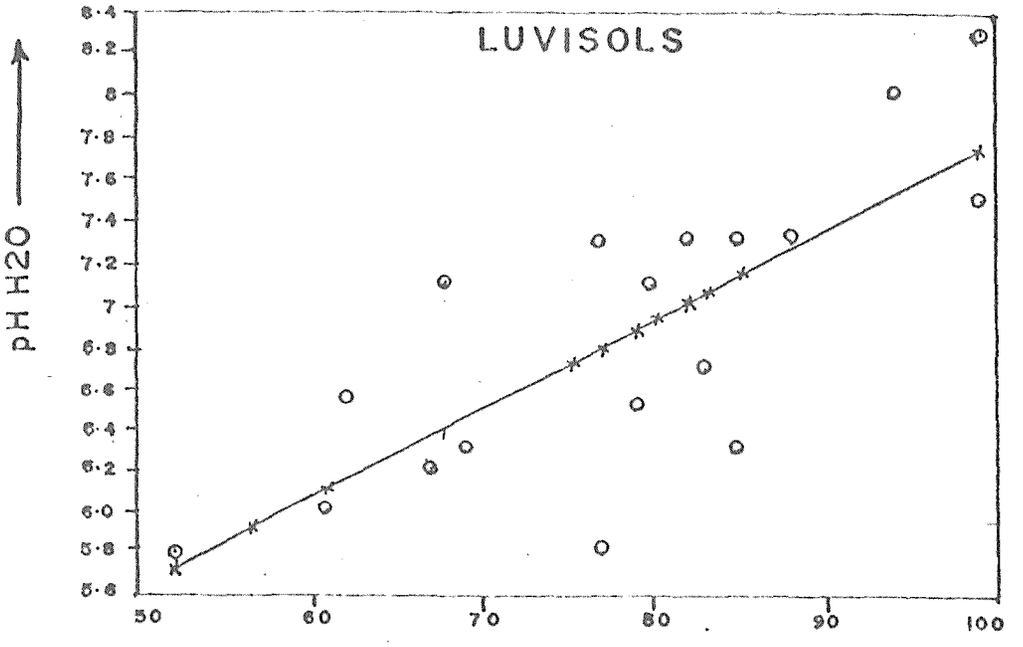
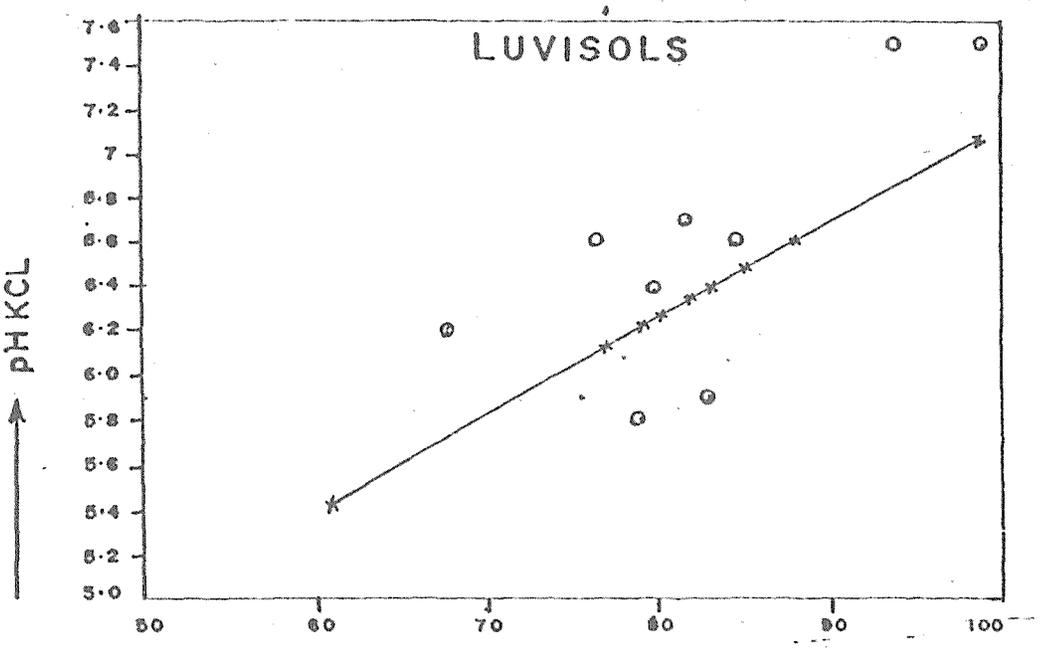


Fig. 15. RELATION BETWEEN pH (KCL) & BS



4.2 CLASSIFICATION

The studied soils (20+20) were classified according to the systems of FAO-UNESCO (1988)[2] and USDA (Soil Survey Staff, 1975)[1]. The FAO-System is undoubtedly much easier to understand and apply for classifying soils as compared with the US Soil Taxonomy. Since the objective is to classify soils in the FAO-System, a brief about the system may help those who are not acquainted with it. This is especially true of the Vietnamese scientists, for whom special seminars/workshops were organised by the NIAPP to highlight the principles of the system.

4.2.1 FAO-SYSTEM & ITS APPLICATION

The FAO-UNESCO System is largely based on compilation of existing materials combined with systematic field identification and correlation of soils over a period of more than two decades. The system is based on observable and measurable soil properties. The use of diagnostic horizons for identification of soil units has proved to be most appropriate. The set of quantitatively defined properties produced by soil forming processes, have made it possible to base the classification on general principles of soil genesis. The processes themselves are not used as criteria, but the inferences of the processes, as expressed in morphology and intrinsic soil properties, form the bases for identifying soil groups, soil units and subunits. The criteria for defining diagnostic horizons and diagnostic properties have been inherited largely from Soil Taxonomy (Soil Survey Staff, 1975)[1] but modified wherever desired. For instance, separating argillic and oxic B horizons has been a problem, especially in the tropical areas where low activity clay prevails. As such argillic and oxic horizons have been redefined under the names of Argic and Ferralic B horizons. In the revised Legend (FAO-UNESCO, 1988)[2] some major soil groups and units have been deleted whereas others have been added in accordance with the additional experience gained. The important additions or alterations (relevant to Vietnamese soils) are highlighted as under:

- Introduction of the LIXISOLS (connotative of strong weathering) for soils having an argic horizon, high base status but low-activity clay which allows their separation from LUVISOLS (which are soils with high-activity clay).

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1. Soil Survey Staff (1975) Soil Taxonomy. US Dept. Agric., SCS; Washington DC, USA.

2. FAO-UNESCO (1988). FAO-UNESCO Soil Map of the World Revised Legend. World Soil Resources Report EC, FAO Publ., p.110.

Splitting the ACRISOLS into two soil groups as:

- Acrisols: Defined as soils with low-clay activity

- Alisols: Soils with high-activity clay

In view of the above changes, the criteria for differentiating different soil groups are outlined in Table 9.

Table 9: Criteria for separatiing of major soils with Bt horizons

CRITERIA	LUVISOLS (LV)	LIXISOLS (LX)	ACRISOLS (AC)	ALISOLS (AL)
• Argic (Bt) horizon	X	X	X	X
• CEC (Cmol(+) kg^{-1} clay)	> 24	> 24	>24	>24
• Kind of clay	High-activity	Low-activity	Low-activity	High-activity
• Base Saturation	> 50%	> 50	<50	<50

- Subdivision of poorly-drained soils into those with a ground water table and those with surface water-logging by introducing STAGNIC units.

- Introduction of PLINTHOSOLS (form Gr. Plinthos, brick; mottled clay material which hardens on exposure), thus separating such soils from Ferralsols.

- Introduction of HUMIC unit for soils which have either mollic or umbric A horizon.

As of today, there are 28 major soil groupings, subdivided at the second level into 153 soil units. The details of soil groups and soil units alongwith the criteria for their separations are given in Table 10. The discussion about the US system of Soil Taxonomy is beyond the scope of this mission.

While classifying the studied soils in the FAO System, some problems were faced. These are briefly discussed here under as these are relevant to the logical classification of Vietnamese Soils.

4.2.2 PROBLEMS AND CONSIDERATIONS IN CLASSIFYING SOILS

The application of FAO-UNESCO System to the studied soils suggests that the criteria and soil units provided in the system may not accomodate all the soils for their

Table 10: FAO Soil Units and their criteria (28 major soil groups & 153 soil units)

NOT BOUND TO ZONALITY CONCENT	CONDITIONED BY PARENT MATERIAL	INITIAL STAGE OF WEATHERING	SALT ACCUMULATION OR DROUGHTY (PHYSIOLOGICALLY)
FL FLUVISOLS	**AR ARENOSOLS**	**CM CAMBISOLS**	**CL CALCISOLS**
FLe Eutric Fluvisols	ARh Haplic Arenosols	CMe Eutric Cambisols	CLh Haplic Calcisols
FLc Calcaric Fluvisols	ARb Cambic Arenosols	CMd Dystric Cambisols	CLl Luvic Calcisols
FLd Dystric Fluvisols	ARl Luvic Arenosols	CMu Humic Cambisols	CLp Petric Calcisols
FLm Mollic Fluvisols	ARo Ferralic Arenosols	CMc Calcaric Cambisols	
FLu Umbric Fluvisols	ARa Albic Arenosols	CMx Chromic Cambisols	**GY GYPSISOLS**
FLt Thionic Fluvisols	Arc Calcaric Arenosols	CMv Vertic Cambisols	
FLs Salic Fluvisols	Arg Gleyic Arenosols	CMo Ferralic Cambisols	GYh Haplic Gypisols
		CMg Gleyic Cambisols	GYk Calcic Gypsisols
		CMi Gelic Cambisols	GYl Luvic Gypsisols
			GYp Petric Gypsisols
GL GLEYSOLS	**AN ANDOSOLS**		**SN SOLONETZ**
GLe Eutric Gleysols	ANh Haplic Andosols		SNh Haplic Solonetz
GLk Calcic Gleysols	ANm Mollic Andosols		SNm Mollic Solonetz
GLd Dystric Gleysols	ANu Umbric Andosols		SNk Calcic Solonetz
GLa Andic Gleysols	ANz Vitric Andosols		SNy Gypsic Solonetz
GLm Mollic Gleysols	ANg Gleyic Andosols		SNj Stagnic Solonetz
GLu Umbric Gleysols	ANi Gelic Andosols		SNg Gleyic Solonetz
GLt Thionic Gleysols			
GLi Gelic Gleysols			
RG REGOSOLS	**VR VERTISOLS**		**SC SOLONCHAKS**
RGe Eutric Regosols	VRe Eutric Vertisols		SCh Haplic Solonchaks
RGc Calcaric Regosols	VRd Dystric Vertisols		SOm Mollic Solonchaks
RGy Gypsic Regosols	VRk Calcic Vertisols		SCk Calcic Solonchaks
RGd Dystric Regosols	VRy Gypsic Vertisols		SCy Gypsic Solonchaks
RGu Umbric Regosols			SCn Sodic Solonchaks
RGi Gelic Regosols			SCg Gleyic Solonchaks
			SCi Gelic Solonchaks
LP LEPTOSOLS			
LPe Eutric Leptosols			
LPd Dystric Leptosols			
LPk Rendzic Leptosols			
LPm Mollic Leptosols			
LPu Umbric Leptosols			
LPq Lithic Leptosols			
LPi Gelic Leptosols			

ACCUMULATION OF BASES BASES & O.M.	ACCUMULATION OF CLAY & R_2O_3	INTENSE WEATHERING	ORGANIC SOILS	HUMAN ACTIVITY
KS KASTANOZEMS	LV LUVISOLS	LX LIXISOLS	HS HISTOSOLS	AT ANTHROSOLS
KSh Haplic Kastanozems	LVh Haplic Luvisols	LXh Haplic Lixisols	HSl Folic Histosols	ATa Aric Antrosols
KSl Luvic Kastanozems	LVf Ferric Luvisols	LXf Ferric Lixisols	HSs Terric Histosols	ATc Cumulic Anthrosols
KSk Calcic Kastanozems	LVx Chromic Luvisols	LXp Plinthic Lixisols	HSf Fibric Histosols	ATf Fimic Anthrosols
KSy Gypsic Kastanozems	LVk Calcic Luvisols	LXa Albic Lixisols	HSt Thionic Histosols	ATu Urbic Anthrosols
	LVv Vertic Luvisols	LXj Saagnic Lixisols	HSi Gelic Histosols	
	LVa Albic Luvisols	LXg Gleyic Luxisols		
	LVj Stagnic Luvisols			
	LVg Gleyic Luvisols			
CH CHRNOZEMS	PL PLANOSOLS	AC ACROSOLS		
CHh Haplic Chernozems	PLe Eutric Planosols	ACh Haplic Acrisols		
CHk Calcic Chernozems	PLd Dystric Planosols	ACf Ferric Acrisols		
CHl Luvic Chernozems	PLm Mollic Planosols	ACu Humic Acrisols		
CHw Glossic Chernozems	PLu Umbric Planosols	ACp Plinthic Acrisols		
CHg Gleyic Chernozems	PLj Gelic Planosols	ACg Gleyic Acrisols		
PH PHAEOZEMS	PD PODZOLUVISOLS	AL ALISOLS		
PHh Haplic Phaeozems	PDe Eutric Podzoluvisols	ALh Haplic Alisols		
PHc Calcaric Phaeozems	PDd Dystric Podzoluvisols	ALf Ferric Alisols		
PHl Luvic Phaeozems	PDj Stagnic Podzoluvisols	ALu Humic Alisols		
PHj Stagnic Phaeozems	PDg Gleyic Podzoluvisols	ALp Plinthic Alisols		
PHg Gleyic Phaeozems	PDi Gelic Podzoluvisols	ALj Stagnic Alisols		
		ALg Gleyic Alisols		
GR GREYZEMS	PZ PODZOLS	NT NITISOLS		
GRh Haplic Greyzems	PZh Haplic Podzols	NTh Haplic Nitisols		
GRg Gleyic Greyzems	PZb Cambic Podzols	NTr Rhodic Nitisols		
	PZf Ferric Podzols	NTu Humic Nitisols		
	PZc Carbic Podzols			
	PZg Gleyic Podzols			
	PZi Gelic Podzols			
		FR FERRALSOLS		
		FRh Haplic Ferralsols		
		FRx Zanthic Ferralsols		
		FRr Rhodic Ferralsols		
		FRu Humic Ferralsols		
		FRg Gerric Ferralsols		
		FRp Plintic Ferralsols		
		PT PLINTHOSOLS		
		PTe Eutric Plinthosols		
		PTd Dystric Plinthosols		
		PTu Humic Plinthosols		
		PTa Albic Plinthosols		

logical classification and necessitate the introduction of some intergrades or subunits and/or proposing new criteria to depict the true nature of these soils.

- Introduction of GLEYIC Intergrades within FLUVISOLS & Vice-Versa

Some Fluvisols show distinct gleyic characteristics within 100 cm of the surface. Such characteristics if occurring within 50 cm of the surface will qualify such soils (P.8) for Gleysols. Since the system provides at the third level to classify such intergrade soils, therefore P-8 has been classified as Gleyi-Eutric Fluvisols (P-8).

On similar analogy, soils qualifying for Gleysols, but showing fluvic properties (secondary) within 1 m of the surface may better be keyed out as Fluvi-Dystric Gleysols (P-6) to highlight the fluvial nature of soils (like P-6), but showing distinct gleying within 50 cm of soils and not keying out as Fluvisols.

Some Gleysols show in addition STAGNIC properties for a large part of a year. To highlight the stagnic properties, a subunit of STAGNIC within Gleysols may be desirable.

- Chromic Unit within PHAEOZEMS

The Dark-Brown soils of Vietnam having developed on decomposed basalt, show strong brown to red colours with an argic (Bt) horizon and a mollic epipedon. As per the key, such soils (P-15) key out as Phaeozems (rather than Luvisols). Within Phaeozems, their characteristic property, viz. red colours, don't find any place as has been provided in Luvisols. We believe the introduction of CHROMIC soil unit may help to highlight the typical nature of these soils,i.e. reddish colours and logically classify them (P-15) as Chromi-Luvic Phaeozems. This appears appropriate as these soils grade to Luvisols on the landscape.

- Ferric Properties

The Ferric units have been provided within Luvisols, Lixisols, Alisols and Acrisols to highlight their transition to Ferralsols. Some soils of Vietnam (P 1,2,3) have characteristic features of Acrisols plus low (<2) SiO_2 /R_2 O_3 ratio, small nodules and show colours redder than 7.5YR (commonly 5YR), but show no mottles or discrete nodules upto 2 cm in diameter. Such soils key out as Haplic Acrisols which does not depict their true nature. We propose to separate such Ferralitic soils (as per Vietnamese legend) by broadening the criteria of FERRIC properties to include:

"have SiO_2 /R_2 O_3 of less than 2 and colours of redder than 7.5YR"

in order to key out such soils (P1-2) as FERRIC ACRISOLS

The pedon-3 showing red or dusky red colours may better be classified as RHODIC ACRISOLS by introducing a SOIL UNIT of RHODIC within ACRISOLS. This will be in line with the Rhodic Ferralsols.

- Thionic Soils

The Acid Sulphate soils occupy a considerable fraction 7% of the land area in Vietnam. These soils are also observed in other countries. The soils, although show gleying characteristics, yet have a diagnostic horizon, viz. sulfuric within 75 cm of the surface (once drained) and pose serious land-use problems. We believe while gleying properties may be taken care of by suitable agronomic practices, such as cultivation on beds with furrows, the sulfuric properties continue to pose serious problems for cultivation of such soils (P-13) and adversely affect crop yields. Since diagnostic horizons, such as calcic, gypsic, salic, natric, enjoy precedent over aridic moisture regime and are taken care of at Soil Group level, we believe the Acid Sulphate Soils also deserve to the enjoying precedent over aquic soil moisture regime to classify such soils (P-13) as THIONOSOLS. The soil group of Thionosols may have the following soil units.

- Gleyic Thionosols
- Fluventic Thionosols
- Histic Thionosols
- Stagnic Thionosols
- Haplic Thionosols

Using the criteria of soil units, as given in the FAO-UNESCO Revised Legend, and keeping in view the above considerations, the studied soils of Vietnam have been classified (Table 11).

Although difficult, an attempt has also been made to classify the additional 20 pedons based on their limited morphology and analytical data. Their classification is given in Table 12.

The data (Table 11 and 12) show that the soils of Vietnam belong to the following 12 (9+3) Soil Groups and over 20 soil units:

ACRISOLS (Ferric, Rhodi-Ferric, Ferri-Gleyic,Haplic, Gleyic, Humic)

ARENOSOLS (Fluvic, Haplic)

CAMBISOLS (Dystric)

FLUVISOLS (Dystric, Gleyi-dystric, Gleyi-Eutric, Eutric, Haplic)

GLEYSOLS (Fluvic, Dystric, Stagni-Dystric, stagni-Eutric, Fluvi-Dystric)

FERRALSOLS (Humic, Rhodic)

PHAEOZEMS (Chromic, Luvic)

THIONOSOLS* (Gleyic)

PLINTHOSOLS (Dystric)
SOLONCHAKS | These Soil Groups are observed to occur
LUVISOLS | in Vietnam based on 20 additional profiles
CHERNOZEMS | used for classification

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* New Proposals

TABLE 11 CLASSIFICATION OF THE STUDIED SOILS

Profile	SOIL CLASSIFICATION		
	VIETNAMESE	FAO-UNESCO	US SOIL TAXONOMY
1.	Red & Yellow Ferralitic Soils on Gneiss	Ferric Acrisols	Paleustult
2.	Red & Yellow Ferralitic Soils on Gneiss	Ferric Acrisols	Paleustult
3.	Red Ferralitic Soils on Mica Schist	Rhodi-Ferric Acrisols	Paleustult
4.	Gley Degraded Grey Soils on Old Alluvium	Ferri-Gleyic Acrisols	Aeric Kanhaplaquult
5.	Grey Degraded Gley Soils on Old Alluvium	Gleyi-Dystric Fluvisols	Thapto Acraquoxic Psammentic Ustifluvent
6.	Gley Alluvial Soils on Recent Alluvium	(Fluvi)-Dystric Gleysols	Dystric Haplaquept
7.	Hydromorphic Gley Soils on Recent Alluvium	Stagni-Dystric Gleysols	Stagnic Fluvaquent/ aquept
8.	Recent Alluvial Gley Soils (on alluvium of the Red River)	Gleyi-Eutric Fluvisols	Aquertic Ustifluvent
11.	Sandy Soils on Dunes	Haplic Arenosols	Fluventic Tropopsamment
12.	Perriodic Solonchaks (influenced by underground water)	Stagni-Eutric Gleysols (with salic Phase)	Aeric Tropaquept (with Saline Phase)
13.	Acid Sulphate Soils on Recent Alluvium	Sulfi-Thionic Gleysols/ Sulfi-Gleyic Thionosols(*) (with Stagnic Phase)	Sulfic Tropaquept(*)
14.	Grey Soils on Old Alluvium	Dystric Cambisols	Dystric Ustropept(*)
15.	Dark Brown Soils on Decomposed Basalt (of Volcanic Origin)	Chromi-Luvic Phaeozems/ (Chromi-Humic Luvisols)	Mollic Ultic Tropustalf Haplustalf
16.	Red-Brown Ferralitic Soils on Decomposed Basalt	Humic Ferralsols	Ustic Kandihumult
17.	Brown Yellow Ferralitic Soils on Old Alluvium	Haplic Acrisols	Typic Kandiustult
18.	Degraded Grey Soils with Lateritic Concretions on Old Alluvium	Gleyic Acrisols	Aquic Kandiustult
19.	Red-Brown Ferralitic Soils on Basalt	Rhodic Ferralsols	Rhodic Haplustox
20.	Gley Degraded Soils with Lateritic Concretions	Dystric Plinthosols	Plinthic Acrustox

* Proposed Classification

Table 12: Classification of the additional pedons (described earlier)

Pedon No. (Map-Symbol)	SOIL CLASSIFICATION	
	VIETNAMESE	FAO-UNESCO
450 (Fs)	Red-Yellow Ferralitic Soils on metamorphosed rock	Ferric Acrisols
439 (Fs)	Red-Yellow Ferralitic Soils on Claystone	Gleyic Acrisols
67 (Fs)	Red-Yellow Ferralitic Soils on Claystone	Luvisols,(data) Acrisols (Logic)
142 (Fv)	Brown-Red Ferralitic Soils on Limestone	Luvic Chernozems
1 (Bg)	Gley Degraded Grey Soils on old alluvium	Gleyic Alisols Gleyic Acrisols
200 (Ph)	Gley Alluvial Soils on Red River alluvium	Gleyi-Eutric Fluvisols
264 (M)	Saline Soils	Fluvic Solonchaks
75 (C)	Sandy Marine Soils	Haplic Arenosols
65 (Fq)	Light-Yellow Ferralitic Soils on sandstone	Acrisols
493 (Fa)	Red-Yellow Ferralitic Soils on granitic rock	Humic Acrisols
39 (Fk)	Red-Brown Ferralitic Soils on Basalt	Humic Acrisols
6 (S)	Acid Sulphate Soils	Thionic Gleysols/Gleyic Thionosols (*)
102 (X)	Grey Soils on old alluvium	Humic Acrisols
1805 (M)	Saline Soils	Gleyic Fluvisols (Saline Phase)
92 (S)	Acid Sulphate Soils	Thionic Gleysols Gleyic Thionosol(*)
45 (Xk)	Brown Grey Soils (in semi-arid region)	Luvisols
53 (Pc)	Alluvial Soils on the Mekong R. alluvium	Gleyic Fluvisols

(*) Proposed Classification

5. SOIL CORRELATION

The studied soils of Vietnam (20 pedons actually studied and described in the field by the Consultant and another *20 pedons already described in different reports by the Vietnamese Soil Survey Staff) typifying some Vietnamese soils, were correlated by directly comparing the taxonomy of these soils in the Vietnamese Soil Map Legend and with that of the FAO-UNESCO System. The results, as presented in Table 13, shows that while some of the studied soils could be correlated without any difficulty, the others were not so easy to correlate.

The sandy soils on dunes (as per Vietnamese legend) (P-11) correlate well with Arenosols. The hydromorphic Gley Soils (P-7) qualify for Dystric Gleysols. The Gley Degraded Grey Soils on old alluvium (P-4), as per Vietnamese Legend, qualify for Gleyic Acrisols. The other Grey Soils on old alluvium (P-14) also correlate with Acrisols or Cambisols depending on the presence or absence of an argic horizon.

The Acid Sulphate Soils (P-13) key out as Thionic Gleysols in the FAO-UNESCO system. These soils, as suggested earlier, may deserve to be abstracted at a higher level in the system, e.g. Gleyic Thionosols (discussed in Section 4).

The Dark Brown Soils on decomposed basalt (P-15) correlate with Phaeozems. Such soils in other areas, not qualifying for a mollic epipedon, may qualify for Humi-Chromic Luvisols.

For other soil units, especially those classified as Ferrallitic Soils (in the Vietnamese legend), the correlation is not that easy. From the morphological descriptions and analytical data of the studied soil profiles (given in Section 4), some such soils qualify for Acrisols and the others as Ferralsols (as per FAO System). Similar problems are faced in respect of Solonchaks and Grey Degraded Soils with lateritic crusts.

A critical look at the morphological descriptions (See Annex. 3 & 4) and analytical data (See Table 7) show that the Red-Brown Ferrallitic Soils (in Vietnamese Legend) have dusky red or red colours, high clay content (70% or so), diffuse boundaries. They commonly occur in the South of 15° N in typical tropical climate and are used for rubber or coffee plantations. The Red-Yellow Ferrallitic Soils, on the other hand, are Yellowish-red in colour (7.5 YR or redder) with clear/gradual boundaries between horizons, have comparatively low clay content (50-60%) and few to common lateritic concretions in their Bs horizon. They commonly occur in the northern sectors (north of 15° N) and are mainly used for tea and lichi plantations and for growing cassava. The laboratory data also show low CEC, low B.S. and high clay content in the former (Red-Brown Ferrallitic) than the latter (Red-Yellow

Ferrallitic) soils. Accordingly, the Red-Brown Ferrallitic Soils are correlated with Ferralsols and the Red-Yellow Ferrallitic Soils with Acrisols of the FAO system. Within the Ferralsols (P-16 and 19), the assertion of the local scientists that the soils, represented by pedon 16, are more degraded and weathered may not be tangible as per the present investigation. The discussions held in the Workshop (on Nov 27-28, 1989) convinced the local scientists of the proposed classification and correlation of their Ferrallitic Soils in Ferralsols (P-16, 19) and in Acrisols (P 1, 2, 3, 17). More field work may be needed to confirm these observations.

The Gley Degraded Grey Soils with lateritic concretions (P-20) as per Vietnamese legend, correlate with Plinthosols of the FAO system. But other comparable soils without lateritic concretions (P-4) and developed on old alluvium qualified for Acrisols. Such soils will need more attention in future studies although it became clear that the former (P-20) has Plinthite and the latter ferric properties.

An attempt was also made to classify and correlate another set of twenty pedons (studied and described by the Vietnamese scientists). The morphology and analytical data of these soils is not adequate/dependable enough to classify these soils in the FAO System. However, the tentative classification of these soils collaborate with the above inferences drawn regarding the correlation of these soils.

From the above, one could conclude that

- while some soils (in Vietnamese legend) could be correlated without any difficulty, the others, especially Ferrallitic and Degraded Grey Soils are not that easy to correlate in the FAO system. The present study did help to correlate Ferrallitic Soils in Ferralsols and Acrisols.

- for proper correlation, fresh descriptions and analytical data may be essential as many of the Ferrallitic Soils qualify for Acrisols, Alisols/Ferralsols or even Luvisols in the FAO-UNESCO System.

An attempt was also made to correlate soils by placing the FAO-UNESCO Soil Map over the Vietnamese Soil Map of the same scale. The results of the overlapping (summarised in Table 14) suggest that no special trend is observed as many soil cartographic units (of the Vietnamese map) qualify for two or more Soil Groups in the FAO map. A critical analysis, however, suggests some trend as:

- Most of the Ferrallitic Soils of Vietnam commonly qualify for Acrisols, Ferralsols, and occasionally for Gley Soils, and rarely for Lithosols.

- The Acid Sulphate Soils qualify for Fluvisols or Gleysols

- The Alluvial Soils qualify for Fluvisols, Gleysols and rarely for Acrisols.

- The Degraded Grey Soils correlate with Acrisols, Gleysols.

- The Sandy Soils correlate with Regosols.

The studies conducted on 20+20 pedons also suggest that while there is no problem to classify Sandy, Acid Sulphate, Alluvial Soils, the problems are faced in respect of Ferrallitic, Degraded Grey and Saline Soils.

Looking to the area covered by each of the major soil unit (as given in Figs. 5 and 6, and Tables 5 and 6), one may notice that Ferrallitic soils (Acrisols, senso FAO-System) are the dominant Soils covering almost 50 percent of the total area. Keeping in view the Soil Correlation, as given in Tables 13 and 14, and the area covered by each of the major Soil Unit, the extent of relationship of the major soil groups (in the Vietnamese Legend) with the soil units in the FAO-System has been worked out and given in Fig. 16.

In view of the above although broad-level relationship between different soils do exists, it may become obvious that direct transfer of Vietnamese Soil Map Legend into the FAO-UNESCO System without making field and laboratory studies may be difficult.

Table 13: Correlation of Vietnamese Soils

PEDON	VIETNAMESE LEGEND	FAO-UNESCO SYSTEM	USDA (Approx.Equi
20	Grey Degraded Gley Soils with Lateritic crust	DYSTRIC PLINTHOSOLS	ACRUSTOX
19	Red & Brown Ferrallitic Soils (on basalt)	RHODIC FERRALSOLS	Rhodic Haplu
16	Red & Brown Ferrallitic Degraded Soils (on basalt)	HUMIC FERRALSOLS	Humic Haplus
1,2,3 & 17	Red & Yellow Ferrallitic Soils (on gneiss/mica schist)	FERRIC ACRISOLS HAPLIC ACRISOLS	Paleustult
4	Gley Degraded Grey Soils	FERRI-GLEYIC ACRISOLS	Aeric Kanhap quult
14	Grey Soils (on old alluvium)	HAPLIC ACRISOLS/ Dystric Cambisols	Dystric Ustr
15	Dark-Brown Soils (on alluvium)	CHROMI-LUVIC PHAEOZEMS/ CHROMI-HUMIC LUVISOLS	Argiustoll/M Ultic Haplus
11	Sandy Soils on Dunes	HAPLIC ARENOSOLS	Fluventic Tropopsammen
6, 8	Gley Alluvial Soils (on recent alluvium)	FLUVI-DYSTRIC GLEYSOLS & GLEYI-GLEYI-EUTRIC FLUVISOLS	Dystric Hapl Aquertic Ust
7	Hydromorphic Gley Soils (on recent alluvium)	STAGNI-FLUVIC GLEYSOLS	Stagnic Fluv
12	Periodic SOLONCHAKS	STAGNI-EUTRIC GLEYSOLS (with SALIC phase)	Aeric Tropaq
13	Acid Sulphate Soils	SULFI-THIONIC GLEYSOLS	Sulfic Tropa

Table 14 : Correlation of Vietnamese soils with the FAO-UNESCO soil mapping units

FAO-UNESCO SOIL UNITS*	VIETNAMESE SOIL UNITS*
ACRISOLS	
+ Af 60 - 1/2 ab	P-X-Xa-R-Fx-Fv-Fs-Fa-Fq-Fp-FH-E
+ Af 61 - 1/2 ab	P-X-Xa-Fa-Fp-FH
+ Ag 16 - 2a	P-X-Xg
+ Ag 17 - 1/2 ab	J-Ph-P-Xg-Fs-Fa-Fp
+ Ao 13 - 3 bc	Fs-FH
+ Ao 90 - 2/3 c	X-Xa-Xx-R-Fk-Fv-Fs-Fa-Fq-FH-HA-E
+ Ao 107 - 2 bc	P-Fk-Fv-Fs-Fa-Fq-Fp-FH-E
FERRALSOLS	
+ Fo 102 - 3 ab	Fk-Fks-Fa
+ Fr 33 - 3 ab	Fkt-Fk-Fs-Fa-Fp-S-X
GLEYSOLS	
+ Gd 29 - 3 a	Cc-C-S-J-P-Xa-Fs-Fa-Fq-E
+ Ge 55 - 3 a	M-Sn-S-T
+ Ge 56 - 3 a	M-Sn-S-J-Pn-Pl-P-X-Fs-Fa-Fp-E
LITHOSOLS	
+ I-Af-3c	Fs-Fq-FH-HA
+ I-Lc-Bk-C	P-Fk-Fs-Fq
FLUVISOLS	
+ Je 72 - 2 a	Ph-Pl
+ Je 73 - 3 a	Mm-M-Sn
+ Jt 13 - 3 a	Mm-M-Sn-S-P-X
+ Jt 14 - 3 a	Sn-S-P-Xg-Fp
LUVISOLS	
+ Lc 99 - 2 b	Xx-Fa
+ Lc 100 - C	Fk-Fv-Fs-Fq-FH
HISTOSOLS	
+ Od 21 - a	T-Sn-S
RIGOSOLS	
+ Re 83 - 1 ab	Cc-Cd-C-M-S-P
VERTISOLS	
+ Vp 64 - 3 a	P-Xa-R-Fk-Fa
+ Vo 66 - 3 a	Fs-Fa

* For detailed decoding of soil units, please see Figs. 5 and 6.

P - Alluvial Soils; X-Degraded Grey Soils; F-Ferrallitic Soils; M-Saline Soils; S-Acid Sulphate Soils; C-Sandy Soils

CORRELATION OF MAJOR VIETNAMESE SOILS WITH FAO SOIL GROUPS

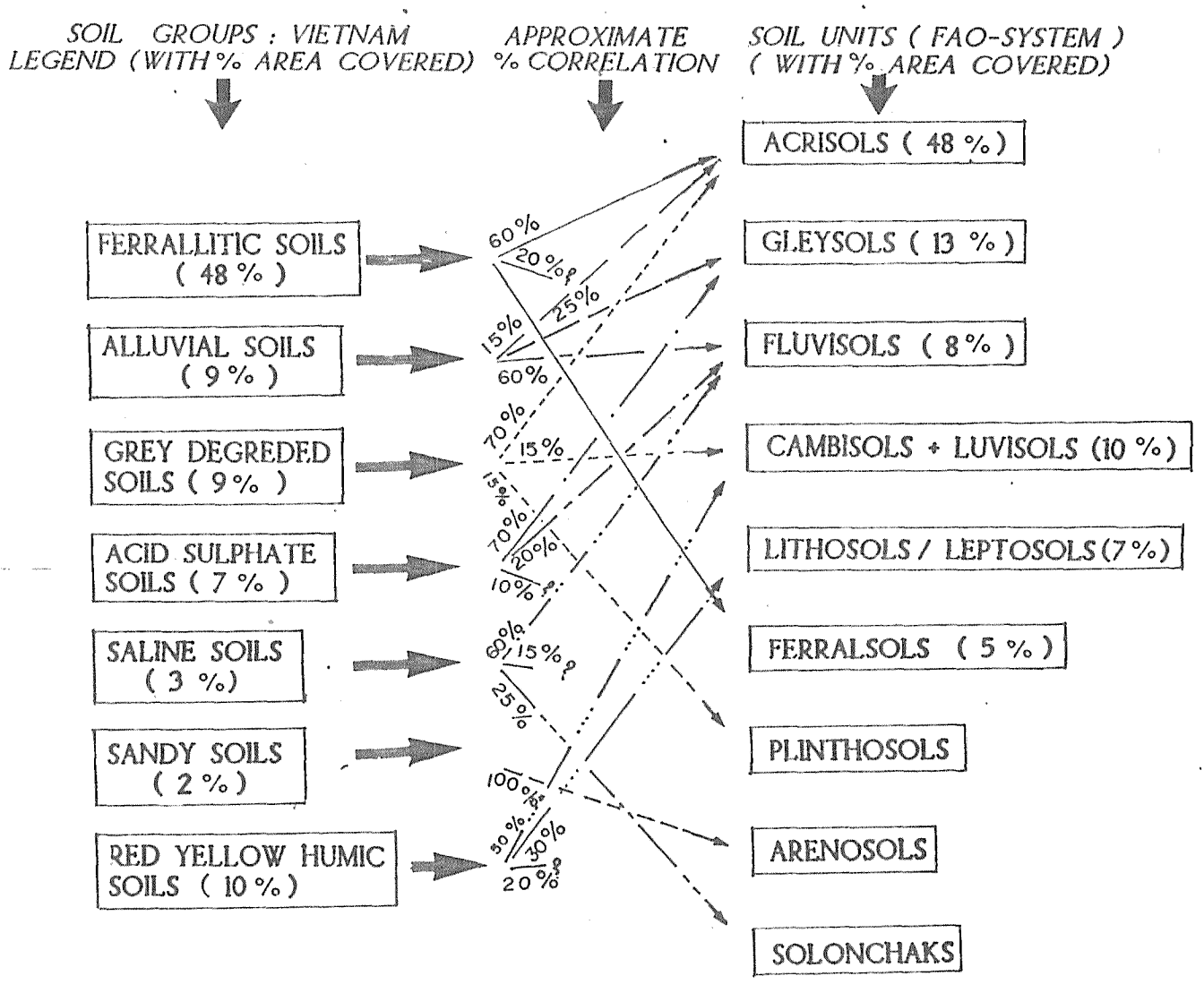

FIG.16 CORRELATION (SEMI-QUANTITATIVE) OF VIETNAMESE MAJOR SOILS WITH THE F A O SOIL GROUPS.

6. PROBLEM SOILS

The major problem soils of Vietnam are:

Red-Brown Ferrallitic Soils (Ferralsols in FAO System) (p-16, 19)

These soils, developed on weathering products of basalt, are occurring in high rainfall areas. The soils show dusky red/red colours, uniform profile with diffuse boundaries with or without humiferous surface horizon. They have high clay content (± 70%) and blocky structure breaking easily to crumb. This enables water to infilterate easily. These soils suffer from the following problems:

- Physical degradation causes degradation of soil structure to compact blocky and renders such soils susceptible to soil erosion resulting in rill or gully-erosion pattern on the landscape
- Low plant nutrients and water holding capacity due to dominance of 1:1 clay minerals
- Chemical depletion of soils as evidenced by low pH (≤ 4.5), exchange capacity (CEC < 16me/100 g clay) and very low base saturation (B.S.) (<25%). The low pH also results in excess of soluble manganese which proves toxic to plants growth;
- Low in available plant nutrients, especially phosphrous (P) and potassium (K). The p-fixation, as Fe-Al-phosphate, is well known in such soils.

Red-Yellow Ferrallitic Soils (Acrisols) (p-1, 2, 3, 17)

The Soils although resemble Red-Brown Ferrallitic Soils as for depth, structure and to some extent, colour, but differ in respect of chemical (and physical) properties. They commonly have lateritic concretions in their B-horizon. The soils are comparatively less red (hue 7.5 to 5 YR), and are observed in less rainfall zone having a pronounced dry period. The major soil problems are:

- Chemical depletion of soils resulting in low pH (around 5), B.S. (<50%) and CEC (<24 me/100 g clay).
- Low available plant nutrients because of fixation of P and 1:1 type of clay minerals.
- Low water and nutrient holding capacity.
- Strong erosion hazard.

Gley Degraded Grey Soils (Acrisols) on old alluvium (p-4, 5)

Such soils show argic horizon with gleying below 50 cm of the surface. They have problems concerned with:

- Fertility depletion due to low B.S. (<50%) and CEC (<24 me/100 g clay).

- Gleying/anaerobic conditions which result in inadequate room for roots to exploit the soil for nutrients and cause an imbalance in soil-air-water relationship which restricts the supply of oxygen for root respiration (rice is exceptional crop which normally roots in anaerobic conditions and have special mechanism for transferring oxygen from the stems and leaves to roots).

Alluvial & Gley Soils (Gleysol/Fluvisols) on recent alluvium (p-6, 7, 8)

Such soils, developed on recent alluvium, occupy appreciable area and are the most potential soils for food production. These soils pose problems of:

- Imperfect to poor drainage conditions resulting from high ground water (generally within 1 m of the surface);

- Poor (Compact) soil structure;

- Heavy texture (silty clay to clay);

- Saline groundwater and the ingress of brackish sea water in the coastal regions are the major causes for the spread of saline soils. The amelioration of such soils demand drainage network. At present, farmers follow an excellent technique of raised beds and furrows to raise subsidiary crops of maize, sweet potato, potato, etc;

- Supply of inadequate irrigation water during dry period (Nov. to Feb./March) is another important question. At present the farmers use stored water in tanks during the dry period. This system needs to be made more effective and efficient.

Acid Sulphate Soils (Sulfi-Thionic Gleysols) (p-13)

Such soils occupying around 2.5 million hectares of land area, occur in the low back swamps, especially Mekong river delta (which alone covers 2.0 m ha). The major problems of these soils are:

- Jarosite material which on oxidation turns to sulfuric acid resulting in extremely low pH (±3) wherein no roots can survive;

- High ground water table and stagnating water for a large part of year

The area is used by planting pine-apple and eucalyptus on raised beds and water is drained through open drains. The yields are low.

Such soils pose a great challenge as on one side the Jarosite material has to be maintained under hydromorphic conditions by not letting it oxidise and on the other side provide sufficient aeration to the growing plants.

Grey Soils (Acrisols/Dystric Cambisols) on old alluvium (p-14)

These soils are deep; Yellowish Brown in colour and have good physical conditions with excellent soil-air-water relationship; but still the yields are low both of rice (and groundnut). These soils suffer from:

- Depletion of soil fertility with low base saturation (<50%) and low cation exchange capacity (<24 me/100 g clay).

Such soils can be ameliorated by liming and introducing a green-manuring crop in the crop rotation.

Dark Brown (Phaeozems/Luvisols) (p-15)

The soils are agriculturally the most fertile soils observed. They have developed on decomposed basalt, have high organic matter and base saturation.

The only limiting factor in such soils is:

- Limiting Soil depth (<50 cm). Although excellent for the growth of annual crops, it may pose problems for perennial and deep-rooting crops.

To sum up, the most important and serious soil problems observed in Vietnam are:

- Soil erosion, especially in the Ferrallitic (Ferrals/ Acrisols) Soils.

- Chemical Degradation/Depletion of Soils resulting in low pH, B.S. and CEC and under extreme situation formation of Kaolin (p-5).
  The problem is of general nature in most of the studied soils and is alarming as it adversely affect the yield and choice of crop.

- Acid Sulphate nature of some soils

- Salinization due to high and brackish ground water in some

areas and ingress of sea water in the coastal areas.

- Gleying due to high ground water table resulting in salinization, making available Fe and Mn in excessive amounts and poor aeration for plant growth.

- Limiting soil depth in selected areas because of excessive erosion and/or the occurrence of bed rock at shallow depth.

7. WORKSHOPS

Workshops are considered an important aspect of consultants activities in this country. Undoubtedly, it is an important exercise for both the consultant and the participants to share views and experience.

The experience of one month mostly studying soils in the field and in the office by going through different documents from different parts of Vietnam was shared in a larger gathering participating from many fields and institutes (see Annex. 4) Through two days (Nov. 27-28), Workshops were organised on the following topics:

- "Recent trends in soil classification", with special emphasis on the FAO-UNESCO and US systems of soil classification.
- "Application of FAO-UNESCO System for classifying and correlating the soils of Vietnam".
- "Soils and climatic inventories for land evaluation towards land use planning".
- "Soil resource mapping using remote sensing technique".

In the first topic, the WHY and HOW of soil classification, general principles, different approaches with emphasis on FAO-UNESCO and US system of soil classification were discussed. The lectures were delivered using visual aids, such as colour slides and overhead projections (given in Annex.) So that the participants can digest the subject matter involving the use of Latin and Greek words.

The **"application of FAO-UNESCO System for classifying and correlating the soil of Vietnam"** was discussed, using the soil micromonoliths (collected during field studies). The topic generated a lot of discussion as some of the names were in contrast to the expectations of some university professors and other pedologists. The morphology and analytical data were used to support our assertions.

The topic **"soil and climatic resource inventories for land evaluation towards Land use Planning"** was presented through a set of colour slides to demonstrate the importance of soils and climate inventories for land evaluation using FAO approach for land use planning. Two case studies were taken as examples for working out the suitability of soils and site conditions for different crops with the objective to develop optimum land-use plan.

The topic **"soil resource mapping using remote sensing techniqus"** was more of our experience in mapping soils at

different scales for land use planning. The topic became interesting because most of the time was used to question and answer session.

It has been very satisfying experience for the consultant as the participants showed a great interest to learn and share their feelings and doubts. The soil micromonoliths collected during field missions proved very handy to demonstrate the differences and similarities in different soils, their problems and potential, and discuss their classification as "seeing was believing".

According to some participants, it has acted as a catalyst to continue the soil correlation and classification work on these lines in Vietnam. Some comments of the participants attending the Workshops are given in Annex.

Consensus Arrived

- The Workshop convinced the administrators and technocrats of the advantages of using the FAO-UNESCO system for classifying and correlating their soils and to initiate preparing a new soil map in the units of FAO System. The seed sown by the study of 20 pedons, representing their typical soils, proved very effective in convincing the participants.

- The available information on soil profiles, although of value for collation, but may not be effective in correlating soils and in bringing out a soil map of Vietnam according to the units of the FAO-Legend. Many profile studies, representing different mapping units, will have to be undertaken to achieve the goal.

- For soil resource mapping, the use of remote sensing technique should be adopted as it will not only help in achieving accuracy in mapping but also in bringing out landform analysis map which will form the base for a new soil resource map of the country.

- For land use planning which is a subsequent step to soil resource mapping, some case studies at regional level based on the soils and climatic resource inventories, be undertaken for developing optimum cropping system.

8. SUMMARY AND RECOMMENDATIONS

8.1 SUMMARY

The one-month mission of the consultant was aimed to establish correlation of the Vietnamese soil classification with the FAO-Unesco classification system by making direct comparison of the available soil profile descriptions with the FAO Revised Soil Map Legend.

The preliminary review of the available data on soil morphology and analytical data at NIAPP showed that these data may not be adequate to serve the purpose. The National Project Director (NPD), Prof. Ton That Chieu with whom the Consultant was to work, desired to undertake field studies of some benchmark soils (as per the Plan of Work already prepared by him) for initiating work on this important aspect of soil classification and correlation, using the FAO-UNESCO and USDA Systems, so that his staff could also learn and benefit from the expert's experience. The FAO at Hanoi was briefed and work initiated.

Several field missions spread over 16 days both in the North and South of Vietnam were undertaken and 20 pedons were studied, of which 18 pedons have been described in the report, using FAO-Guidelines. The morphological features, diagnostic horizons and the classification of the studied pedons were discussed with the Soil Survey Staff of NIAPP. The tentative classification was later confirmed with limited analytical data undertaken on the collected soil samples. For estimating base saturation and cation exchange capacity, correlations were worked out with pH and clay content, respectively. The derived values on base saturation and exchange capacity were used to classify soils.

In addition, 20 more soil profile descriptions and their analytical data from the available reports were selected and reviewed with the help of the Chief, Soil Survey Division, NIAPP. Their morphological and analytical characteristics were translated in english and soils classified in the FAO-UNESCO Revised Legend. The classification of these soils is not satisfactory and be considered as tentative because of the inadequate or undependable data.

The twenty studied soils (actually studied and described) belong to 8 Soil Groups and 16 Soil Units as per FAO-UNESCO Legend. In the US Soil Taxonomy, these belong to 5 Soil Orders and 14 Great Groups. Some of the classified soils could not find logical places in the above systems. As such some intergrades had to be suggested and/or new subgroups proposed to accommodate these soils in these systems.

Correlating the Vietnamese soils in the FAO-UNESCO System, it became obvious that Sandy, Acid Sulphate, Gley and Alluvial (Recent) soils correlate without any difficulty with the FAO-UNESCO System/criteria. The Sandy Soils on dunes correlate with Arenosols, the Hydromorphic Soils with Gleysols and the Acid Sulphate Soils qualify for Sulfi-Thionic Gleysols. However, it is felt that Acid Sulphate Soils should be abstracted at a higher level to give precedent to sulfuric horizon/sulfuric properties. The other soil cartographic units, representating Ferrallitic, Grey soils (on terraces and developed on old alluvium) do not correlate well with the FAO-UNESCO class criteria. Such soils qualify for more than one soil group. Hence, correlation is not that easy in such soils.

The data, however, suggest that Red-Brown Ferrallitic Soils (as per Vietnamese Legend) correlate better with Ferralsols and the Red-Yellow Ferrallitic Soils with Ferric/Humic Acrisols. These observations demand further confirmation from soils in other areas. The Gley Degraded Grey Soils with a lateritic material/concretions correlate with Plinthosols and those without lateritic material and others developed on old alluvium qualify for Acrisols. These observations are highlighted in Table 14.

The study of the Vietnamese soils also suggest that these are suffering from the following degradation problems:

- Chemical depletion of soils, that is leaching of both available and reserve plant nutrients.
- Soil acidity, resulting from bleaching of soils.
- Soil erosion, resulting in loss of surface soils and formation of rills and gullies.
- Acid sulphate soils (cat clays) which on drying lead to the formation of sulphuric acid resulting in extremely low pH and death of all plant roots.
- Soil salinity - unstable depending on the provision of structures against infringement of saline water or their destruction.
- Gleying/hydromorphic nature due to high groundwater table (< 1 m)

The whole work on soil classification and correlation and the application of FAO-UNESCO system of soil classification on the Vietnamese soils was presented and discussed in two days of Workshops, attended by distinguished professors from the universities, staff of the national institutions and of the NIAPP from all over Vietnam, on the

following topics:

- Principles of soil classification systems (FAO-UNESCO and USDA).
- Application of FAO System in classifying and correlating soils of Vietnam.
- Soil and climate inventories for land evaluation towards land use planning.
- Soil resource mapping using remote sensing technique.

The Workshops generated great interest among the participants who asked many questions about the proposed classification and correlation of the Vietnamese soils. Their remarks are given in Annex . To the consultant, this has been a very satisfying experience.

Based on the field work, laboratory studies on the studied pedons and review of the profile descriptions, their classification and correlation, etc., the following recommendations may be made:

8.2 RECOMMENDATIONS

8.2.1 Adoption of FAO System for classifying Vietnamese Soils

A fairly good soil resource map of Vietnam (on 1:1 m scale) is already available. The map units show major soil groups following a qualitative approach since the soil classification system used in Vietnam is not based on measurable soil properties. It becomes difficult (if not impossible) to transform this map to any of the recognized international systems, like FAO-UNESCO, which is based on measurable and observable soil properties. The USDA System (as discussed in one of the Workshops) is comparatively more complex and may not be easy to understand and apply. Since the FAO System is better understood at international level, it is recommended that the FAO-UNESCO system be adopted for classifying soils of Vietnam.

8.2.2 Need of Soil Map for transfer of agro-technology

The Vietnamese have generated limited technology on their major soil groups for land-use planning. The adoption of FAO-System of soil classification will help to transfer technology from other parts of the world where such soils and technology exist, through the soil taxa which act as wheels for such a transfer. It is further recommended that a soil

map of Vietnam, according to the units of FAO System, is imperative for such a transfer of agro-technology.

8.2.3 Charter of Vietnamese Soils

The FAO-UNESCO map of SE Asia (on 1:1 m scale) covering Vietnam has been found to be very useful for recognising broad soil units occurring in Vietnam. But due to its scale limitations , it does not delineate all soil polygons and their characteristics for developing rational use of the country's finite soil resources. Moreover, the soils of Vietnam have been suffering from various soil degradation problems. It is therefore imperative that a comparatively large-scale map (on 1:250,000 or larger) with soil families as the mapping units should be prepared for making land use recommendations. Accordingly, it is, recommended that NIAPP prepares a SOIL MAP on 1:250,000 scale or larger, using an internationally accepted system of soil classification (FAO-UNESCO).

This can be realised by collating and correlating the existing reliable information plus additional efforts in terms of:

- Landform analysis using remote-sensing technique.
- Detailed field work in selected areas for developing land form-soil relationships and at reconnaissance scale in other areas
- Studying soils at regular interval (say at 5 km grid) for generating thematic maps.
- Studying typical soil profiles, representing major map units, for generating dependable data base.

- For optimising land use recommendations, the mapping units should be association of soil families and its phases.

In view of the available staff at NIAPP, it is recommended that FAO-UNDP may consider providing NIAPP with needed expertise. This will also imply that the NIAPP scientists receive training in latest technology in soil mapping, interact with other institutes for gaining experience and taking initiatives to improve their mapping and cartographic techniques.

8.2.4 Correlation of Vietnamese Soils with FAO-System

When correlating the soil of Vietnam with the FAO-UNESCO System, it become obvious that while some cartographic units (such as Sandy Soils, Recent Alluvial Soils, Acid sulphate Soils, etc. could be correlated without any difficulty, the other soils (such as Ferrallitic, Grey, Gley, etc.) are not easy to correlate since such soils could equally well qualify for different soil groups, such as

Acrisols, Ferralsols, Alisols, Fluvisols, Gleysols, etc, depending upon their chemical properties. This is because of the legend of Vietnamese Soil Map is based on qualitative approach, that is based largely on colour and parent material with limited weightage to measurable soil properties. This figured in one of the Workshops where the participants realised that the Vietnamese soil map, especially the units relating to Ferralitic Grey, Gley soils, need revision after understanding the concepts of Ferralsols and Acrisols before proper correlation could be attempted. Moreover, the available information on soil profile descriptions and analytical data are not adequate enough to classify and correlate soils in the FAO-System as it became evident from the additional 20 pedon's scanty descriptions and data received from the NIAPP (see Annex. 4). It is, therefore, recommended that correlation work on Vietnamese soils be largely based on freshly-described pedons, representing major soil cartographic units. This would imply continuing the present effort of studying 20 pedons by undertaking further field work to strengthen the correlation work in Vietnam, otherwise the seed sown for initiating soil classification and correlation work during this mission will die of its own death.

8.2.5 Generating Data Base

The principal soils from different mapped units be studied, described and characterised precisely as per standard norms. This effort can form the data base on benchmark soils of Vietnam for: generating agro-technology, longterm planning and monitoring the soil resources of the country, in view of the fast degradation of soils.

8.2.6 Assessing Degraded Lands and Suggesting Alternative Cropping Pattern

Vietnam has been following a very intensive cropping system with (2 to 3) crops in a year (3 paddy crops (rarely) or 2 paddy crops + 1 subsidiary crop (during winter) without giving any rest to its soils. Many of the soils studied during this mission do suggest of their degraded nature or are fast degrading, especially in respect of chemical depletion. The use of finite soil resources on sustainable basis, according to their capacity (keeping in view the country's needs), demands:

- that the soil resources of the country, especially the degraded and those which are degrading, be assessed on priority in order to know the kind, degree and the extent of such problematic soils for their amelioration.
- determining soil-site suitability of soils for alternative crops for developing rational land use by

introducing new crops in the rotation to avoid monoculture of paddy, wherever feasible.

- introduction of a green-manure crop in the rotation. This will not only provide relief to the soils but also help to improve the degrading physical condition and fertility status of the soils, apart from increasing the yield of subsequent crop(s).

8.2.7 Land Evaluation

The land evaluation towards optimising land use in a subsequent step following soil and climatic resource inventories. The scientists at NIAPP and ISF have shown great interest to develop soil-site suitability models for different crops. It becomes important as the soils are being mined for repeated rice culture, the yield are therefore stagnating (2t/ha/crop) or even declining.

It is, therefore, recommended that the work be initiated by undertaking assessment of these soils for soil-site suitability evaluation for different crops using the FAO System for land evaluation. The work can be undertaken by comparing soil-site conditions of each mapped unit with the soil site and climatic requirements of each crop. This will help to make better land use recommendations.

8.2.8 Strengthening Soil Correlation and Classification

The soil correlation and classification work in Vietnam is at the initial stages. The interaction of the consultant with the NIAPP scientists during field trips and free and frank discussions during the Workshops strongly suggest that scientists of NIAPP need strong support in the field of soil classification (internationally-accepted system) and correlation on a long-term basis. The present mission of the consultant motivated the scientist and administrators, including the high personalities in the Planning Committee, to strengthen these wings in order to keep pace with the recent developments in the world. It is, therefore, recommended time that UNDP/FAO recognises the genuine needs of Vietnam and provide needed expertise to strengthen their soil correlation and classification wings.

8.2.9 Training Young Scientists

During several field missions both in north and south of Vietnam, the consultant realised that the NIAPP's Soil Survey Staff are willing and devoted workers both at Hanoi and at Sub-NIAPP, Ho-Chi-Minh. They are very enthusiatic to learn recent developments in the field of soil resource mapping, soil classification (especially FAO and USDA systems) and soil correlation. The preparation of a new

soil map in the units of FAO Revised Legend largely depends on these workers. It is therefore recommended that soil survey staff are provided training in soil survey and mapping using remote sensing technqiue, soil correlation and classification system(s) so that they could work with confidence and prove useful to their country. This may be, possible through a SECOND PHASE of the present project.

8.2.10 Field Training in Application of FAO System

According to the NPD, Prof. Chieu, the present mission proved to be a turning point in the Vietnamese history of soil correlation and classification for accepting in principle the use of FAO System for classifying and correlating soils of the country. The University Professors, after discussion on the recent systems of soil classification, felt convinced to introduce the FAO-UNESCO (and USDA) System in their course-curriculae for teaching at the undergraduate level.

Since the systems of Soil Taxonomy and of the FAO-UNESCO are new to the Vietnamese, it is recommended that on-the-job (field) training should be provided to learn them the use of the system for better appraisal of their soil resources. This can be done either through the support of another institute having bilateral exchange or by short-term mission of an expert to provide them with the details of the soil classification system and its use in the field. The experts mission should include studying 100 benchmark soils, classifying and correlating these in the FAO-Unesco System involving the local staff. This will help to transform the existing soil map of Vietnam in the units of FAO-System.

ANNEXURES

ANNEXURE 1

Terms of Reference (TOR)

SOIL CLASSIFICATION (SOIL CORRELATION) CONSULTANT

VIE 86/024 PROJECT

AGRICULTURAL PLANNING AND PROJECTIONS

Duration: One Month Duty Station: Hanoi

Under the supervision of - and in close collaboration with the Lead Consultant and the National Project Director, the Consultant will:

1. Have to establish correlation of the Vietnamese soil classification with FAO classification as given in the FAO/UNESCO Soil Maps of the World Revised Legend. This should be undertaken by first writing in English the soil profile descriptions and soil properties of each of the Vietnamese soil groups and classes, and then by making a direct comparison with the descriptions in the Revised Legend of the FAO Soil Groups and Units.

2. Upon completion of the assignment, prepare and submit to the CPO in Rome, a detailed report in English in five copies, giving findings and recommendations for future implementation, as per the attached Annex.

ANNEXURE 2

Detailed itinerary of Consultant (Dr. J. Sehgal)

DATE	STATIION (TIME-HRS.) FROM	TO	REMARKS
Oct. 30, 1989 (MON)	Nagpur 7.55 hr	Delhi 10.50 hr	Travel to Delhi as no flight available on 31.10 night stay Delhi Visited FAO Office for briefing
Oct. 31 (TUE)	Delhi 19.05 hr	Bangkok 00.10	Night stay Bangkok
Nov. 1, 1989 (WED)	Bangkok 11.00	HANOI 12.50	
Nov. 2, (THU)	At HANOI		Briefing meetings and general exchange with NIAPP staff (Dir. & Proj. Director) with FAO and UNDP staff (Mr. A.D. SPIJKERS), etc.
	Field Trip-1		
Nov.3 (FRI)	HANOI-VINH PHU Province		Study of Pedons 1-3
Nov. 4 (SAT)	At HANOI. Visited Agricultural University No.1 to review work done and see soil monoliths, Meeting with the UNDP-Deputy Rep. (Mr. Winston TEMPLE)		
Nov. 5 (SUN)	..... FREE		
	Field Trip-2		
Nov. 6 (MON)	HANOI-SOC SON Distt		Study of Pedons 4, 5
	Field Trip-3		
Nov. 7 (TUE)	HANOI-CAM DONG - CAM BINH Distt (HAI HUNG PROVINCE)		Study of Pedons 6, 7*

* Studied auger holes because of stagnating water

Nov. 8 to 9	AT HANOI ● Discussions at NIAPP about the classification of Soil Profiles (1-7) studied during the three field trips. ● Introductory Lecture on Soil Classification System of FAO-UNESCO and Soil Taxonomy to soil survey staff of NIAPP (at their request).
	Field Trip-4
Nov. 10 (FRI)	HANOI - Suberb — Study of Pedon 8 TRAVEL TO SUB INSTITUTE NIAPP at HO-CHI-MINH
Nov. 11 (SAT)	HANOI - HO-CHI-MINH (6.30) ● Meeting with the NIAPP Sub Institute Staff ● Discussion on Programme developed by the Director, Sub Institute NIAPP
Nov. 12 (SUN)	**Field Trip-5:** HO-CHI-MINH — Study of Pedons 11-12* LONG HAI Area, DUNG HAI Province
Nov. 13 (MON)	**Field Trip-6:** — Study of Acid-Sulphate Soils; Pedons 13-14* HO-CHI-MINH LE MINH XUAN State Farm
Nov. 14 (TUE)	**Field Trip-7:** HO-CHI-MINH — Study of Pedons 15, 16 TAN PHU district area (DONG NAI Province)
Nov. 15 (WED)	Lectures to Soil Survey Staff at HO-CHI-MINH on principles of: ● Soil Classification System (Soil Taxonomy) ● FAO-UNESCO Soil Mapping Legend Preparation for discussion on soils of southern Vietnam
Nov. 16 (THU)	● Discussion on classification of studied soil profiles ● **Field Trip-8:** HO-CHI-MINH — Study of pedon 17 DONG NAI Province
Nov. 17 (FRI)	**Field Trip-9:** HO-CHI-MINH — Study of pedons 18, 19, 20 TIEN GIANG Province ● Lecture on Application of Soil Survey for Land Use Planning (19-21 hr.)

Nov. 18 (SAT)	• Discussion on classification of studied soils Return to HO-CHI-MINH - HANOI (Afternoon)
Nov. 19 (SUN)	.... FREE ....
Nov. 20 (MON)	At HANOI. • Checking profile descriptions of studied soils. • Writing work
Nov. 21 (TUE)	• Review of studied pedons for their classification • Meeting with the FAO Programme Officer at NIAPP
Nov. 22 (WED)	• Review of soil classification of 20 pedons with Prof. Chieu. • Writing of profile descriptions • Meeting with Vice Director, NIAPP, and • Indian Embasssador along with the NIAPP Director and NPD (VIE/86/024)
Nov. 23 (THU)	Discussions with NIAPP staff regards WHY and HOW of proposed soil classification of 20 studied pedons
Nov. 24 (FRI)	Desk work for the planned workshop and rewriting of profile descriptions
Nov. 25 (SAT)	• Visit to Institute of Soil and Fertilizer (ISF). • Brief discussions with Prof. Chieu, NPD regarding the workshop topics, timings and contents
Nov. 26 (SUN)	Preparing seminars and writing the transparent sheet for projections
Nov. 27 to Nov 28, (MON & TUE)	Workshops on different topics as suggested by the NPD
Nov. 29 (WED)	Desk work for soil correlation and classification for additional 20 pedons
Nov. 30 (THU)	Desk work for writing of report
Dec. 1, 1989 (FRI)	Desk work for writing of report Working out relationship of pH Vs BS and Clay Vs CEC
Dec. 2 (SAT)	Desk work for writing of report

Dec. 3 (SUN)	.... FREE .... Looked into typed profile descriptions.	
Dec. 4 (MON)	• Morning: meeting with Dr. Gallagher of FAO, Rome • Afternoon: Continued writing and typing of report • Evening: Discussions with Dr. Gallagher	
Dec. 5 (TUE)	Discussions on report with NPD	
Dec. 6 (WED)	Dep. Hanoi for Bangkok and Delhi	
Dec. 7 (THU)	Delhi - Bombay	Since there was no direct flight available for Nagpur because of Indian Airlines rescheduling of flights and some agitation by the staff of IA.
Dec. 8,1989	Bombay - Nagpur	

Morphological description of studied soils pedons

PEDON 1 (VIE/86/024)

I. INFORMATION ON THE SITE Date of Exam: Nov. 3, 1989

1. Soil name - High catergoric classification:

Vietnamese: Red & Yellow Ferralitic soils on Gneiss

FAO : Ferric Acrisols

USDA : Paleustults

2. Author(s): J. Sehgal (accompanied by Prof. Chieu, Mrs Binh and Mr. Khang)

3. Location: 21°15'N, 105°15'E. 100 km North of Hanoi, Vinh Phu province

4. Elevation: ±20 m above MSL

5. Land-form:

i) Physiographic position: Sloping land
ii) Surrounding land form : Undulating (to rolling)

6. Slope on which pedon is sited: Gently sloping (2-6%)

7. Land-use: Cassava cultivated with poor yield. Other crops grown are: Paddy (2 crops/year) with yield of 6 tonnes/ha (for 2 crops) and maize, sweet potatoes, soyabeans (on broad beds with furrows).

8. Climate: Station PHU THO (Vinh Phu province)

Annual rainfall (AR)	MAT	MST	MWT
1862 mm	26.3°C	30.0°C	15.0°C

II. GENERAL INFORMATION ON THE SOIL:

1. Parent material: Gneiss

2. Drainage: Well drained

3. Moisture conditions in pedon: Dry in the upper 50 cm

4. Depth of ground-water table: Deep, not observed

5. Evidence of erosion: Slight/moderate

III. **BRIEF DESCRIPTION OF THE PEDON:** Very deep, red soils with a concretionary layer of Fe-Al-oxides developed on gneisses which is observed as saprolite at ±2 m depth. The soils have low water holding capacity (except for the surface soils having medium water holding capacity). They show excessive leaching of silica and concentration of R_2O_3 in nodular form. The dominant clay minerals in the area are kaolinite and goethite (as per local staff).

IV. **PEDON DESCRIPTION:** (P-1)

A (0-20 cm) Strong brown (7.5 YR 4/6 D) clay loam; strongly developed angular blocky; dry hard, moist friable; many fine and medium pores; occasional termite activity; common fine roots; clear smooth boundary.

Bs1 (20-50 cm) Strong brown (7.5 YR 5/8 D) clay; moderate medium angular blocky; few small nodules; dry hard, moist friable, wet slightly sticky and plastic; clear smooth boundary.

Bcs1 (50-95 cm) Strong brown (7.5 YR 5/8 M) slightly gravelly clay, (+45% clay); moderately developed, medium angular blocky; common (+15%) small and large, indurated, irregular, black nodules; dry hard, moist friable, wet slightly sticky and plastic; clear smooth boundary.

Bcs2 (95-140 cm) Strong brown (7.5 YR 5/8 D) gravelly clay; moderately developed, fine medium angular blocky; frequent (±40%) small and large indurated, irregular, black nodules; dry hard, moist friable, wet slightly sticky and plastic; clear smooth boundary.

Bcs3 (140-165 cm) Yellowish red (5 YR 5/7 D&M) slightly gravelly clay; moderate fine and medium angular blocky; few (10%), small indurated, irregular, black nodules; dry hard, moist friable; wet slightly sticky and plastic; gradual smooth boundary.

Bcs4 (165-180 cm) Yellowish red (5 YR 5/7 D&M) slightly gravelly silty clay loam; few (5%) small, hard, irregular, black nodules; dry hard, moist friable; clear smooth boundary.

C1 (180-230 cm) Silty material from th weathered rock (gneiss)

C2 (230 cm+) Silty saprollitic material from the weathered gneiss.

PEDON 2 (VIE/86/024)

I. INFORMATION ON THE SITE Date of Exam: Nov. 3, 1989

1. Soil name - High catergoric classification:

   Vietanamese: Red & Yellow Ferralitic soils on gneiss

   FAO : Ferric Acrisols

   USDA : Paleustults

2. Author(s): J. Sehgal accompanied by Prof. Chieu and Mrs. Binh.

3. Location: $21^{o}26'N$; $105^{o}15'E$. Industrial plantation (Tea) research Inst. 120 km North of Hanoi (in Vinh Phu province)

4. Elevation: 20 m above MSL

5. Land-form:

   i) Physiographic position: Terrace
   ii) Surrounding land form : Undulating

6. Slope on which pedon is sited: Gently sloping (2-6%)

7. Land-use: Tea plantation, showing very good growth of tea.

8. Climate: Station : PHU THO

Annual rainfall (AR)	MAT	MST	MWT
1862 mm	$26.3^{o}C$	$30.0^{o}C$	$15.0^{o}C$

II. GENERAL INFORMATION ON THE SOIL:

1. Parent material: Mica schist and gneiss

2. Drainage: Well drained

3. Moisture conditions in pedon : Partly moist below 53 cm.

4. Depth of ground-water table: N.O.

5. Evidence of erosion: Slight

III. BRIEF DESCRIPTION OF THE PEDON: Very deep, yellowish red coloured soils with enrichment of clay (Bt) in the sub-surface horizons and of iron-oxihydrates in the B3 horizon below 1m of the surface. The soils have developed on gneisses which is deeper than 2m (and could not be observed).

IV. **PEDON DESCRIPTION:** (P-2)

Ap (0-15 cm) Strong brown (7.5 YR 4/6 D) and brown (7.5 YR 4/4 M) clay loam; moderate, medium subangular blocky, breaks partly to crumb; dry slightly hard, moist friable; many fine and medium pores; many fine and medium roots; clear smooth boundary.

B1 (15-53 cm) Yellowish red (5 YR 4/5 D); yellowish brown (5 YR 4/4 M); silty clay loam; moderate, medium subangular blocky; dry hard, moist friable; common fine and medium tubular and interstitial pores; common fine roots; gradual smooth boundary.

Bt1 (53-90 cm) Yellowish red (5 YR 5/6 M); silty clay loam; moderate, fine and medium subangular blocky (breaks partly to crumb); dry hard, moist friable; common fine and medium pores, few fine roots; gradual smooth boundary.

Bt2 (90-120 cm) Yellowish red (5 YR 5/6 M); silty clay (±40-50% silty); moderate, medium angular blocky; moist friable, dry hard; common fine and medium tubular and interestitial pores; few fine roots; gradual smooth boundary.

Bcs1 (120-175 cm) Yellowish red (5 YR 5/8 M); slightly gravelly, silty clay; moderate, fine angular and medium subangular blocky; dry hard, moist gritty and friable; few (10-15%), small hard, irregular and angular nodules; common, fine (and medium) tubular and vesicular pores; few very fine roots; gradual smooth boundary.

Bcs2 (175-200+ cm) Yellowish red (5 YR 4.5/6); silty clay; moderate medium and coarse angular blocky; dry hard, moist friable; few (5-10%) small, hard, angular nodules; common fine pores.

PEDON 3 (VIE/86/024)

I. **INFORMATION ON THE SITE** **Date of Exam:** Nov. 3, 1989

1. **Soil name - High catergoric classification:**

   Vietnamese: Red Ferralitic soils on mica schist

   FAO : Rhodic Acrisols

   USDA : Paleustults

2. **Author(s):** J. Sehgal (accompanied by Prof. Chieu and Mrs. Binh)

3. **Location:** 21°27'N; 105°15'E. Industrial Plantation Research Institute, 20 km North of Hanoi (Vinh Phu province); 100 m away from Pedon 2.

4. **Elevation:**

5. **Land-form:**

   i) **Physiographic position:** Terrace
   ii) **Surrounding land form :** Undulating

6. **Slope on which pedon is sited:** ±5%

7. **Land-use:** Tea plantation (dominant)
   Litchi plantations growing well

8. **Climate:** Station PHU THO

Annual rainfall (AR)	MAT	MST	MWT
1862 mm	26.3°C	30.0°C	15.0°C

II. **GENERAL INFORMATION ON THE SOIL:**

1. **Parent material:** Mica schist (and gneiss)

2. **Drainage:** Well drained

3. **Moisture conditions in pedon:** Moist throughout

4. **Depth of ground-water table:** N.O.

5. **Evidence of erosion:** Slight

III. **BRIEF DESCRIPTION OF THE PEDON:** Deep, red coloured soil with a B-horizon showing common illuviated clay cutans. The soil show prismatic structure which breaks to angular blocky.

IV. PEDON DESCRIPTION: (P-3)

Ap (0-15 cm) Yellowish red (5 YR 4/6 M) with common coatings of reddish brown (5 yR 4/3 M); silty clay; weak, fine subangular blocky, breaks to crumb; wet slightly sticky and plastic; many fine and medium tubular and interstitial pores; many fine and medium roots; clear smooth boundary.

Bt1 (15-50 cm) Red (2.5 YR 4/7 M) with common organic and ferriargillan coatings of reddish brown (10 YR 4/3); clay, prismatic in place breaks to angular blocky; many fine and medium pores; many, fine and medium roots; gradual smooth lower boundary.

Bt2 (50-90 cm) Red (2.5 YR 5/6 M); silty clay/clay; prismatic in place, breaks to angular blocky; moist firm; common fine tubular and interstitial pores; common fine roots; NB horizon sampled for CEC and B.S. Horizon determinations; clear smooth boundary.

Bt3 (90+ cm) Red (2.5 YR 4/7 M); clay; weak, fine and medium subangular blocky, breaks partly to crumbs; moist firm.

PEDON 4 (VIE/86/024)

I. INFORMATION ON THE SITE Date of Exam: Nov. 6, 1989

1. **Soil name - High catergoric classification:**

   Vietnamese: Grey degraded gley soils on old alluvium

   FAO : Ferric-Gleyic Acrisols

   USDA : Aeric Kanhaplaquults

2. **Author(s):** J. Sehgal (accompanied by Prof. Chieu and Mrs. Binh)

3. **Location:** 21°16'N; 105°50'E; 50-60 km North of Hanoi in Hanoi province

4. **Elevation:** 12 - 15 m above MSL

5. **Land-form:**

   i) **Physiographic position:** Plain (Midland)
   ii) **Surrounding land form :** Almost flat

6. **Slope on which pedon is sited:** Flat (or almost flat)

7. **Land-use:** Paddy/harvested (intensively cultivated with 2 paddy crops per year)

8. **Climate:**

Station	Annual rainfall (AR)	MAT	MST	MWT
Hanoi	1664 mm	23.5°C	28.7°C	17.1°C
Bac Giang	1476 mm	23.3°C	28.5°C	17.0°C

II. GENERAL INFORMATION ON THE SOIL:

1. **Parent material:** Alluvium

2. **Drainage:** Poor

3. **Moisture conditions in pedon:** Moist, but wet below 30 cm

4. **Depth of ground-water table:** ± 1 m

5. **Evidence of erosion:**

III. **BRIEF DESCRIPTION OF THE PEDON:** Deep, alluvium-derived, brownish grey mottle with red, poorly drained soils with ground water table around 1 m depth. Strong oxidation reduction process throughout especially below 30 cm depth with brownish grey matrix and reddish mottles. The soils have massive surface (15 cm) with a thin (5 cm) compact subsurface soil and clay enriched Bt horizon below 20 cm and almost uniformly gleyed below 30 cm depth. Most of the roots are confined to surface horizon.

IV. **PEDON DESCRIPTION:** (P-4)

Ap (0-15 cm) Greyish brown (10 YR 5/2 M; 6/2 D) with common, fine distinct sharp root rust mottles; loam; massive (in place) breaks to blocky; moist friable, dry hard; many very fine, tubular pores; many fine and very fine roots; clear smooth boundary.

A3 (15-20 cm) Grey brown (2.5 Y 5/2 M; 6/2 D) with common, fine distinct, sharp strong brown (7.5 YR 5/6) mottles; silt loam; compact and massive, breaks to subangular blocky; moist firm, dry hard; a few fine roots; clear smooth boundary.

IIBt1 (20-29 cm) Dark brown (7.5 YR 4/4 M) with common fine, distinct, clear yellowish red (5 YR 4/6) mottles; silty clay; moderately developed, medium and coarse prismatic; wet slightly sticky and plastic; common patchy, thin cutans on ped faces; a few fine roots; diffuse smooth boundary.

IIB21g (29-52 cm) Greyish brown (10 YR 5/2 M) mottled with many medium, coarse, distinct/prominent, sharp contrasting red (2.5 YR 4/6) mottles; silty clay; massive in place, breaks to blocky peds; wet slightly sticky and plastic; few fine roots; diffuse smooth boundary.

IIB22g (52-78 cm) Light brownish grey (10 R 6/2 M) with many, medium, coarse prominent, sharp, red (2.5 YR 4/6) mottles; silty clay; massive in place (breaks to blocky); wet slightly sticky and plastic; few fine roots; diffuse smooth boundary.

IIB3g (78-102 cm) Light brownish grey (10 YR 6/2 M) with many fine and medium, coarse, priminent, sharp contrasting dark red (2.5 YR 3/6) mottles; silty clay; massive; wet slightly sticky and plastic; no roots.

PEDON 5 (VIE/86/024)

I. INFORMATION ON THE SITE Date of Exam: Nov. 6, 1989

1. **Soil name - High catergoric classification:**

   Vietnamese: Grey degraded gley soils on old alluvium

   FAO : Gleyi-Dystric Fluvisols

   USDA : Thapto Acraquoxic Psammentic Ustifluvents

2. **Author(s):** J. Sehgal (accompanied by Prof. Chieu and Mrs. Binh)

3. **Location:** 21°18'N; 105°50'E; Village Phu Linh, district Soc Son; province Hanoi

4. **Elevation:** 15 m above MSL

5. **Land-form:**

   i) **Physiographic position:** Almost flat plain
   ii) **Surrounding land form :** Undulating to rolling due to hills around

6. **Slope on which pedon is sited:** Almost flat

7. **Land-use:** Fallow (paddy harvested); sweet potato, cassava are other crops grown.

8. **Climate:**

Annual rainfall (AR)	MAT	MST	MWT
1476 mm	23.3°C	28.5°C	17.0°C

II. GENERAL INFORMATION ON THE SOIL:

1. **Parent material:** (Younger colluvial material) over old alluvium

2. **Drainage:** Imperfect

3. **Moisture conditicns in pedon:** Moist, but wet below 50 cm

4. **Depth of ground-water table:** 100 cm

5. **Evidence of erosion**

III. **BRIEF DESCRIPTION OF THE PEDON:** Deep, alluvium-derived coarse textured greyish and pale brown soils (upto 50 cm) underlain by fine-textured mottled over Kaolin material. They are imperfectly drained and have ground water table at 1m depth. These bisequum soils show strong oxidation reduction process below 50 cm with contrasting colours of dark grey, dark yellowish brown and white. These are underlain by a Kaolin layer below 78 cm of the surface. They are poor in nutrient and water-holding capacity. The roots are generally confined to the surface.

IV. **PEDON DESCRIPTION** (P-5)

Ap (0-12 cm) Greyish brown (10 YR 5/2 M, crushed) with common fine, distinct, clear root-rust mottles of dark yellowish brown (10 YR 3/4); coarse sandy loam; massive in place, breaks to weak subangular blocky; moist very friable; many, fine, and medium roots; clear smooth boundary.

A3 (12-28 cm) Grey (10 YR 5/1.5 M); loamy coarse sand; massive; dry/moist loose; few roots; clear smooth boundary.

C (28-50 cm) Pale brown (10 YR 6.5/3 M) with common, fine distinct reddish mottles in the lower 5 cm soil mass; very gravelly coarse sand; structureless; loose; rare roots; clear smooth boundary.

II Bgb (50-78 cm) Mottled horizon with three-colours (dark grey - 10 YR 4/1; Dark yellow brown - 10 YR 4/6 and white - 10 YR 8/1); strongly oxidised and reduced horizon with common Kaolin material; silty clay loam; massive in place; wet very slightly sticky and plastic; negligible roots; clear smooth boundary.

II B3gb (78-100 cm) Very light grey (7.5 YR 7.5/0 M); wet soil material dominated by Kaolin; silty clay loam; massive; wet non-sticky and non-plastic.

PEDON 6 (VIE/86/024)

I. INFORMATION ON THE SITE Date of Exam: Nov. 7, 1989

1. Soil name - High catergoric classification:

   Vietnamese: Gley Alluvial Soils on recent alluvium (of Thaibinh river)

   FAO : Fluvi-Dystric Gleysols

   USDA : Dystric Haplaquepts

2. Author(s): J. Sehgal (accompanied by Mrs. Binh)

3. Location: 20°55'N; 106°28'E. CAMDONG village, CAMBINH district, HAI HUNG province; 50 km east of HANOI

4. Elevation: 3 m above MSL

5. Land-form:

   i) Physiographic position: Alluvial plain (mid upland)
   ii) Surrounding land form : Almost flat

6. Slope on which pedon is sited: < 1%

7. Land-use: Paddy harvested; generally two crops of paddy and one subsidiary crop of sweet potato, maize or groundnut are grown.

8. Climate:

Station	Annual rainfall (AR)	MAT	MST	MWT
HAI HUNG	1611 mm	23.4°C		

II. GENERAL INFORMATION ON THE SOIL:

1. Parent material: Alluvium (recent)

2. Drainage: Poor

3. Moisture conditions in pedon:

4. Depth of ground-water table: 80 cm

5. Evidence of erosion:

III. BRIEF DESCRIPTION OF THE PEDON: A very deep, hydromorphic soil developed on recent alluvium having ground water table within 1 m of the surface for most of the year. The soils are brown at the surface and mottled below.

IV. PEDON DESCRIPTION (P-6)

Ap (0-12 cm) Light yellowish brown (10 YR 6/4 D), brown (10 YR 5/3 M) with common, yellowish red (5 YR 5/7) root rust mottles; silty clay loam (+); massive; dry hard, wet slightly sticky and plastic; common fine pores; common fine roots; abrupt smooth boundary.

Bg1 (12-23 cm) Brown (10 YR 5/3 M) upper and greyish brown (2.5 Y 5/2 M); lower part with many distinct sharp, reddish brown (5 YR 4/4) oxidation mottles; silty clay loam (+); moderate, coarse prismatic; moist firm, wet slightly sticky and plastic; a few very fine and fine pores; few very fine roots; clear smooth boundary.

Bg2 (23-50 cm) Light yellowish brown (10 YR 6/4 M, crushed) mottled with grey (2.5 Y 6/1 M) and reddish yellow (7.5 YR 6/6 M) materials; silty-clay loam; massive in place, breaks to weak, coarse prismatic (sedimentary); wet slightly sticky and plastic; gradual smooth boundary.

Bg3 (50-85 cm) Strong brown (7.5 YR 5/6 M) mottled with light brownish grey (2.5 Y 6/2) in 50:50 ratio; silty clay loam; massive (in place), breaks to weak, fine subangular blocky; wet slightly sticky and plastic; ground water at $\pm$ 80 cm.

Cr (85-155 cm) Grey (2.5 Y 6/1 M) and light brownish grey (2.5 Y 6.5/2 D) with common, medium distinct mottles of strong brown (7.5 YR 5/6); silty clay loam; massive material (drawn by auger).

PEDON 7 (VIE/86/024)

I. INFORMATION ON THE SITE Date of Exam: Nov. 7, 1989

1. Soil name - High catergoric classification:

Vietnamese: Hydromorphic Gley Soils on recent alluvium

FAO : Stagni - Dystric Gleysols

USDA : Stagnic Fluvaquents/Fluvaquepts

2. Author(s): J. Sehgal (accompanied by Mrs. Binh)

3. Location: 20°52'N; 106°28'E; Cam Dong village, Cam Binh district Hai Hung province, 50 km East of Hanoi

4. Elevation: 3 m above MSL

5. Land-form:

i) Physiographic position: Depression plain
ii) Surrounding land form : Almost level plain

6. Slope on which pedon is sited: < 1%

7. Land-use: Fallow at present; but one crop of rice/year is cultivated after removing water which is used for irrigation for other standing crops during Oct. Nov. (dry period).

8. Climate:

Station	Annual rainfall(AR)	MAT	MST	MWT
HAI HUNG	1611 mm	-23.4°C		

II. GENERAL INFORMATION ON THE SOIL:

1. Parent material: Alluvium

2. Drainage: Very poor

3. Moisture conditions in pedon: Wet throughout with water stagnating at the surface

4. Depth of ground-water table:

5. Evidence of erosion:

III. BRIEF DESCRIPTION OF THE PEDON:

IV. AUGER-HOLE DESCRIPTION: (P-7)

Apg (0-22 cm) Gray (10 YR 5/1 - wet); silty clay (with few shinning mica); massive; negligible roots; gradual boundary.

Ag (22-45 cm) Olive grey (5 Y 4/2 - wet) with common, fine, distinct dark brown (10 YR 4/4) mottles; (micaceous) silty clay; massive; no roots, gradual boundary.

Cr1 (45-60 cm) Very dark grey (10 YR 3/1.5 - wet); (micaceous) silty clay; massive; clear boundary.

Cr2 (60-90 cm) Very dark greyish brown (10 YR 3/2 - wet); loam (+); massive; clear boundary.

Cr3 (90+ cm) Dark greyish brown (10 YR 4/2 - wet); stratified sandy loam; massive

PEDON 8 (VIE/86/024)

I. INFORMATION ON THE SITE Date of Exam: Nov. 10, 1989

1. Soil name - High catergoric classification:

   Vietnamese: Recent Alluvial Gley soils

   FAO : Gleyi-Eutric Fluvisols

   USDA : Aquertic Ustifluvents

2. Author(s): J. Sehgal (accompanied byProf. Chieu, Mrs. Binh and Mr. Khang).

3. Location: 21°04'N; 105°56'E; 12 km from Hanoi, and 4 km from Red river in village KOBL, Gia Lam district, Hanoi province

4. Elevation: 5 m above MSL

5. Land-form:

   i) Physiographic position: Alluvial plain (recent)
   ii) Surrounding land form : Flat or almost level Plain

6. Slope on which pedon is sited: < 1%

7. Land-use: Paddy (two crops per year)

8. Climate:

Annual rainfall	MAT	MST	MWT
1664 mm	23.5°C	28.7°C	17.1°C

II. GENERAL INFORMATION ON THE SOIL:

1. Parent material: Recent alluvium

2. Drainage: Imperfect (poor)

3. Moisture conditions in profile: Moist throughout; wet below 82 cm

4. Depth of ground-water table: ± 1.5 m

5. Evidence of erosion: Nil-slight

III. BRIEF DESCRIPTION OF THE PEDON: Very deep, dark brown, fine stratified soils, mottled with strong brown and grey material. They have typical sedimentary structure (prismatic-breaking to angular blocky) showing poor horizonation, except the surface ochric epipedon. The soils show gleying characteristics below 50 cm and strong reduction below 82 cm depth. They are successfully used for 2 paddy crops a year. The pedon shows flood coatings on ped faces in the subsurface horizon and superficial flood cracks of 1.5 cm width and 5-10 cm deep at the surface.

IV. PEDON DESCRIPTION: (P-8)

Ap (0-12 cm) Dark brown (7.5 YR 3/5 M); silty clay loam (+); weak, fine and medium subangular blocky; moist firm, wet slightly sticky and plastic; common silt (flood) coatings on some ped faces and root channels; many fine and medium tubular pores; many fine and medium roots; clear smooth boundary.

A3 (12-25/28 cm) Brown/dark brown (7.5 YR 4/2 M); a few root rust mottles; few, fine and medium, distinct clear mottles of strong brown (7.5 YR 5/6); silty clay; sedimentary blocky structure; moist very firm, wet sticky and plastic; common flood coatings on ped faces; common fine roots; occasional sand pockets; clear wavy boundary.

C1 (25/28-43 cm) Brown/dark brown (7.5 YR 4/2 M); a few root rust mottles; silty clay; sedimentary prismatic like structure, breaks to coarse angular blocky; moist very firm, wet sticky and plastic; frequent flood coatings of 10YR 4/3; common, fine tubular pores; few fine roots; clear smooth boundary.

C2 (43-63 cm) Brown/dark brown (7.5 YR 4/2 M); with many coarse distinct, clear yellowish brown (10 YR 5/4), and few fine distinct sharp, strong brown (7.5 YR 5/6) and dark brown (7.5 YR 3/2) oxidation-reduction mottles; moist very firm, wet sticky and plastic; common fine and very fine tubular and vesicular intra and inped pores; few very fine roots; gradual smooth boundary.

Cg (63-82 cm) Brown/dark brown (7.5 YR 4/2 M); with many fine and medium, distinct, clear mottles of grey (10 YR 6/1) and light yellowish brown (10 YR 6/4); silty clay; weakly-developed, medium and coarse, sedimentary prismatic structure; common clayey (flood) coatings on ped faces; moist very firm, wet sticky and plastic; common fine and very fine tubular pores; few, micro, intraped roots; clear smooth boundary.

Cr (82-115 cm) Grey (2.5 Y 6/1 M) dominant matrix colour with many medium-coarse, distinct, clear oxidation mottles of yellowish brown (10 YR 5/6) and reddish brown (10 YR 4/3); clay (fine); massive,breaks to angular blocky (sedimentary); moist very firm; wet sticky and plastic; common, micro and very fine vesicular pores; no roots.

Note: a gleyed horizon

PEDON 11 (VIE/86/024)

I. INFORMATION ON THE SITE

Date of Exam: Nov. 12, 1989

1. Soil name - High catergoric classification:

   Vietnamese: Sandy Soils on Dunes

   FAO : Haplic Arenosols

   USDA : Fluventic Tropopsamments

2. Author(s): J. Sehgal (accompanied by Prof. Chieu and pedologists of sub-NIAPP.

3. Location: 10°20'N latitude; 107°12'E longitude; 120 km East of Ho Chi Minh city on the Sea Coast

4. Elevation: 2- 3 m above MSL

5. Land-form:

   i) Physiographic position: Coastal plain
   ii) Surrounding land form : Rolling to hilly

6. Slope on which pedon is sited: Almost flat (0 - 2%)

7. Land-use: Natural grasses (Eupatoria); planted; Cocoa, casuarina; palm

8. Climate: Typic tropical

Annual rainfall (AR)	MAT	MST	MWT
1352 mm	26.3°C	MST and MWT differ by < 5°C	

II. GENERAL INFORMATION ON THE SOIL:

1. Parent material: Coastal sand

2. Drainage: Excessively drained

3. Moisture conditions in pedon: Dry up to 1.30 cm; moist below 130 cm.

4. Depth of ground-water table: N.O.

5. Evidence of erosion: Slight

III. **BRIEF DESCRIPTION OF THE PEDON:** Very deep, coarse sandy soil (with wary lamellae of dark coloured organic matter of <1 cm at 5-30 cm interval) below 75 cm of the surface. The soils have developed on coastal sand under tropical environments. The soils show ochric epipedon underlain by a burried A1 horizon (darker in colour) with a C horizon below. The soils show no diagnostic horizon except a darker coloured ochric epipedon.

IV. **PEDON DESCRIPTION:** (P-11)

A1 (0-22 cm) Light brownish grey (10 YR 6/2 D), coarse sand; very weak; fine subangular blocky, breaks mostly to single grains; dry slightly hard, moist very friable, wet non-sticky and non-plastic throughout with depth; common fine roots; clear smooth boundary.

A1b (22-45 cm) Greyish brown (10 YR 5/2 D), dark greyish brown (10 YR 4/2 M); coarse sand; masisve in place, breaks largely to single grains; dry slightly hard; moist very friable; highly porous; common organic coatings on skeletal grains; common fine to very fine and few coarse roots; clear smooth boundary.

C1 (45-75 cm) Pale brown (10 YR 6/3 D) brown(10 YR 5/3 M); coarse sand; massive (in place), breaks dominantly to single grains and a part to very weak, fine subangular blocky; dry loose, moist very friable; highly porous; few fine and very fine roots; gradual smooth boundary.

C2 (75-105 cm) Pale brown (10 YR 6/4.5 D) to light yellowish brown (10 YR 5/4 M); few fine (<1 m deep) darker coloured (10 YR 4/2 d; 3/2 m) lamellae (wavy) at 7-20 cm depth interval, the distance of their occurrence decreases (from 20 to 7 cm) as ones moves with depth to C3 and C4 horizons; coarse sand; massive (in places), breaks to single grains and very weak, fine subangular blocky; dry loose; a few fine and occasional coarse roots; gradual smooth boundary.

C3 (105-130 cm) (light) yellowish brown (10 YR 5.5/4 D), yellowish brown (10 YR 5/4 M); sand; massive (in place) breaks to single grains; dry and moist loose; few fine and rare coarse roots;gradual smooth lower boundary.

C4 (130-180 cm) Light yellowish brown (10 YR 6/4 M); sand; single grain; moist loose; common fine and medium roots.

PEDON 12 (VIE/86/024)

I. INFORMATION ON THE SITE Date of Exam: Nov. 12, 1989

1. Soil name - High catergoric classification:

Vietnamese: Periodic Solonchaks (influenced by underground-water)

FAO : Stagni-Eutric Gleysols (with salic phase)

USDA : Aeric Tropaquepts (with saline phase)

2. Author(s): J. Sehgal (accompanied by Prof. Chieu and soil survey staff of Sub-NIAPP)

3. Location: $10^{o}22'N$; $107^{o}18'E$; 20 km away from the sea; village LONGDIEU Ho Chi Minh province

4. Elevation: $\pm$ 1 m above MSL

5. Land-form:

i) Physiographic position: Alluvial plain
ii) Surrounding land form : Almost flat land

6. Slope on which pedon is sited: <1%

7. Land-use: Paddy harvested; generally used for 1 crop of paddy Apr./May to Oct./Nov. (yield 2.5 tonnes/ha).

8. Climate: Typical tropical environemnts

Annual rainfall (AR)	MAT	MST	MWT
1352 mm	$26.3^{o}C$	MST and MWT differ by $<5^{o}C$.	

II. GENERAL INFORMATION ON THE SOIL:

1. Parent material: Recent alluvium

2. Drainage: Poor (the fields remain submerged due to rain water from June to November

3. Moisture conditions in pedon: Wet throughout the pedon

4. Depth of ground-water table: 1 - 2 m

5. Evidence of erosion:

III. **BRIEF DESCRIPTION OF THE PEDON:** A very deep, sandy clay loam, hydromorphic soil (about 20 km from sea) where ingris of sea water brings in soil salinity. The present status of salts is < 4 mmhos/cm; but from January to March the area experiences salinity problem.

IV. **PEDON DESCRIPTION:** (P-12)

Ap (0-15 cm) Dark grey (10 YR 4/1 M); sandy clay loam (+); massive wet slightly sticky; many pores; profuse fine roots; clear smooth boundary.

A3g (15-40 cm) Gleyish brown (10 YR 4/2 M) with many, fine and medium sharp, root-rust and other mottles of strong brown (7.5 YR 5/6); sandy clay loam; massive; dry hard, moist firm; wet slightly sticky; many fine and medium pores; few fine roots.

(B)g (40-70 cm) Light brownish grey (2.5 Y 6/2 M) with common, fine, distinct mottles of yellowish brown (10 YR 5/8); sandy clay; moist firm, wet sticky and plastic; few fine roots; clear smooth boundary.

csg (70-110 cm) Greyish brown (2.5 Y 5/2 M) with many, medium, prominent, sharp red (2.5 YR 4/6,) mottles; clay; moist firm; wet sticky and plastic; frequent (± 15%) small, hard irregular Fe-Mn concretions (broken colour; dark red - 2.5 YR 3/6).

PEDON 13 (VIE/86/024)

I. INFORMATION ON THE SITE Date of Exam: Nov. 13, 1989

1. Soil name - High catergoric classification:

Vietnamese: Acid Sulphate Soils on recent alluvium

FAO : Sulfi-Thionic Gleysols (Sulfi-Gleyic Thionosol - proposed)

USDA : Sulfic Tropoquepts

2. Author(s): J. Sehgal (accompanied by Prof. Chieu, Mr. Khang, Khanh, Nhan

3. Location: $11^{o}588'N$; $106^{o}34'E$; 30 km from Ho-Chi-Minh city; Nhi-Xuan. Acid Sulphate Soil Amelioration station (developed in cooperation with Belgian Government)

4. Elevation: 0.5 m above MSL

5. Land-form:

i) Physiographic position: Depression land (with stagnating water)

ii) Surrounding land form : Almost flat

6. Slope on which pedon is sited: <1%

7. Land-use: Eleocharis (Nang), Dulcis (dominant in water); Fougere (on edges); Eucalyptus planted (2 years old; ±10 m high) on beds; pine apple (ananas) on beds.

8. Climate: Hydromorphic (local)

Annual rainfall (AR)	MAST	MST	MWT
2102 mm	$27.0^{o}C$	MST and MWT differ by $<5^{o}C$	

II. GENERAL INFORMATION ON THE SOIL:

1. Parent material: Alluvium (recent)

2. Drainage: Very poor (despite installing open drainage system)

3. Moisture conditions in pedon: Wet throughout

4. Depth of ground-water table: Stagnating water at surface (50-100 cm) which gets drained by March.

5. Evidence of erosion:

III. **BRIEF DESCRIPTION OF THE PEDON:** Deep, hydromorphic humiferois soil developed in alluvium under very poor drainage conditions. The surface soils show undecomposed plant remains with dark coloured subsurface horizon and garosite mottles in the subsoil (below 75 cm of the surface) and completely reduced soil below 1m depth.

IV. **PEDON DESCRIPTION:** (P-13)

H. (± 15-0 cm) Reddish brown (5 YR 3/3.5); with fresh plant leaves

A1 (0-21 cm) Black (5 Y 2.5/1 M); loam (+)/ clay loam with high organic matter (+12%); partly and completely decomposed plant remains; moderate crumb and subangular blocky; strongly smelling sulphudic material; moist friable; clear smooth boundary.

Ag (21-33 cm) Black (5 Y 2.5/2 M); clay loam; moderately developed structure; wet slightly sticky and plastic.

(B)g (33-61 cm) (dark) greyish brown (2.5 Y 3.5/2 M); clay loam; moderately developed subangular blocky structure; wet slightly sticky and plastic; common roots; moderately smelling material.

(B)g (61-77 cm) Very dark greyish brown (2.5 Y 3/2 M); clay loam (+); moderately developed, subangular blocky structure; wet slightly sticky and plastic; few roots.

B3r (77-100 cm) Dark olive grey (5 Y 3/2 M) with jarosite mottles (in 30% area) of olive yellow (5 Y 6/6); very strong smelling (due to sulfudic material); wet sticky and plastic; no roots; common fine pores; abrupt/clear smooth boundary.

Cr (100+) Grey (5 Y 5/1 M); clay; massive; wet sticky (reduced layer) and plastic; no roots.

PEDON 14 (VIE/86/024)

I. INFORMATION ON THE SITE Date of Exam: Nov. 13, 1989

1. Soil name - High catergoric classification:

Vietnamese: Grey Soils on old alluvium

FAO : Dystric Cambisols

USDA : Dystric Ustropepts

2. Author(s): J. Sehgal with prof. Chieu and Soil Survey Staff, Sub-NIAPP,Ho-Chi-Minh.

3. Location: 11°00'N; 106°32'E; Village PHUOC VINH AN, district CUCHI, Ho-Chi-Minh city.

4. Elevation: ± 30 m above MSL

5. Land-form:

i) Physiographic position: Terrace
ii) Surrounding land form : Almost flat

6. Slope on which pedon is sited: <1%

7. Land-use: Fallow after paddy; paddy in adjoining field; one crop of paddy (July- Oct.) and Groundnut (Nov. - Feb.); Yield; Paddy - 2.5 tonnes and groundnut 0.7 toones/ha.

8. Climate:

Station	Annual rainfall (AR)	MAT	MST	MWT
DAU TIENG	2102 mm	27.0°C	<5°C	
Close by	1943 mm	27.2°C	<5°C (generally 1-2°C)	

II. GENERAL INFORMATION ON THE SOIL:

1. Parent material: Old alluvium

2. Drainage: Well drained

3. Moisture conditions in pedon: Moist throughout the pedon

4. Depth of ground-water table: N.O.

5. Evidence of erosion: Slight

III. BRIEF DESCRIPTION OF THE PEDON: Very deep, alluvium-derived soils on terrace, developed under well drained, tropical environments. The soils have a dark coloured mollic-like ochric epipedon underlain by an agric horizon with shinning peds and few illuviated ferri-argillans.

IV. PEDON DESCRIPTION: (P-14)

Ap1 (0-17 cm) Greyish brown (10 YR 5/2 M); sandy clay loam; weak to moderate, fine and medium subangular blocky; moist very friable, wet slightly sticky and plastic; many fine and medium pores; common fine and medium roots; gradual smooth boundary.

Ap2 (17-30 cm) Brown (10 YR 4/3 M); loam (+) clay loam; weak, fine and medium subangular blocky; moist friable, wet slightly sticky; many fine, medium pores; many fine and very fine roots; few pedotubules.

B21 (30-53 cm) Brown (10 YR 5/3 M); sandy clay loam/clay loam; moderate fine and medium subangular blocky; few occasicnal shinning ped faces (in-situ weathering of primary minerals + humus coatings; moist friable, wet slightly sticky and plastic; many fine and medium pores; common fine and very fine roots, few pedotubules; clear smooth boundary.

B22 (53-78 cm) Yellowish brown (10 YR 5/4 M); sandy clay loam/clay loam; occasion/few clay cutans (clay skins) on ped faces and root channels; common fine and medium tubular pores; common roots; moderate fine and medium subangular blocky; moist friable, wet slightly sticky and plastic; clear smooth boundary.

B3 (78-100+ cm) Yellowish brown (10 YR 5/5 M); sandy clay loam/sc; weak fine and medium subangular blocky; moist friable, wet slight sticky and plastic; few root channels; common fines pores.

PEDON 15 (VIE/86/024)

I. INFORMATION ON THE SITE Date of Exam: Nov. 14, 1989

1. Soil name - High catergoric classification:

   Vietnamese: Dark Brown Soils on basalt

   FAO : Chromi-Luvic Phaeozem (Chromi-Humic Luvisols)

   USDA : Mollic Ultic Haplustalfs (Tropustalf-proposed)

2. Author(s): J. Sehgal with sub-NIAPP staff

3. Location: 11°14'N; 107°27'E; PHU HOA village TAN PHU district; DONGNAI province

4. Elevation: 90 m above MSL

5. Land-form:

   i) Physiographic position: Upland
   ii) Surrounding land form : Hilly

6. Slope on which pedon is sited: Almost level 0-2°C

7. Land-Use: Presently under tobacco crop and banana plantation around, but the area is intensively cultivated for 2-3 crops per year (2 crops of soyabean from March to Sept. and 1 crop of tobacco from Oct. to March).

8. Climate:

II. GENERAL INFORMATION ON THE SOIL:

1. Parent material: Volcanic ash material

2. Drainage: Well drained

3. Moisture conditions in pedon: Moist throughout (not irrigated)

4. Depth of ground-water table: ± 20 m

5. Evidence of erosion: Slight

III. BRIEF DESCRIPTION OF THE PEDON: Moderately shallow (ruptic), dark yellowish brown soils developed on basalt (decomposed) under typical conditions. The soils show a well-developed mollic epipedon underlain by an argic horizon with common thin shinning ped faces and ferriargillans in pores. They show ruptic properties below 50 cm depth.

IV. PEDON DESCRIPTION: (P-15)

Ap (0-20 cm) Dark reddish brown (5 YR 3-2.5/2 M); clay loam; well developed, fine and very fine, granular; moist friable, wet slightly sticky and plastic; porous; many fine and medium roots; clear smooth boundary.

Bt (20-40 cm) Dark yellowish brown (5 YR 3/2.5 M); (silty) clay; moderate fine and very fine granular (dominant) and subangular blocky (subdominant); moist friable, wet very sticky and plastic; common fine and medium roots; many fine and medium tubular pores; soil material is interrupted by basaltic stones (fine grained volcanic) - chemically weathered indicating pitty appearance.

Note: The soils have boulders in between soil below 50 cm depth and continuous rock (probably) below 1 m of the surface.

PEDON 16 (VIE/86/024)

I. INFORMATION ON THE SITE Date of Exam: Nov. , 1989

1. Soil name - High catergoric classification:

Vietnamese: Red-Brown Ferralitic Soils on decomposed basalt

FAO : Humic Ferralsols

USDA : Ustic Kandihumults

2. Author(s): J. Sehgal

3. Location: $10^{o}57'N$; $107^{o}08'E$. BAU HAM villages THONG NHAT district; DONG NAI province.

4. Elevation: 100 m

5. Land-form:

i) Physiographic position: Sloping land
ii) Surrounding land form : Rolling

6. Slope on which pedon is sited: 5%

7. Land-use: Cassava cultivated, rubber plantation in surrounding area.

8. Climate: N.O.

II. GENERAL INFORMATION ON THE SOIL:

1. Parent material: Basalt

2. Drainage: Moderately well drained

3. Moisture conditions in pedon: Moist through

4. Depth of ground-water table: 10-15 m below the surface

5. Evidence of erosion: Slight

III. BRIEF DESCRIPTION OF THE PEDON: Very deep, dark reddish brow soils developed on decomposed basalt under moderately well drained and tropical climatic conditions. The soils show an umbric epipedon and an argic horizon with low CEC and base saturation.

IV. PEDON DESCRIPTION: (P-16)

Ap (0-13 cm) Dark reddish brown (5 YR 3/2 M); clay loam (+); moderate fine and medium, subangular blocky (breaks to granular); moist very friable, wet slightly sticky and plastic; few organo-clay coatings on ped faces; many very fine, fine continuous, vertical and horizontal imped tubular interstitial pores; many very fine and fine roots; clear smooth boundary.

A3/B1 (13-35 cm) Dark reddish brown (5 YR 3/3 M) clay; moderate, fine medium, prismatic (in place), breaks to angular blocky and crumb; moist very friable; wet slightly sticky and plastic; common thin patchy shinning coatings on ped faces; common fine and medium tubular interstitial pores; common fine and medium roots; few aggrotubules; clear smooth boundary.

Bs1 (35-57 cm) Dark reddish brown (5 YR 3/4 M) clay; moderate, medium and coarse prismatic, breaks to fine, medium angular blocky; common thin, clay cutans on ped faces and in pores; moist (slightly) firm, wet slightly sticky and plastic; few small, hard, irregular Fe-Mn nodules; common fine and medium tubular and interstitial pores; few fine roots; clear smooth boundary.

Bs2 (57-113 cm) Reddish brown (5 YR 4/4 M); moderate, medium and fine prismatic, breaks to fine and medium angular blocky and crumb; common, thin, patchy clay coatings or shinning ped faces and very few coatings in pores; most friable, wet slightly sticky and plastic; common fine and medium pores; common fine medium roots; few, small, soft Fe-Mn nodules; clear smooth boundary.

Bs3 (113-150 cm) (Dark) Red (2.5 YR 3.5/6 M); clay; moderate, medium and fine subangular blocky, breaks partly to crumb; moist friable; few, thin coatings; common fine and medium pores; few fine roots; gradual smooth boundary.

Bs4 (150-200 cm) Dark red (2.5 YR 3/6 M) clay; weak fine and medium subangular blocky; few fine (<1 cm) rock fragments; common fine and medium pores; few fine and medium roots.

PEDON 17 (VIE/86/024)

I. INFORMATION ON THE SITE Date of Exam: Nov. 16, 1989

1. Soil name - High catergoric classification:

Vietnamese: Brown Yellow Ferralitic Soils on old alluvium

FAO : Haplic Acrisols

USDA : Typic Kandiustults

2. Author(s): J. Sehgal (accompanied by Prof. Chieu and Sub-NIAPP staff

3. Location: TAN PHONG village; THU DUC district; Ho-Chi-Minh city

4. Elevation: 50 m above MSL

5. Land-form:

i) Physiographic position: Terrace (upper)
ii) Surrounding land form : Almost flat

6. Slope on which pedon is sited: Slightly sloping (2-4%)

7. Land-use: Local grasses

8. Climate:

Annual rainfall (AR)	MAT	MST	MWT
1943 mm	27.2°C	27.6°C	26.4°C

II. GENERAL INFORMATION ON THE SOIL:

1. Parent material: (Old) Alluvium

2. Drainage: Somewhat excessively drained

3. Moisture conditions in pedon: Moist throughout

4. Depth of ground-water table: Not observed

5. Evidence of erosion: (Slight to) moderate, with truncalted surface

III. BRIEF DESCRIPTION OF THE PEDON: Very deep, sandy-like soil on gently sloping land developed under well drained and tropical climatic conditions. The soils have a deep Bt horizon below an ochric epipedon. The C horizon is observed only below 150 cm.

IV. PEDON DESCRIPTION: (P-17)

A1 (0-12 cm) Light reddish brown to reddish yellow (7.5 YR 6/5 M); loamy coarse sand; massive (in place) breaks dominantly to single grains; bleached sandy horizon; porous; many fine and medium roots; clear smooth boundary.

Bt1 (12-28 cm) Yellowish red (5 YR 5/7 M) coarse sandy loam; moderate fine and medium subangular blocky; moist slightly firm; common thin clay coatings on ped faces and on skeletal grains; few charcoal pieces; common, fine and medium pores; many very fine, fine and medium roots; clear smooth boundary.

Bt2 (28-68 cm) Yellowish red (5 YR 5/6 M); (7.5 YR 7/6 D) coarse sandy loam (finer than above); moderate, fine and medium, sub-angular blocky; moist friable, common thin patchy ferriargillans on skeletal grains and ped faces; many fine medium pores; many very fine and fine roots; few charcoal pieces; gradual smooth boundary.

Bt3 (68-96 cm) Yellowish red (5 YR 5/6 M); coarse sandy loam(coarser than above) weak, fine and medium subangular blocky; moist friable; few clay coatings as above; many fine and medium pores; few to common very fine roots; few charcoal pieces; clear smooth boundary.

B3 (96-150 cm) Reddish yellow (5 YR 6/8 M); coarse sandy loam; weak, fine and medium, subangular blocky, partly breaks to crumb; moist very friable; many fine and medium tubular and interstitial pores; few very fine roots; clear smooth boundary.

C (150-208 cm) Reddish yellow (7.5 YR 6/8 M); loamy coarse sand; massive, breaks to weak, fine subangular blocky and single grains; moist very friable; many, fine and medium pores; few very fine roots; rare fine (1-2 mm) round Fe-Mn nodules (perhaps deposited with alluvium).

PEDON 18 (VIE/86/024)

I. INFORMATION ON THE SITE Date of Exam: Nov. 17, 1989

1. Soil name - High catergoric classification:

   Vietnamese: Degraded Grey Soils on old alluvium

   FAO : Gleyic Acrisols

   USDA : Aquic Kandiustults

2. Author(s): J. Sehgal accompanied by Sub-NIAPP Staff

3. Location: 11°17'N; 106°40'E; BEN CAT district; SONG BE province

4. Elevation: 100 cm

5. Land-form:

   i) Physiographic position: Terrace
   ii) Surrounding land form : Rolling to undulating

6. Slope on which pedon is sited: 2-6% (slight sloping)

7. Land-use: Pepper, cashew-nut plantation

8. Climate:

Station	Annual rainfall (AR)	MAT	MST	MWT
DAU TIENG	2102 mm	27.0°C	MST and MWT differ by <5°C	

II. GENERAL INFORMATION ON THE SOIL:

1. Parent material: Alluvium (old)

2. Drainage: Imperfect

3. Moisture condition in pedon: Dry throughout

4. Depth of ground-water table: Not observed

5. Evidence of erosion: Moderate to severely eroded surface

III. BRIEF DESCRIPTION OF THE PEDON: Deep, imperfectly drained grey coloured soils developed on alluvium. The soils show an ochric epipedon underlain by an argic horizon within 1m of the surface. The C horizon material is dominantly kaolinitic.

IV. PEDON DESCRIPTION: (P-18) (short)

E (0-15 cm) Gleyish brown (2.5 Y 5/2) and light grey (2.5 Y 7/2 D); sandy loam; massive, dry very hard, common fine and medium tubular and vesicular pores; negligible roots; clear smooth boundary.

Bt1 (15-35 cm) Grey (5 Y 5.5/1 D); loam; moderate, fine and medium subangular blocky; dry hard, moist friable; common fine and medium pores; common charcoal pieces; negligible roots; clear smooth boundary.

Bt2 (35-50 cm) Dark grey (5 Y 4/1 D); loam; moderate fine and medium angular blocky; dry hard, moist friable; common fine pores; few charcoal pieces; clear smooth boundary.

B3 (50-90/100 cm) Dark greyish brown (2.5 Y 4/2 D) with few fine distinct (high chroma) roof rust mottles; loam; moderate, fine and medium subangular blocky; dry hard, moist friable; common fine pores; abrupt smooth boundary.

C (90/100+ cm) Light grey (2.5 Y 7/2 D) Kaolin material with few gravels; massive, dry very hard.

PEDON 19 (VIE/86/024)

I. INFORMATION ON THE SITE Date of Exam.: Nov. 17, 1989

1. Soil name - High catergoric classification:

   Vietnamese: Red-Brown Ferralitic Soils

   FAO : Rhodic Ferralsols (FRr)

   USDA : Rhodic Haplustox

2. Author(s): J. Sehgal accompanied by Sub-NIAPP Staff

3. Location: 11°37'N; 106°40'E; THANH BINH village; BINH LONG district; SONG BE Province

4. Elevation: ± 120 m above MSL

5. Land-form:

   i) Physiographic position: Terrace
   ii) Surrounding land form : Rolling (8-16% slope)

6. Slope on which pedon is sited: ±8%

7. Land-use: Bamboo, coffee (Robusta), rubber, cocoa etc.

8. Climate:

Annual rainfall (AR)	MAT	MST	MWT
2102 mm	27.0°C	(MST and MWT differ by <5°C)	

II. GENERAL INFORMATION ON THE SOIL:

1. Parent material: Basalt (volcanic)

2. Drainage: Somewhat excessive

3. Moisture conditions in pedon: Moist throughout

4. Depth of ground-water table: 18-20 m

5. Evidence of erosion: Sheet erosion

III. BRIEF DESCRIPTION OF THE PEDON: Very deep, dusky red coloured soils developed on basalt under well drained and tropical climate conditions. The soils are extremely weathered with high clay content, shining ped faces with high free sesquoxide content, low silt; clay ratio, weak structure and diffuse boundaries are characteristic features of these soils.

IV. PEDON DESCRIPTION: (P-19)

A1 (0-30 cm) Dusky red to dark reddish brown (2.5 YR 3/3 M); fine clay (60-70% clay); moderate and weak fine and medium subangular blocky, breaks to weak crumbs; moist very friable, wet sticky and plastic; porous; many very fine to coarse roots; common shinning ped faces; common ant activity; gradual smooth boundary.

Bs1 (30-78 cm) Dark reddish brown (2.5 YR 3/3.5 M); fine clay; weak fine and medium subangular blocky, breaks partly to weak crumbs; moist very friable, wet sticky and plastic; porous, many very fine to coarse roots; many shinning ped faces; common organic coatings on ped faces; clear smooth boundary.

Bs2 (78-120 cm) Dusky red (10 R 3/3 M) (fine clay lighter than above); weak fine and medium subangular blocky; moist very friable wet slightly sticky; common fine and medium and few coarse roots; common shinning ped faces; diffuse smooth boundary.

Bs3 (120-165 cm) Dusky red (10 R 3/4 M); fine clay; weak, fine subangular blocky; moist very friable, wet slightly sticky and plastic; many fine and medium pores; few very fine and coarse roots; diffuse smooth boundary.

Bs4 (165-220 cm) Dusky red (10 R 3/4 M); fine clay; weak, fine subangular blocky; moist friable; common fine and medium roots; few ant nests; diffuse boundary.

Bc (220+ cm) Dusky red (10 R 3/3 M); fine clay; weak fine subangular blocky; moist friable; few roots.

PEDON 20 (VIE/86/024)

I. INFORMATION ON THE SITE Date of Exam: Nov. 17, 1989

1. Soil name - High catergoric classification:

Vietnamese: Gley Degraded Soils with Lateritic concretion

FAO : Dystric Plinthosol

USDA : Plinthic Acrustox

2. Author(s): J. Sehgal accompanied by Prof. Chieu and Soil Survey Staff of Sub-NIAPP

3. Location: 11°06'N; 106°37'E, BEN CAT area

4. Elevation: 100 m above MSL

5. Land-form:

i) Physiographic position: Upper terrace
ii) Surrounding land form : Undulating (2-6%)

6. Slope on which pedon is sited: ±5%

7. Land-use: Barren (abondoned); brick kiln is operating nearby. The surrounding area shows cashew-nut plantation.

8. Climate:

Annual rainfall (AR)	MAT	MST	MWT
2102 mm	27.0°C (MST and MWT differ by <5°C)		

II. GENERAL INFORMATION ON THE SOIL:

1. Parent material: Alluvium (old)

2. Drainage: Moderately well to imperfect

3. Moisture conditions in pedon: Dry surface; moist below 50 cm depth

4. Depth of ground-water table: Not observed

5. Evidence of erosion: Moderate to strong; forming rills and gullies.

III. BRIEF DESCRIPTION OF THE PEDON: Deep, mottled material - plinthite (iron and Kaolin rich) suggesting oxidation/ reduction process. The soils appear to have lost A horizon due to erosion.

IV. PEDON DESCRIPTION: (P-20)

Bs1 (0-15 cm) White to light grey (5 Y 7.5/1 D) mottled with yellowish red (5 YR 5/8 D) in 1:2 ratio plinthite material; sandy clay loam; strong medium angular blocky; dry extremely hard, wet slightly sticky and plastic; no roots; few interstitial pores; gradual wavy boundary.

Bs2 (15-50 cm) White to light grey (5 Y 7.5/1 D) mottled with yellowish red (5 YR 5/8 D) material in 1:2 ratio (plinthite); sandy clay loam; strong, medium angular blocky; dry extremely hard, wet slightly sticky; gradual smooth boundary.

Bs3 (50-90 cm) Light grey (5 Y 7/1 M) mottled with yellowish red (5 YR 4/6 M) in 1:2 ratio; sandy clay; strong fine and medium angular blocky; moist very firm, dry extremely hard; gradual smooth boundary.

Bs4 (90+ cm) As above; but ratio of light grey (5 Y 7/1 M) and yellowish red (5 YR 4/6 M) material changes to 1:3.

EXISTING PEDONS INFORMATION

Another set of twenty pedons representative of the extensively occurring soils in Vietnam were selected (location shown in Fig. 7); their available morphological descriptions and analytical data were translated in English and presented in tabular form (See Annex.4) From the review of these data, it becomes evident that the information given in Annex.4 is either scanty and/or undependable to classify soils with confidence. However, efforts were made to use the available data to classify soils in the FAO System of soil classification (See Annex.4).

Morphological descriptions and analytical data of additional 20 pedons provided by NIAPP(Not studied in the field) (arranged from North to South)

Annex.4.1: Morphological descriptions and analytical data of pedon 450 (Source NIAPP)

MAP UNIT	HORIZON	DEPTH	COLOUR MATRIX	COLOUR MOTTLES	SOIL STRUCTURE	SOIL TEXTURE	CONSISTENCE MOIST	CONSISTENCE WET	COATINGS CUTANS	CONCRETIONS (Fe-Mn)	PORES	ROOTS	BOUNDARY	REMARKS
	o PROFILE: 450						o LOCATION: HOANG LIEN SON Province							
	o CLASSIFICATION		(Vietnamese) - Red Yellow Ferralitic soils on Metamorphosed Rocks (FAO) - Ferric Acrisols											
	A	0-15	7.5 YR 6/4		Fine crumb	Sandy loams	firm					many	gradual	
Fs	Bt1	15-37	7.5 YR 6/8		mode rate angu lar blocky	silty loam	very firm					many	gradual	
	Bt2	37-93	7.5 YR 6/8		ibid	clay loams						Many fragment of quartzs		
		>93			This is extremely firm horizon (with 80-90% quartz)									

Map Unit	Horizon	Depth (cm)	pH (1:5) Water	pH (1:5) KCl	Salts (ds/m)	Organic matter %	Soil Particle Size Sand > 0.05	Silt 0.05-0.002	Clay <0.002	CEC me/100g (soil)	CEC me/100g (clay)	Exchangeable cations Cmal/kg Ca	Mg	Na	Base Saturation %
	o PROFILE: 450						o LOCATION: HOANG LIEN SON								
	o CLASSIFICATION: Vietnamese - Red-Yellow Ferralitic on Metamorphosed rock														
	A	0-15	4.5			3.2	35.4	24.0	40.0	7.4		1.2	1.2		32
Fs	Bt1	15-37	5.0			2.1	26.2	25.0	48.0	6.0		1.6	0.4		33
	Bt2	37-93	5.5			0.6	22.8	26.0	50.9	4.0		0.8	0.7		38

Remarks: $SiO_2 / Al_2O_3 = 1.79$

$SiO_2 / R_2O_3 = 1.43$

Annex.4.2: MORPHOLOGICAL DESCRIPTION AND ANALYTICAL DATA OF P-439

MAP UNIT	HORIZON	DEPTH	COLOUR MATRIX	COLOUR MOTTLES	SOIL STRUCTURE	SOIL TEXTURE	CONSISTENCE MOIST	CONSISTENCE WET	COATINGS CUTANS	CONCRETIONS (Fe-Mn)	PORES	ROOTS	BOUNDARY	REMARKS
	o PROFILE: 439						o LOCATION: PKONG CHAU DIS VINH PHU Province							
	o CLASSIFICATION		(Vietnamese) - Red-Yellow Ferralitic soil on Claystone											
			(FAO) - Gleyic Acrisol											
	A	0-20			sub angular	clay loam				~35%		very fine roots		
Fs	B	20-80	10 YR 5/8		granular	clay								
	Bg1	80-210	2.5YR 5/8		ibid	silty clay loam								

Map Unit	Horizon	Depth (cm)	pH (1:5) Water	pH (1:5) KCl	Salts ($EC \times 10^3$)	Organic matter %	Soil Particle Size Sand > 0.05 mm	Silt 0.05-0.002 mm	Clay <0.002 mm	CEC me/100g (soil)	CEC me/100g (clay)	Base Saturation (%)	Exchangeable cations me/100g soil Ca	Mg	Na
	o PROFILE: 439					o LOCATION: VINH PHU									
	o CLASSIFICATION: Vietnamese - Red-Yellow Ferralitic Soils on Claystones														
	A	0-20	3.9		1.7	40	28	32	12	37	31	3.2	0.6		
Fs	La	20-80	3.9		1.1	36	24	40	11	27	35	3.2	0.5		
	Fg1	80-210	4.0		-	28	20	52	9	17	43	3.4	0.4		

Remarks: Rainfall : 1948 mm
MAT : 23.2°C
MST & MWT Differ by: >5°C

Annex.4.3: MORPHOLOGICAL DESCRIPTION AND ANALYTICAL DATA OF P-67

MAP UNIT	HORIZON	DEPTH	COLOUR MATRIX	COLOUR MOTTLES	SOIL STRUCTURE	SOIL TEXTURE	CONSISTENCE MOIST	CONSISTENCE WET	COATINGS CUTANS	CONCRETIONS (Fe-Mn)	PORES	ROOTS	BOUNDARY	REMARKS
o PROFILE: 67									o LOCATION: SON LA Province					
o CLASSIFICATION									(Vietnamese) - Red Yellow Ferralitic soil on Claystone (FAO) - Luvisols Acrisols					
	A	0-13	10YR 6/3		medium angular blocky	silty clay loam	friable					Many	clear	ant activity
Fs	AB	13-41	7.5YR 7/8		medium and coarse angular blocky	silty clay loam	firm					Many	diffuse	
	B	41-100	7.5YR 7/8		medium and coarse angular blocky	silty clay	firm							

Map Unit	Horizon	Depth (cm)	pH (1:5) Water	pH (1:5) KCl	Salts ($ECx10^3$)	Organic matter %	Soil Particle Size Sand > 0.05	Silt 0.05-0.002	Clay <0.002	CEC me/100g (soil)	CEC me/100g (clay)	Base Saturation (%)	Exchangeable cations me/100g soil Ca	Mg	Na
o PROFILE: 67										o LOCATION: SON-LA					
o CLASSIFICATION: Vietnamese - Red-Yellow Ferralitic soil on Claystone															
	A	0-13	4.5		2.5	11	73.4	16	17			56	5.7	3.7	
Fs	AB	13-41	4.3		1.8	12	69.0	19	16			57	5.9	3.7	
	Bt	41-100	4.4		1.3	18	58.0	24	24			70	11.0	5.5	

Remarks: Ochric epi. Agric. Horizon
Base Saturation >50% (So LUVISOLS, But should be Acrisol -
Rainfall :1456 mm, MAT 20.8°C; MST & MWT > 5°C

Annex.4.4 MORPHOLOGICAL DESCRIPTION AND ANALYTICAL DATA OF P-142

MAP UNIT	HORIZON	DEPTH	COLOUR MATRIX	COLOUR MOTTLES	SOIL STRUCTURE	SOIL TEXTURE	CONSISTENCE MOIST	CONSISTENCE WET	COATINGS CUTANS	CONCRETIONS (Fe-Mn)	PORES	ROOTS	BOUNDARY	REMARKS
o PROFILE: 142										o LOCATION: TRUNG KHANH Disk - CAO BANG Province				
o CLASSIFICATION										Vietnamese - Brown-Red Ferralitic soil on Limestone FAO - Luvic Chernozem				
	Ap	0-18	5YR 3/2		granular	clay loam						very fine		
Fv	B1	18-44	5YR 3/4		-	clay loam				15-20%				
	B2	44-80	5YR 4/4		granular	clay loam				15%				
	C	80-120	2.5YR 4/6		granular	clay				15%				

Map Unit	Horizon	Depth (cm)	pH (1:5) Water	pH (1:5) KCl	Salts ($ECx10^3$)	Organic matter %	Soil Particle Size Sand > 0.05 mm	Silt 0.05-0.002 mm	Clay <0.002 mm	CEC me/100g (soil)	CEC me/100g (clay)	Base Saturation (%)	Exchangeable cations me/100g soil Ca	Mg	Na
o PROFILE: 142															
o LOCATION: CAO-BANG															
o CLASSIFICATION: Vietnamese - Brown-Red Ferralitic Soil on Limestones															
	A_H	0-18	6.5	6.0	no	7.2	12	49	39	14.5		86	8.6	4.0	
Fv	B1	18-44	6.3	6.0	-	2.0	16	34	51	9.1		92	6.1	2.3	
	B2	44-80	6.9	6.6	-	1.8	24	30	46	10.8		87	5.1	4.4	
	C	80-120	6.9	6.6	-	-	17	31	51	10.2		78	4.7	3.3	

Remarks: Mollic epi.
Base Saturation >50°
Classification: Luvic Chernozem, Argiustoll

Annex.4.5 MORPHOLOGICAL DESCRIPTION AND ANALYTICAL DATA OF P-1

MAP UNIT	HORIZON	DEPTH	COLOUR MATRIX	COLOUR MOTTLES	SOIL STRUCTURE	SOIL TEXTURE	CONSISTENCE MOIST	CONSISTENCE WET	COATINGS CUTANS	CONCRETIONS (Fe-Mn)	PORES	ROOTS	BOUNDARY	REMARKS
o PROFILE: 1					o LOCATION: THUN THANH Dis HA BAC Province									
o CLASSIFICATION					(Vietnamese) - Gley Degraded-Grey soils on Old Alluvial									
					(FAO) - Gleyic Alisol (Acrisol)									
	A2	0-15	10Y 8/1		single grain	loamy sands	loose					many rice	clear	
Bg	AB	15-25	5 Y 7/6		coarse angular blocky	silty clay loam	very firm					few fine roots	clear	
	Bg	25-49	7.5YR 5/6		Medium prismatic	clay	firm						diffuse	
	Bg	49-70	7.5YR 5/6		Medium prismatic	clay	firm						diffuse	
	Bg	70-100	10YR 6/2		Medium prismatic	clay	firm							

Map Unit	Horizon	Depth (cm)	pH (1:5) Water	pH (1:5) KCl	Salts ($EC \times 10^3$)	Organic matter %	Soil Particle Size Sand > 0.05 mm	Silt 0.05-0.002 mm	Clay <0.002 mm	CEC me/100g (soil)	CEC me/100g (clay)	Base Saturation (%)	Exchangeable cations me/100g soil Ca	Mg	Na
o PROFILE: 1						o LOCATION: HA-BAC									
o CLASSIFICATION: Vietnamese - Degraded-Gley-Grey Soil on Old Alluvial															
	A	0-15	4.2		1.40	28	58	13	5.1	39	47	1.2	1.2		
Bg	AB	15-25	4.5		0.45	34	54	12	5.7	47	49	1.6	0.6		
	Bg	25-49	4.0		0.45	35	50	15	5.3	35	61	2.1	3.0		
	Bg	49-70	4.0		0.45	27	40	33	11.7	35	51	2.5	3.9		
	Bg	70-100	4.0		0.45	13	45	38	14.9	38	47	4.5	5.0		

Remarks: Ochric epi. Gleyic properties; Agric - ; CEC : >24me ;
Base Saturation: <50%; Gleyic ALISOL

Annex.4.6: MORPHOLOGICAL DESCRIPTION AND ANALYTICAL DATA OF P-200

MAP UNIT	HORIZON	DEPTH	COLOUR MATRIX	COLOUR MOTTLES	SOIL STRUCTURE	SOIL TEXTURE	CONSISTENCE MOIST	CONSISTENCE WET	COATINGS CUTANS	CONCRETIONS (Fe-Mn)	PORES	ROOTS	BOUNDARY	REMARKS
	o PROFILE: 200					o LOCATION: CHAU GIANG Dis HAI HUNG Province								
	o CLASSIFICATION				Vietnamese - Gley Alluvial Soils of Red River Alluvium									
					FAO - Gleyi-Entic Fluvisol									
P^h_g	A	0-12	7.5YR 5/2		Sub-angular blocky	clay loam						many fine roots	clear	
	AB	12-35	7.5YR 5/2		Sub-angular blocky (sediment blocky)	clay loam	Moist friable					a few fine roots	clear	
	B1	35-60	7.5YR 5/2		Sub-angular blocky	clay loam	Moist friable			a few fine, black Fe-Mn concretions (<5%)			clear	
	Bg	60-110	5YR 6/1	10YR 5/6 5YR 4/3 (Cutans clay oxidation)	massive	clay	Moist	firm						

Map Unit	Horizon	Depth (cm)	pH (1:5) Water	pH (1:5) KCl	Salts ($EC \times 10^3$)	Organic matter %	Soil Particle Size Sand > 0.05 mm	Silt 0.05-0.002 mm	Clay <0.002 mm	CEC me/100g (soil)	CEC me/100g (clay)	Base Saturation (%)	Exchangeable cations me/100g soil Ca	Mg	Na
	o PROFILE: 200					o LOCATION: HAI HUNG Province									
	o CLASSIFICATION:					Vietnamese - Gley Alluvial Soil of the Red River									
						FAO - Gleyic, Eutric Fluvisols									
	A	0-12		6.0	1.9	7	70	23	14			50	6.8	7.2	
P^h_g	AB	12-35	6.8		1.0	13	59	28	13			51	8.8	4.0	
	B1	35-60		7.2	0.5	9	69	22	12			50	6.8	5.6	
	Bg	60-110		6.8	0.5	6	52	42	11			49	9.2	2.0	

Remarks: Rainfall : 1825 mm
MAT : 23.4°C
MWT & MST difference: $\geq 5^oC$
No Diagnostic Horizon
Base Saturation: 100%
CEC : >24

Annex.4.7: MORPHOLOGICAL DESCRIPTION AND ANALYTICAL DESCRIPTION OF P-264

MAP UNIT	HORIZON	DEPTH	COLOUR MATRIX	COLOUR MOTTLES	SOIL STRUCTURE	SOIL TEXTURE	CONSISTENCE MOIST	CONSISTENCE WET	COATINGS CUTANS	CONCRETIONS (Fe-Mn)	PORES	ROOTS	BOUNDARY	REMARKS
	o PROFILE: 264						o LOCATION: HAI PHONG CITY							
	o CLASSIFICATION:		Vietnamese - Saline Soils FAO - Fluvial Solonchaks											
	A1	0-35	7.5YR 5/3			Silty clay			No		Very fine	gra-dual		
M	B1	35-70	2.5YR 6/4		massive	clay			No		a few	gra-dual		
	B2	70-100	2.5YR 6/4		massive	clay			No		No	--		

Map Unit	Horizon	Depth (cm)	pH (1:5) Water	pH (1:5) KCl	Salts ($ECx10^3$)	Organic matter %	Soil Particle Size Sand > 0.05 mm	Silt 0.05-0.002 mm	Clay <0.002 mm	CEC me/100g (soil)	CEC me/100g (clay)	Base Saturation (%)	Exchangeable cations me/100g soil Ca	Mg	Na
	o PROFILE: 264					o LOCATION: AN HAI - HAI PHONG									
	o CLASSIFICATION:			Vietnamese - Saline Soils FAO - Fluvic Solonchaks.		of Salt % of 0.6									
	A1	0-35	7	6.6	0.6	0.2	-	8	47	44	11	25	75	4.2	4.0
M	B1	35-70	7	6.6	0.6	0.2	-	6	43	50	11	14	80	4.5	4.0
	B2	70-100	7	7.0	0.2	0.1	-	3	40	57	9	10	93	4.1	4.0

Remarks: Salic Horizon :

Fluvatile :

Annex.4.8: MORPHOLOGICAL DESCRIPTION AND ANALYTICAL DESCRIPTION OF P-75

MAP UNIT	HORI-ZON	DEPTH	COLOUR MATRIX	COLOUR MOTTLES	SOIL STRUCTURE	SOIL TEXTURE	CONSISTENCE MOIST	CONSISTENCE WET	COATINGS CUTANS	CONCRETIONS (Fe-Mn)	PORES	ROOTS	BOUNDARY	REMARKS
	o PROFILE: 75					o LOCATION: NGHE TINH Province								
	o CLASSIFICATION		Vietnamese - Sandy Marine Soils FAO - Arenosols											
	A	0-20	10YR 7.5/1	7.5YR 5/6	massive	loamy sands	moist firm	wet massive		No		very fine	clear	
C	B	20-90	10YR 8/4	"	"	sand	..ibid..			30% Mn				
	C	90-120	10YR 8/4	"	"	sand	..ibid..			40% Mn				

Map Unit	Horizon Colour	Depth (cm)	pH (1:5) Water	pH (1:5) KCl	Salts ($EC \times 10^3$)	Organic matter %	Soil Particle Size: Sand > 0.05 mm	Silt 0.05-0.002 mm	Clay <0.002 mm	CEC me/100g (soil)	CEC me/100g (clay)	Base Saturation (%)	Exchangeable cations me/100g soil: Ca	Mg	Na
	o PROFILE: 75					o LOCATION: DIEN CHAU, NGE AN									
	o CLASSIFICATION:		Vietnamese - Sandy Marine Soils FAO - Arenosols												
	A10YR 5/1	0-20	7.2		1.7	83	12	5	7			100	6.3	1.1	
C	C10YR 8/4	20-90	7.0		1.1	80	11	9	7			100	6.8	1.1	
	C10YR 8/4	90-120	7.0		-	81	13	6	9			-	7.9	1.9	

Remarks: Rainfall : 2033 mm
MAT : 23.8°C
MST & MWT difference: >5°C
Ochric Epipedon; A-C Profile; Base Saturated; Sandy

Annex.4.9: MORPHOLOGICAL DESCRIPTION AND ANALYTICAL DESCRIPTION OF P-65

MAP UNIT	HORIZON	DEPTH	COLOUR MATRIX	COLOUR MOTTLES	SOIL STRUCTURE	SOIL TEXTURE	CONSISTENCE MOIST	CONSISTENCE WET	COATINGS CUTANS	CONCRETIONS (Fe-Mn)	PORES	ROOTS	BOUNDARY	REMARKS
o PROFILE: 65					o LOCATION: TRI THIEN-HUE Province									
o CLASSIFICATION			(Vietnamese) - Lightly Yellow Ferralitic Soil on Sandstone											
			(FAO) - Not possible											
	AB	0-14	7.5YR 6/4		sub-angular blocky when break	sandy loam	moist	firm		No		very fine roots	smooth gradual	
Fq	B	14-55	7.5YR 7/6		sub-angular blocky	sandy loam	very moist	firm		No		a few	same	
	BC	55-70	7.5YR 7/8		massive	sandy loam		firm		No		No	clear	
	D	>70			Weathering Rock									

Map Unit	Horizon	Depth (cm)	pH (1:5) Water	pH (1:5) KCl	Salts ($EC \times 10^3$)	Organic matter %	Soil Particle Size: Sand > 0.05 mm	Silt 0.05-0.002 mm	Clay <0.002 mm	CEC me/100g (soil)	CEC me/100g (clay)	Base Saturation (%)	Exchangeable cations me/100g soil: Ca	Mg	Na
o PROFILE: 65					o LOCATION: BINH-TRI-THIEN										
o CLASSIFICATION:			Vietnamese - Light Yellow Ferralitic on Sandstone												
			FAO -												
	AB	0-14	4.5		1.6	73	15	12.0	7.0			22	0.8	0.8	
Fq	B1	14-55	4.3		1.0	77	20	3.0	8.0			30	0.8	1.8	
	Bc	55-70	4.5		1.2	85	9	6.0	8.0			30	1.2	1.2	
	D	>70	-		-	-	-	-	-			-	-	-	

Remarks: No Bt. Undependable data

Annex.4.10: MORPHOLOGICAL DESCRIPTION AND ANALYTICAL DESCRIPTION OF P-493

MAP UNIT	HORI-ZON	DEPTH	COLOUR MATRIX	COLOUR MOTTLES	SOIL STRUCTURE	SOIL TEXTURE	CONSISTENCE MOIST	CONSISTENCE WET	COATINGS CUTANS	CONCRETIONS (Fe-Mn)	PORES	ROOTS	BOUNDARY	REMARKS
	o PROFILE: 493				o LOCATION: GIA-KUN TUM Province									
	o CLASSIFICATION		Vietnamese - Red - Yellow Ferralitic Soils on Granitic Rocks											
			FAO - Humic (Acrisols)											
	A	0-10	7.5YR 6/1		very fine angular	silty loam	friable				many		gradual	
Fa	B1	10-30	7.5YR 6/2		same	same	same				many		gradual	
	B2	30-70	7.5YR 6/6		fine angular	clay loam	firm				a few		gradual	
	B3	70-150	7.5YR 6/6		angular	same	firm							

Map Unit	Horizon	Depth (cm)	pH (1:5) Water	pH (1:5) KCl	Salts ($ECx10^3$)	Organic matter %	Soil Particle Size Sand > 0.05 mm	Silt 0.05-0.002 mm	Clay <0.002 mm	CEC me/100g (soil)	CEC me/100g (clay)	Base Saturation (%)	Exchangeable cations me/100g soil Ca	Mg	Na
	o PROFILE: 493				o LOCATION: GIA LAI KON TUM										
	o CLASSIFICATION:		Vietnamese - Red-Yellow ferralitic on Acid Magma												
					FAO - (Humic) Acrisols										
	A	0-10	4.6	3.9	3.9	53	14	33	10.6	32	19	1.5	0.5		
Fa	B1	10-30	4.9	4.1	2.8	49	6	45	8.0	18	20	1.3	0.3		
	B2	30-70	5.4	4.1	1.7	47	2	51	6.1	12	15	0.7	0.2		
	B3	70-150	5.6	4.3	0.9	49	4	47	4.6	10	21	0.3	0.7		

Remarks: Agric. Horizon; Base Saturation : <2; CEC: <24

Annex.4.11: MORPHOLOGICAL DESCRIPTION AND ANALYTICAL DESCRIPTION OF P-39

MAP UNIT	HORIZON	DEPTH	COLOUR MATRIX	COLOUR MOTTLES	SOIL STRUCTURE	SOIL TEXTURE	CONSISTENCE MOIST	CONSISTENCE WET	COATINGS CUTANS	CONCRETIONS (Fe-Mn)	PORES	ROOTS	BOUNDARY	REMARKS
	o PROFILE: 39						o LOCATION: BUON ME THUOT - BAK LAC Province							
	o CLASSIFICATION		(Vietnamese) - Red-Brown Ferralitic Soil on Basalt (FAO) - Humic Acrisols											
	A	0-20	2.5YR 3/2		fine crumb	clay loam	loose				many fine	many fine	clear smooth	
Fk	AB	20-50	2.5YR 4/6		fine crumb	clay	moist firm				many fine	many fine	smooth gradual	
	B1	50-70	2.5YR 4/6		Medium crumb	clay	moist friable				many fine	few roots	diffuse smooth	
	B2	70-110	2.5YR 4/6		Medium crumb	clay	moist very friable				many fine			

Map Unit	Horizon	Depth (cm)	pH (1:5) Water	pH (1:5) KCl	Salts ($ECx10^3$)	Organic matter %	Soil Particle Size Sand > 0.05 mm	Silt 0.05-0.002 mm	Clay <0.002 mm	CEC me/100g (soil)	CEC me/100g (clay)	Base Saturation (%)	Exchangeable cations me/100g soil Ca	Mg	Na
	o PROFILE: 39						o LOCATION: DAKLAK								
	o CLASSIFICATION:			Vietnamese - Red-Brown Ferralitic soils on Bazan FAO - Humic Acrisols											
	A	0-20	5.0	4.9		4.8	38	16	45	17.5		18	1.8	1.2	
Fk	AB	20-50	4.8	4.2		2.9	28	12	59	10.0		17	1.0	0.6	
	B1	50-70	4.8	4.3		1.7	27	12	60	6.9		19	0.8	0.4	
	B2	70-110	4.8	4.4		1.5	25	13	61	6.0		21	0.8	0.5	

Remarks: Rainfall: 1770 mm; MAT : 23°C; MST & MWT difference <5°C
Mollic Epipedon; Agric. Horizon, Base Saturation: <50; CEC <24

Annex.4.12: MORPHOLOGICAL DESCRIPTION AND ANALYTICAL DESCRIPTION OF P-6

MAP UNIT	HORIZON	DEPTH	COLOUR MATRIX	COLOUR MOTTLES	SOIL STRUCTURE	SOIL TEXTURE	CONSISTENCE MOIST	CONSISTENCE WET	COATINGS CUTANS	CONCRETIONS (Fe-Mn)	PORES	ROOTS	BOUNDARY	REMARKS
	o PROFILE: 6						o LOCATION: MOC HOA Dis LONG AN Province							
	o CLASSIFICATION		Vietnamese - Acid Sulphate Soils FAO - Thionic Gleysols											
	A1	0-25	5Y 4/2			clay loam	Moist firm	wet						
S	Ag	25-40	5Y 4/2			clay loam	"							
	Bg	40-60	2.5YR 6/2			clay	"							
	C	60-80	2.5Y 8/3			clay	"							

Map Unit	Horizon	Depth (cm)	pH (1:5) Water	pH (1:5) KCl	Salts ($EC \times 10^3$)	Organic matter %	Soil Particle Size Sand > 0.05 mm	Silt 0.05-0.002 mm	Clay <0.002 mm	CEC me/100g (soil)	CEC me/100g (clay)	Base Saturation (%)	Exchangeable cations me/100g soil Ca	Mg	Na
	o PROFILE: 6						o LOCATION: IN LONGAN PROVINCE								
	o CLASSIFICATION:		Vietnamese - Acid Sulphate Soils FAO - Thionic Gleysols												
	A1	0-25	3.2	2.9	0.66	2.1	2.2	28	70	17.9		32	1.6	3.0	0.4
S	Ag	25-40	3.2	3.0	0.58	2.7	3.1	30	66	15.7		33	1.6	3.0	0.3
	Bg	40-60	3.1	2.9	0.85	2.6	2.2	28	69	19.3		32	3.0	3.0	0.4
	C	60-80	3.2	3.0	0.92	3.4	2.7	25	72	20.6		29	1.4	4.0	0.4

Remarks: Rainfall : 1548 mm
MAT : 29.0°C
MST & MWT difference: <5°C

Annex.4.13: MORPHOLOGICAL DESCRIPTION AND ANALYTICAL DESCRIPTION OF P-102

MAP UNIT	HORIZON	DEPTH	COLOUR MATRIX	COLOUR MOTTLES	SOIL STRUCTURE	SOIL TEXTURE	CONSISTENCE MOIST	CONSISTENCE WET	COATINGS CUTANS	CONCRETIONS (Fe-Mn)	PORES	ROOTS	BOUNDARY	REMARKS
o PROFILE: 102							o LOCATION: PHUOC LONG Dis SONG BE Province							
o CLASSIFICATION			(Vietnamese) - Grey soils on Old Alluvial (FAO) - Humic Acrisols											
	A	0-20	10YR 6/4		single grain	loamy sands	very friable moist					many fine	smooth gradual	
X	B1t	20-45	10YR 5/3		same	sandy loams	same			a few fine concretion (5-10%)			gradual	
	B2t	45-80	10YR 5/3	10YR 5/6	very fine crumb	loams	same						gradual	
	B3t	80-110	10YR 5/3		fine crumb	sandy loams	firm			fine concretion (50-70%)				

Map Unit	Horizon	Depth (cm)	pH (1:5) Water	pH (1:5) KCl	Salts ($ECx10^3$)	Organic matter %	Soil Particle Size Sand > 0.05 mm	Silt 0.05-0.002 mm	Clay <0.002 mm	CEC me/100g (soil)	CEC me/100g (clay)	Base Saturation (%)	Exchangeable cations me/100g soil Ca	Mg	Na
o PROFILE: 102							o LOCATION: PHUOC-LONG PROVINCE								
o CLASSIFICATION:					Vietnamese - Grey Soils on Old Alluvial FAO - Humic Acrisol										
	A	0-20	3.4		3.4	64	2	34		~7.0	21		0.5	1.0	
X	Bt	20-45	3.9		1.3	65	4	31			~20		0.6	1.0	
	Bt1	45-80	4.1		-	65	2	33					0.5	1.0	
	Bt2	80-110	4.1		-	65	1	34					0.7	0.7	

Remarks: Rainfall : 2286 mm
MAT : 26°C
MST & MWT difference: <5°C
Texture : Clay content
Ochric Epipedon
Bt possible
Base Saturation: <20
CEC : < 20

Annex.4.14: MORPHOLOGICAL DESCRIPTION AND ANALYTICAL DATA OF P-1805

MAP UNIT	HORIZON	DEPTH	COLOUR MATRIX	COLOUR MOTTLES	SOIL STRUCTURE	SOIL TEXTURE	CONSISTENCE MOIST	CONSISTENCE WET	COATINGS CUTANS	CONCRETIONS (Fe-Mn)	PORES	ROOTS	BOUNDARY	REMARKS
o PROFILE: 1805					o LOCATION: LONG AN Province									
o CLASSIFICATION					Vietnamese - Saline Soils									
					FAO - Gleic Fluvisols (Salic Phase)									
	A	0-40	7.5YR 6/2		medium coarse prismatic	clay	firm			10%		many fine roots	clear	
Mn	B1	40-70	7.5YR 6/2		same	clay	firm			soft Mn concretion			clear	
	B2	70-110	7.5YR 6/1		coarse prismatic	clay	firm			few fine soft Mn concretion (<10%)				

Map Unit	Horizon	Depth (cm)	pH (1:5) Water	pH (1:5) KCl	Salts ($EC \times 10^3$)	Organic matter %	Soil Particle Size Sand > 0.05 mm	Silt 0.05-0.002 mm	Clay <0.002 mm	CEC me/100g (soil)	CEC me/100g (clay)	Base Saturation (%)	Exchangeable cations me/100g soil Ca	Mg	Na
o PROFILE: 1805						o LOCATION: LONG AN									
o CLASSIFICATION:						Vietnamese - Strongly Saline Soils									
						FAO - Gleyic Fluvisols (Saline phase)									
	A 7.5YR6/2	0-40	5.0	3.2	0.2	0.04	0.9	28.4	10.7	60.8	26	60	3.7	12	
Mn	B1 7.5YR6/2	40-70	6.0	6.7	0.4	0.06	0.5	24.4	10.7	64.8	22	75	3.5	13	
	B2 7.5YR6/1	70-110	6.4	6.4	0.4	0.04	1.1	25.5	10.0	64.4	21	75	3.2	12	

Remarks: ECe : 6-8 mmhos/cm; Salic properties

Annex.4.15: MORPHOLOGICAL DESCRIPTION AND ANALYTICAL DATA OF P-92

MAP UNIT	HORIZON	DEPTH	COLOUR MATRIX	COLOUR MOTTLES	SOIL STRUCTURE	SOIL TEXTURE	CONSISTENCE MOIST	CONSISTENCE WET	COATINGS CUTANS	CONCRETIONS (Fe-Mn)	PORES	ROOTS	BOUNDARY	REMARKS
o PROFILE: 92							o LOCATION: CHAU THANH Dis AN GIAWG Province							
o CLASSIFICATION			Vietnamese - Acid Sulphate Soils											
			FAO - Thionic Gleysols											
	AH	0-10	2.5Y 4/1		massive	clay loam	loose					very fine roots	diffuse	
S	B1g	10-48	2.5Y 5/1	2.5Y 7/8	same	clay	firm					same	clear	
	B21g	48-70	2.5Y 6/2	2.5Y 6/8	same	clay	same					very little	smooth gradual	
	B22g	70-110	2.5Y 6/1		same	clay	same					No	--	

Map Unit	Horizon	Depth (cm)	pH (1:5) Water	pH (1:5) KCl	Salts ($EC \times 10^3$)	Organic matter %	Soil Particle Size Sand > 0.05 mm	Silt 0.05-0.002 mm	Clay <0.002 mm	CEC me/100g (soil)	CEC me/100g (clay)	Base Saturation (%)	Exchangeable cations me/100g soil Ca	Mg	Na
o PROFILE: 92						o LOCATION: AN GIANG									
o CLASSIFICATION:			Vietnamese - Acid Sulphate Soils												
			FAO - Thionic Gleysols												
					% SO_4^{--}										
A	2.5Y 4/1	0-10	4.6	4.0	0.12	5.2	25.5	22	52.5	18		22	1.8	5.5	0.4
S Bg	2.5Y 5/1	10-48	4.1	3.2	0.06	2.7	27.5	22	50.5	19		18	3.1	3.9	0.3
Bj	2.5Y 6/2	48-70	3.7	2.9	0.24	2.5	27.5	24	48.5	17		15	3.1	-	0.5
Bj	2.6Y 6/1	70-110	3.4	3.2	0.24	-	27.5	22	50.5	20		20	4.2	3.6	0.5

Annex.4.16: MORPHOLOGICAL DESCRIPTION AND ANALYTICAL DATA OF P-45

MAP UNIT	HORI-ZON	DEPTH	COLOUR MATRIX	COLOUR MOTTLES	SOIL STRUCTURE	SOIL TEXTURE	CONSISTENCE MOIST	CONSISTENCE WET	COATINGS CUTANS	CONCRETIONS (Fe-Mn)	PORES	ROOTS	BOUNDARY	REMARKS
o PROFILE NO: 45								o LOCATION: PHAUN THIET - THUAN HAI Province						
o CLASSIFICATION			Vietnamese - Brown-Grey Soils (Semi arid region)											
			FAO - Luvisols											
	Ap	0-24	10YR 4/2		medium sub-angular blocky to massive	sandy loam	very hard (moist)						clear smooth	
Xk	E	24-37	5YR 5/6		sub-angular blocky	sandy loam	hard						clear irregular	
	Btg	37-76	10YR 6/6		coarse sub-angular	sandy loam	hard		weak clay coatings	some fine iron concretions			abrupt irregular	
	Ces	76-120	Plinthite with lateritic gravel of 2 to 10 mm diameter											

Map Unit	Horizon	Depth (cm)	pH (1:5) Water	pH (1:5) KCl	Salts ($EC \times 10^3$)	Organic matter %	Soil Particle Size: Sand > 0.05 mm	Silt 0.05-0.002 mm	Clay <0.002 mm	CEC me/100g (soil)	CEC me/100g (clay)	Base Saturation (%)	Exchangeable cations me/100g soil: Ca	Mg	Na
o PROFILE: 45						o LOCATION: PHAN-THIET									
o CLASSIFICATION:			Vietnamese - Brown-Grey Soils												
			FAO - Luvisols (Semi acid region)												
	A	0-24	5.9		0.7	71	13	15	4.1			<40%	3.4	0.5	
	E	24-37	6.0		0.4	69	13	17	4.0		~<24		3.1	0.7	
Xk	Btg	37-76	5.7		0.5	65	15	19	3.8		~<24	83	2.7	0.1	
	C	76-120	6.4		0.3	60	19	21	4.3		~<24	80	2.5	0.1	

Remarks: Rainfall : 1110 mm; MAT : 26.6°C; MST & MWT difference: <5°C;
Bt Horizon; Base Saturation: <40; CEC: < 24

Annex.4.17: MORPHOLOGICAL DESCRIPTION AND ANALYTICAL DATA OF P-53

MAP UNIT	HORI-ZON	DEPTH	COLOUR MATRIX	COLOUR MOTTLES	SOIL STRUCTURE	SOIL TEXTURE	CONSISTENCE MOIST	CONSISTENCE WET	COATINGS CUTANS	CONCRETIONS (Fe-Mn)	PORES	ROOTS	BOUNDARY	REMARKS
o PROFILE : 53							o LOCATION: AN GIANG Province							
						Vietnamese - Alluvial Soils of the Mekong River								
o CLASSIFICATION														
						FAO - Gleyic Fluvisols								
	A	0-16	10YR 5/6		Sub-angular	clay					very fine		gradual	
Pc	B1	16-54	10YR 4/6			clay					a few		gradual	
	B2	54-140	10YR 4.5/6	7.5YR 8/6	sub-angular	clay ioams					No			

Map Unit	Horizon	Depth (cm)	pH (1:5) Water	pH (1:5) KCl	Salts ($EC \times 10^3$)	Organic matter %	Soil Particle Size Sand > 0.05 mm	Silt 0.05-0.002 mm	Clay <0.002 mm	CEC me/100g (soil)	CEC me/100g (clay)	Base Saturation (%)	Exchangeable cations me/100g soil Ca	Mg	Na
o PROFILE: 53						o LOCATION: AN-GIANG									
						Vietnamese - Alluvial Soils of The River Mekong									
o CLASSIFICATION:															
						FAO - Gleyic Fluvisols									
	Ap	0-16	6.6	5.0		1.77	23.5	32.0	44.5	17	38	65	8.6	2.8	
Pc	A3	16-54	7.5	5.7		0.83	23.5	32.5	42.4	17	40	70	10.0	2.3	
	B1	54-140	8.3	7.1		0.57	25.5	25.5	36.5	18	51	75	10.5	3.6	

Remarks: Rainfall : 2051 mm;
MAT : 27.4°C
MS & MWT : <5°C
Ochric epipedon; No diagnostic horizon;

Institutes and Persons consulted/contacted

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oo Criteria Used in Different Systems

SYSTEM	CATEGORIC LEVEL NUMBER						
	1	2	3	4	5	6	7
USSR (Russia)	BELT FOR-MATION	FACIES CLASS -	TYPE	SUB-TYPE	GENOUS	SPECIES	VARIETY
USDA (America)	ORDER	SUBORDER	GREAT GROUP	SUB-GROUP	FAMILY	SERIES	PHASE
ORSTOM (France)	CLASSE	SOUS-CLASSE	GROUPE	SOUS-GROUPE	FAMILY	SERIES	TYPE/ PHASE

(eg. Borial, Polar, Trop., Equatorial)

USSR: Each climate Belt corresponds to a characteristic SOIL FORMATION (Proposed). The Intertrop. Soils - (Trop-Et)

LEVEL 1 USDA: 10-ORDERS; Each Groups soils that differ LITTLE in their kind and relative strength of processes-that develop Horizons.

ORSTOM: According to mode and intensity of soil evolution (be Weathering stage, Profile dev., OM, RO, etc) eg.soils pH evolues (Entisols),Soils Halomorphes hydromorphes, sols isohumigues, sols and oxides

USSR: Facies defined by dayt exceeding 10°C, and R/Evop. Ratio (eg. Trop., continental monsoon, Equ. fani)

LEVEL 2 USDA: Differentise used are:Chem. and Phy. properties that reflect waterlogging or genetic variability due to.

ORSTOM: Based on Pedoclimate conditions (Temp.Humidity) eg. Sols of S_2O_3 hrs divided on content and behaviour of RO_3 as: solrouge meditterean; sols ferruginous trop etc. sols hydromorphic are based on G.W., OM, etc.

LEVEL 3 Categories from this downwards, become increasingly similar eg. GG/Type/Groups are defined kind of Phy.

SOIL TAXONOMY

DEVELOPMENT : Thru diff. Approximations; thru Approx (1960)

SALIENT FEATURES

- Based on measureable soil properties
- Classes defined in terms of soil properties
- Soil properties which are the outcome of soil genesis
- New nomenclature
- A new category - Subgroup - added
- Orderly scheme for naming diff. categories

DIAGNOSTIC HORIZONS

- Surface - EPI (Mollic, Umbric, Ochric .....)
- Subsurface (Argillic, Cambic, Oxic, Salic...)

NOMENCLATURE

- Crieteria
- Greek or Latin origin

STRUCTURE

- Higher Categories : Orders - 10
  Suborders - 47
  Great Groups-227
- Lower Categories : Subgruops - 1000
  Families -
  Series - Type/Phase

ORDERS

- Naming : . Coined words and ends with 'SOL'
  . Have a connecting vovel 'i'/'o'
  . First syllable repr. order name, eg. MOLLIC
  . AWAMIHOUSE - for all order name
- Formative Element : Abstracted from each order

  How - 'Table'

Formative Elements and Names of Orders - Thru derivations, Approx. Equiv. in different systems

Name of Orders	Formative Element	Derivation of Formative Elem.	Approx. Equivalents In: Genetic System	FAO-Unesco Legend
AR/ID/I SOL	ID	L.Aridus, dry	Desert, Sierozem, Subclass	Gypsisols,Calcareous,Xerosols,
V/ERT/I SOL	ERT	L.Verto. Turm	Grumisols,Black (cotton),Ragi	Vertisols
/ALF/I SOL	ALF	Nonsense Pedalfem	Gray-loam,Podzol Non-calcic,Brown Plonosols	Luwsols(Nitisols)
M/OLL/I SOL	OLL	L.Molls, soft	Chestnut,Chermozomes,Brunizome, Pendzinos	Chermozons, Kasterozome, Phasozoms
INC/CEPT/I SOL	EPT	L.Inception begining	Sol Brown acid, Forest,hamia phy	Cambisols
M/IST/O SOL	IST	Gx,Histes, Tissue	Bog soils	Hostosols
/OX/I SOL	OX	F.Oxide, oxide	Lalosols,Laterite soils	Ferrolsols
/ULT/I SOL	ULT	L.Ultimns, Last.	Redyellow,Podzolic Laterite	Borisols, Slisols
SP/OD/O SOL	OD	Gx.spodos, weed	Podsols,Brown Podzolic	Podsols
/ENT/I SOL	ENT	Nonsense, Recent	Azonal,Low humic gley	Regosols,Arenosols, Fluvis

•	Formative Elements id,ert,oll etc.	Used as Inentifier of the order name at all the lower categories(suborders) eg. UD 'OLL'

SUBORDERS : Consists of 2 Sylables (1) Suggests, property of class
(2) Suggests name of order
id. UD, OLL, UST, ALF, UD ULT, UST OX, FLUV EM

GREAT GROUPS:

SUBGROUPS

- Names consists of name of appropriate great group modified by one adjective eg. Typic Hapludoll
- Nomenclature of different categories is shown as:

M OLL I SOL	Order
UST OLL	Suborder
Argi UST OLL	Great Group
Typic Argi Ustoll	Sub Group

CRITICISM

- It departs from Genetic approach
- Have strong Geog. bias towards and orders (Enti, Verti., Histo, Incep., i.e. Azonol and Interzonal soils
- Soils with different genesis, but having similar properties go in one unit
- No place (at order level) for Hydroprofine, Saline/Sodic/Acidsol soils

APPRECIATION

- Most elaborate
- Bases are soil properties
- Nomenclature suggess soil properties
- Built-in-mechanism
- Permits class of soils, not of soil forming processes
- Permits Uniformity among different scientists

Tavernier said " It is a Greatest contribution in recent years".

HOW TO USE (for classifying soils)

- First Step - Identify soil order (see Key - Table after understanding soil genetic system)

SIMPLIFIED KEY FOR CLASSIFYING SOILS

C O N C E P T S		ORDER
Soils with 30% OM to a depth of 40 cm	-Yes→	HISTOSOL
NO ↓		
Soils with Spodic or Placic hor, but No Plaggen epi.	-Yes->	SPODOSOL
NO ↓		
Highly weathered soils with an Oxic hor within 2 cm and have no argilic or natric overlying the Oxic hor.	Yes ----->	OXISOL
NO ↓		
Swell-Shrink Soils; have 30% or more Clay (upto 1m) + Deep cracks + Suceensides or Quomon Relief	Yes ----->	VERTISOL
NO ↓		
Dry Soils with Ochric or Authrepic epi; Fine, have calcic, Gypsic, Cambic or Argillic hor.	Yes ----->	ARIDISOL
NO ↓		
Dark colored, base rich (>50 upto 1.8 cm depth) Soils of Grassland with Mollic epi.	Yes ----->	MOLLISOL
NO ↓		
Low base status soils (<35%) of warm humid Reg. MAT>8°C; + have Argillic hor.	Yes ----->	ULTISOL
NO ↓		
High base status (>35%) soils of Humid and subhumid Reg. with an Ochric epi. + Argillic Hor.	Yes ----->	ALFISOL
NO ↓		
Recent soils with No Diagnostic Hor. except Ochric or	Yes ----->	ENTISOL
NO ↓		
Others; have no spodic, Argillic, Matric, Oxic Petrocatcic, Plinthits; have Cambic B-hor	Yes ----->	INCEPTISOL

DIAGNOSTIC PROPERTIES OF ORDERS

BASED ON	DIAGNOSTIC PROPERTY	ORDER
• Nature of soil material,	- Very high O.M. content....	HISTOSOL
	- Carcking clays or swell shrink clays.....	VERTISOL
• Presence/Absence Diagnostic Hor.	- No diag. Hor.	ENTISOL
	- Cambic Hor. or Umbic epi....	INCEPTISOL
	- Mollic epi. and High B.S....	MOLLISOL
	- Spodic hor.	SPODOZOL
	- Argillic hor. - High B.S....	ALFISOL
	- low B.S.....	ULTISOL
	- Oxic hor.	OXISOL
• Soil Moisture Reg.:	Ustic thru. or Saline.....	ARIDISOL

WORKSHOP-2 FAO - UNESCO REVISED LEGEND FOR SOIL MAP OF THE WORLD

by:
Prof. J. SEHGAL, Consultant FAO-UNDP

Nov. 27,1989 (Afternoon Session)(1.30-5.00 PM)

BACKGROUND

- 1960 ISSS (at Madison) recommended prep. of World Soil Map
- 1961 Work started; successive drafts of the Soil Map and legend prepared from existing inform.; systematic Soil Correlation done.
- 1968 ISSS (at Adelaide) approved Legend, Nomenclature and definition of soil units.
- 1971 1st Sheet of Map finalized
- 1981 The last 2 sheets of 19-sheets Soil Map of World purlished thru 25 yr. involving 300 scientists

OBJECTIVES

- Appraisal of the World Soil Resources
- Provide scientific base for transfer of Tech.
- Establish generally accepted soil classification and nomenclature
- Establish common framework for detailed investigations
- Serve as a basic document for teaching, research and development
- Strengthen international cooperation

BUT HOW ?

- Lack of internationally accepted system
- Divergenes in different approaches
- Dissimilarities in environments

THE NEED

GENERAL PRINCIPLES

SELECTION OF SOIL UNITS

- Was based on the existing knowledge about soil formation characteristics and distribution of soils
- Generally comparable to the Great Groups in the systems

DEFINING SOIL UNITS

- Soil units defined in terms of Measureable and observable propertion
- The differentise used are properties of soils
- Soil properties are selected based on Principle of Soil Formation so as to correlate with many other characteristics
- No units are defined using Climate as crietria

LEGEND CONSTRUCTION

- Based on Intern. agreement reg. Major Soils to be represented
- No concensus reached on weightage each unit should have within the classification system
- Concepts of Climate, Zonality, Evolution, Morphology, Ecology or Geology differ most of the soil classification and
- The available knowledge make it difficult to apply many of the concepts on general basis.
- Degree of profits developent cannot be used consistently because soils in difficult parts are not members of a contineous sequence of Soil Formation (eg. Podzols and Feramalsols) since they are product of different Environments.
- Similarly climate (concept of zonanility) cannot be used because infl. of clim. is secondary to the effect of AM or Age. eg. Podzols may occur both under Boreal and Tropical climates, Planosols are formed due altern. wet dry conditions (Physing after)
- The legend used is based on factual inventories reg. distribution and characteristics of world soils, and
- Can be used for practical and scientific purposes.

SYSTEM OF LISTING SOILS

- Based on geophysical distribution and

Table. SOIL UNITS AND MAJOR SOIL GROUPING (Level - 1)

Not bound to zonality concept	Conditioned by Parent Material	Initial Stage	Salt accumulation or Physiologically dry
● Fluvisols(FL)	o Arenosols(AR)	o Cambisols (CM)	o Calcisols(CL)
● Gleysols(GL)	o Andisols(AN)		o Gypsisols(GY)
● Regosols(RG)	o Vertisols(VR)		o Soloneti(SN)
● Leptisols(LP)			o Solonchaks(SK)

Accum.of Bases + O.M.	Accum. of Clay $+RO_3$	Intense weathring(Trop., Subtrop.Reg.	Organic Soils
● Kastanozems(KS)	o Luvisols(LV)	o Lixisols(LX)	o Histosols(HS)
● Cnersnozems(CN)	o Planosols(PL)	o Acrisols(AC)	
● Phaeozems(PN)	o Podzoluvisols (PD)	o Alisols(AL)	
● Greyzems(GR)	o Podzols(PZ)	o Nitisols(NT)	o Humn Infli.
		o Ferralsols(FR)	
		o Plinthosols (PT)	o Anthrosols (AT)

MAJOR CHANGES IN SOIL GROUPS

- Lithosols, Renoznas, Kankers have been grouped as LEPTOSOLS
- Ferosols grouped into Arenosols (as sandy soils are)
- Luvisols separated into Luvisols and Lixisols
- Actisols separated into Acrisols and Alisols as under:

Prop.	Luvisols	Lixisols	Acrisols	Alisols
Argic(Bt)	x	x	x	x
CEC	>24me/100gm	<24	<24	>24(me/100g clay)
BS	>50	>50	<50	<50

- Yermosols, Xerosols dropped because they were based on Aridic moisture regime
- Calcisols, Gypsisols have been introduced
- Plinthosols being different than Ferralsols, hence separated at highest level
- Anthorosols added

NOMENCLATURE

- Laterite dropped and new words coined
- Phaglam newly coined word soils with Bt occurring in
- Us traditional names (existing and well known internationally) eg. Soldnst, Chernozims, Podzols, Planosols, Solonosols, Soldnchard, Solonatz, Regosols.
- Name have acquired acceptance (Tertisols, Andosols, Acto Ferrai

FORMATIVE ELEMENTS

- Major Soil Groups (Level 1)
- Soil Units (Level 2) e.g. Albic, Andic, Acric, Calcaric, Calcic, Cambic, Chromic, Carbic, Cumabic, Dystric, Febric, Glaeyic, Luvic)

DIAGNOSTIC HORIZONS

- Soil hors. that combine a set of properties used for identifying soil units are diag. hor. These are produced by Soil Genesis
- Definition and nomenclature are drawn from Soil taxo (1975). However somewhere these are simplified
- Terminology used for describing soils is as given in FAO's Soil Des.

DIAGNOSTIC PROPERTIES

- Characteristics used to separate soil units are not considered as No. These are diag. features of hor. which are quantified for classifying soils. They are:

- Abrupt Tex. Change	- Gletic	- Slickensides
- Andic Properties	- Stagnic	- Sodic
- Calcareous	- Gypsiferous	- Humic
- Calcaria	- Nitic	- Sulphedic
	- Salic	- Vertic, etc.

PRINCIPLES FOR SOIL GROUPING

- Soil units have their upper boundary at the surface or <50cm
- Hor. burried by 50cm of new material are no longer treated diagnostic
- Diag. Hor. and Diag. properties are assumed to have their upper boundary <12cm
- When 2 or more diag. Hor. occur, the upper B-hor.(except Cambic) is considered
- Climatic data are not used to separate soil units

SUBUNITS CRITERIA (3rd Level Separation)

Comprehensive list not available for use at Global level. Defined in terms of NEED of National or Regional level. The Principles foilowed are given at P 56.

- Intergrades between major soils (5 possibilities)
- Intergrades season soil units (2nd level) when two occur
- Properties/Hor. send at PHASE level
- Characteristics need is addition to the and 1st and 2nd level units.
- Characteristics
- Use of 2 intergrades

PHASES

Limitations factors related to surface or subsurface features of land

KEY

For classifying soils + Discussion on soil profile classification

" WORKSHOP-3 APPLICATION OF FAO-UNESCO SYSTEM FOR CLASSIFYING AND CORRELATING THE SOILS OF VIETNAM"

Nov. 28,1989 (Morning Session)

The application of FAO-UNESCO system of soil classification for classifying and correlating the soils of Vietnam was discussed and demonstrated using the SOIL MICROMONOLITHS (collected during field studies). A lot of discussiion took place as some of the names were in contrast to the imagination of some university profesors and other pedologists. The morphology and analytical data were used to support our assertion which convinced them all. Some scientists even commented

> "We may have to change some of our earlier concepts regarding soil evolution and degradation of soils and follow the recent thinking to classify and correlate our soils "for land use planning".

The comments of some renowned pedologists are appended as Annex..... In short the house highly appreciated the efforts put in by the consultant to explain the hard subject matter in much simpler ways that all of the persons could follow. To the consultant, it was a satisfying experience.

"WORKSHOP-4 SOILS AND CLIMATIC RESOURCE INVENTORIES FOR LAND EVALUATION TOWARDS LAND USE PLANNING"

Nov. 28,1989 (2nd Morning Session)

A set of SLIDES was used to demonstrate the importance of soils and climatic inventories for land evaluation using FAO approach for land use planning. Two case studies were taken as examples for working out the suitability of soils and site conditions for different crops with the objective to improve the existing cropping pattern.

"WORKSHOP-5 SOIL RESOURCE MAPPING USING REMOTE SENSING TECHNIQUE"

Nov. 28,1989 (Afternoon session)

Basic principles of soil survey and mapping were explained. The advantages and disadvantages of tradtional and other techniques were highlighted.

The topic arose a lot of interest as a lot of discussion was generated. The question and answer session was most interesting part of this session.

In the end, different persons spoke about the Seminars/Workshops arranged during the two days (full).

It has been, although heavy, yet a very satisfying experience to the consultant as there has been a great demand from the NPD to offer seminars to his and other staff (soil scientists and pedologists) working in Vietnam.

The comments and list of participants are given in Annex.... and Annex.....

ANNEXURE 7

LIST OF PARTICIPANTS ATTENDED THE WORKSHOPS
ON
Soil Classification, Soil Survey and Land Use Planning
held on November 27-28, 1989, at NIAPP-Hanoi (Vietnam)

Sr.	NAME	TITLE AND INSTITUTE
1.	Dr. TRAN AN PHONG	Director, NIAPP
2.	Dr. TRAN KHAI	Vice Chairman of the State Planning Committee
3.	Dr. Prof. TON THAT CHIEU	NDP-VIE/86/024 - NIAPP
4.	Dr. Prof. LE DUY THUOC	Specialist - NIAPP
5.	Dr. Prof. CAO LIEM	Professor of the Agriculture University No. 1
6.	Dr. TRAN CONG TAU	Hanoi University
7.	Dr. VU NGOC TUYEN	General Department for Land Management
8.	Mr. DO DINH THUAN	Pedologist, Institute of Agro-Chemistry and Pedology
9.	Mrs. PHAM THI BINH	Head of the Soil Science Department - NIAPP
10.	Dr. Pham Duong Ung	Deputy Chief of The Soil Science Department - NIAPP
11.	Mr. Nguyen Quang Huyen	Soil Scientist - NIAPP
12.	Dr. Nguyen Khang	Soil Scientist - NIAPP
13.	Mr. Pham Quang Khanh	Chief of the Soil Science Deptt. - Sub - Institute, (NIAPP)
14.	Mr. Nguyen Cong Pho	Head of the Centre of Planning and Soil Science NIAPP
15.	Mr. Nguyen Van Khiem	Deputy Head of the Centre
16.	Mr. Nguyen Ngoc Thinh	Soil Scientist - NIAPP
17.	Mr. Chu dac Thinh	Soil Scientist - NIAPP
18.	Mr. Nguyen van Tan	Soil Scientist - NIAPP
19.	Mr. Le Thai Bat	Head of the Chambre of Science - NIAPP
20.	Mr. Dao Can	Deputy Head of The Chambre of Science - NIAPP
21.	Dr. Rao Chau Thu	Soil Scientist - Agriculture University No. 1 Hanoi
22.	Mr. Le Van Hieu	General Department of Land Management
23.	Mr. Do Dinh Dai	Soil Scientist - NIAPP
24.	Mr. Tran Huy Nghi	Soil Scientist - NIAPP
25.	Mr. Nguyen Thanh Thong	Soil Scientist - NIAPP
26.	Mr. Can Trieu	Soil Scientist - NIAPP
27.	Mr. Tran Mong Tan	Soil Scientist - NIAPP
28.	Mr. Nguyen Dac Dan	Soil Scientist - NIAPP
29.	Mr. Nguyen Viet Thanh	Soil Chemist - NIAPP
30.	Mr. Chu Dinh Lam	Soil Chemist - NIAPP
31.	Mr. Hoang Xuan Tin	Soil Scientist - NIAPP

32.	Mrs. Vo Thi Minh Chau	Soil Scientist - NIAPP
33.	Dr. Le Hong Son	Soil Scientist - NIAPP
34.	Mr. Nguyen Dinh Khang	Soil Scientist - NIAPP
35.	Nguyen Canh Phong	Soil Scientist - NIAPP
36.	Mr. Lam Quang Hinh	Remote Sensing Department
37.	Mr. Do Ninh	Assistant - Project VIE/ 86/024
38.	Mr. Pham Nguyen Dien	Assistant - Project VIE/ 86/024
39.	Mr. Duong Anh Tuyen	Chambre of Science - NIAPP
40.	Mr. Nguyen Van Hien	Soil Scientist NIAPP

COMMENTS OF LEADING SCIENTISTS about the WORKSHOPS/SEMINARS (No 1-5)

by: Prof.Dr. J.SEHGAL FAO-CONSULTANT

at: NATIONAL INST. AGRIC. PLANNING & PROJECTIONS (NIAPP)

HANOI, November 27-28, 1989

Lectures given by Dr. J Sehgal in this workshop for 2 days are very interesting and helpfull for all pedologists present in the. The presentation of D. Sehgal about the Soil Taxonomy and the Legend of the World soil map (FAO/UNESCO) is quite clear, easily understood for us.

Pedology of Vietnam, in particular soil classification and soil mapping should be improved and opened over the world - To this for this challenge, it must be helped by other country consultants especially the help and consultancy of D. Sehgal.

I hope Dr. Sehgal will come back to Vietnam for several missions to work together with our pedologists.

Thank you very much -

Good luck for Dr. Sehgal -

Hanoi Nov - 28th 1989.

Nguyen

Do Dinh Thuan

Institute for Soils & Fertilizers (ISF)

HANOI

(Prof Dr. TRAN CONG TAU)

Dr of Botanical Sciences

Hanoi City of Flowers

NOV. 28, 1989

The term of Workshop was very short, but I think that it was a significant important and useful for our MAPP and for all of our soil scientists. I hope that the relationship between our MAPP and your institute is/is will be strengthened and our discussion on soil mapping and soil classification is the future to be useful for the our country. Thank you very much for entertain and assistance to us.

Lê Thai Bat
Head of Science division
of MAPP Soil Scientist

(DR. LE THAI BAT)

By: G/S. Lê duy Thước
nguyên-hiệu trưởng Trường-đại học nông nghiệp I mang tên HÔXÊ MACTÍ
Trưởng-ban xây dựng bản đồ đất Việt Nam
Hanoi

Thay thức cảm ơn giáo sư J. Sengal nhà bác-học uyên thâm về thổ nhưỡng Hoa Kỳ đã truyền dạy những kiến thức mới nhất về khoa học thổ nhưỡng cho anh chị em Việt Nam.

Mong rằng giáo sư còn dịp trở sang Việt Nam với anh chị em chúng tôi.

Rất mong giáo sư truyền đạt cho cơ quan nghiên cứu khoa học các nhà thổ nhưỡng Hoa Kỳ đi đôi hợp tác trong lĩnh vực thổ nhưỡng toàn Liên Bang Mỹ để mà giáo sư là Hội trưởng.

Prof. Dr. LE DUY THUOC
Former Head, State Agric. Univ. No 1
HANOI - VIET.

Lê duy Thước

Nhận xét đợt làm việc với ông Dr. C. Sengal

Trong đợt làm việc với ông Sengal chuyên gia thổ nhưỡng, từ 1/11 đến 2 tháng 12 1989, tôi đã đi hỏi thì giả cùng điều tra nghiên cứu đất ngoài đồng không lo phẫu diện của 2 miền Bắc và Nam. Với các loại đất còn nhiều vấn đề trong việc xếp loại, nhất là các soils unit Fluvisol. Gley sol Acrisol Ferrasol.

Chuyên gia đã góp ý kiến tốt để giúp chúng tôi xây cái phần diện tiện theo đơn vị bản đồ của FAO Unesco và theo Taxonomy USDA. Đây là công đóng lớn nhất của chuyên gia giúp chúng tôi xếp các loại đất Việt nam theo những đơn vị tiêu chuẩn của bản đồ ... loại đất quốc tế. Công tác điều tra nghiên cứu nó đã cụ thể là một khối lượng rất lớn không thể làm trong một thời gian ngắn được.

Chuyên gia đã giúp khá cụ thể về phương pháp điều tra đánh giá đất ngoài đồng vận dụng tiêu chuẩn phân loại FAO Unesco và Taxonomy USDA.

Trong 2 ngày nói chuyện và trao đổi ở Viện chuyên gia đã làm rõ các hệ thống phân loại đất quốc tế vận dụng xếp 20 năm kinh nghiệm nghiên cứu, cho người kinh nghiệm về việc dùng đất và [illegible] tới lĩnh triển vọng chuyên của Viện, các hướng đi này và [illegible] quan tâm.

Nhưng do có còn nêu trên tiếp vụng yêu cầu mong muốn của chúng tôi, chuyên gia đã làm việc nhiệt tình. [illegible] Xin cảm ơn [illegible] tiến sĩ [illegible]

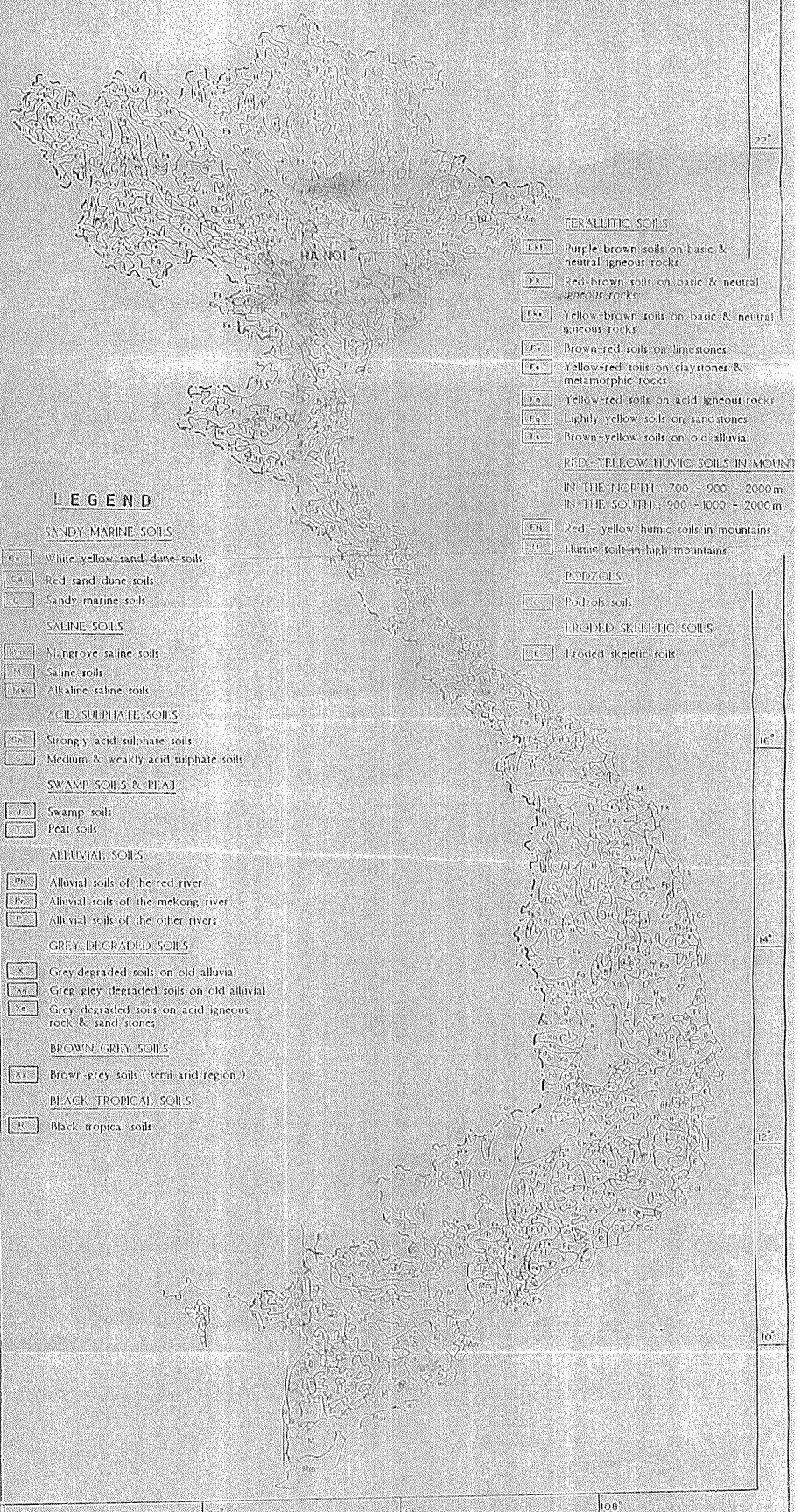
[illegible] 1/1/[illegible]

[illegible]

Fig. 5

VIETNAM – *SOILS*

Km 0 30 60 90 120 150 Km



LEGEND

SANDY MARINE SOILS
- White yellow sand dune soils
- Red sand dune soils
- Sandy marine soils

SALINE SOILS
- Mangrove saline soils
- Saline soils
- Alkaline saline soils

ACID SULPHATE SOILS
- Strongly acid sulphate soils
- Medium & weakly acid sulphate soils

SWAMP SOILS & PEAT
- Swamp soils
- Peat soils

ALLUVIAL SOILS
- Alluvial soils of the red river
- Alluvial soils of the mekong river
- Alluvial soils of the other rivers

GREY-DEGRADED SOILS
- Grey degraded soils on old alluvial
- Greg. gley degraded soils on old alluvial
- Grey degraded soils on acid igneous rock & sand stones

BROWN GREY SOILS
- Brown-grey soils (semi arid region)

BLACK TROPICAL SOILS
- Black tropical soils

FERALLITIC SOILS
- Purple-brown soils on basic & neutral igneous rocks
- Red-brown soils on basic & neutral igneous rocks
- Yellow-brown soils on basic & neutral igneous rocks
- Brown-red soils on limestones
- Yellow-red soils on claystones & metamorphic rocks
- Yellow-red soils on acid igneous rocks
- Lightly yellow soils on sandstones
- Brown-yellow soils on old alluvial

RED – YELLOW HUMIC SOILS IN MOUNT
IN THE NORTH : 700 – 900 – 2000 m
IN THE SOUTH : 900 – 1000 – 2000 m
- Red – yellow humic soils in mountains
- Humic soils in high mountains

PODZOLS
- Podzols soils

ERODED SKELETIC SOILS
- Eroded skeletic soils

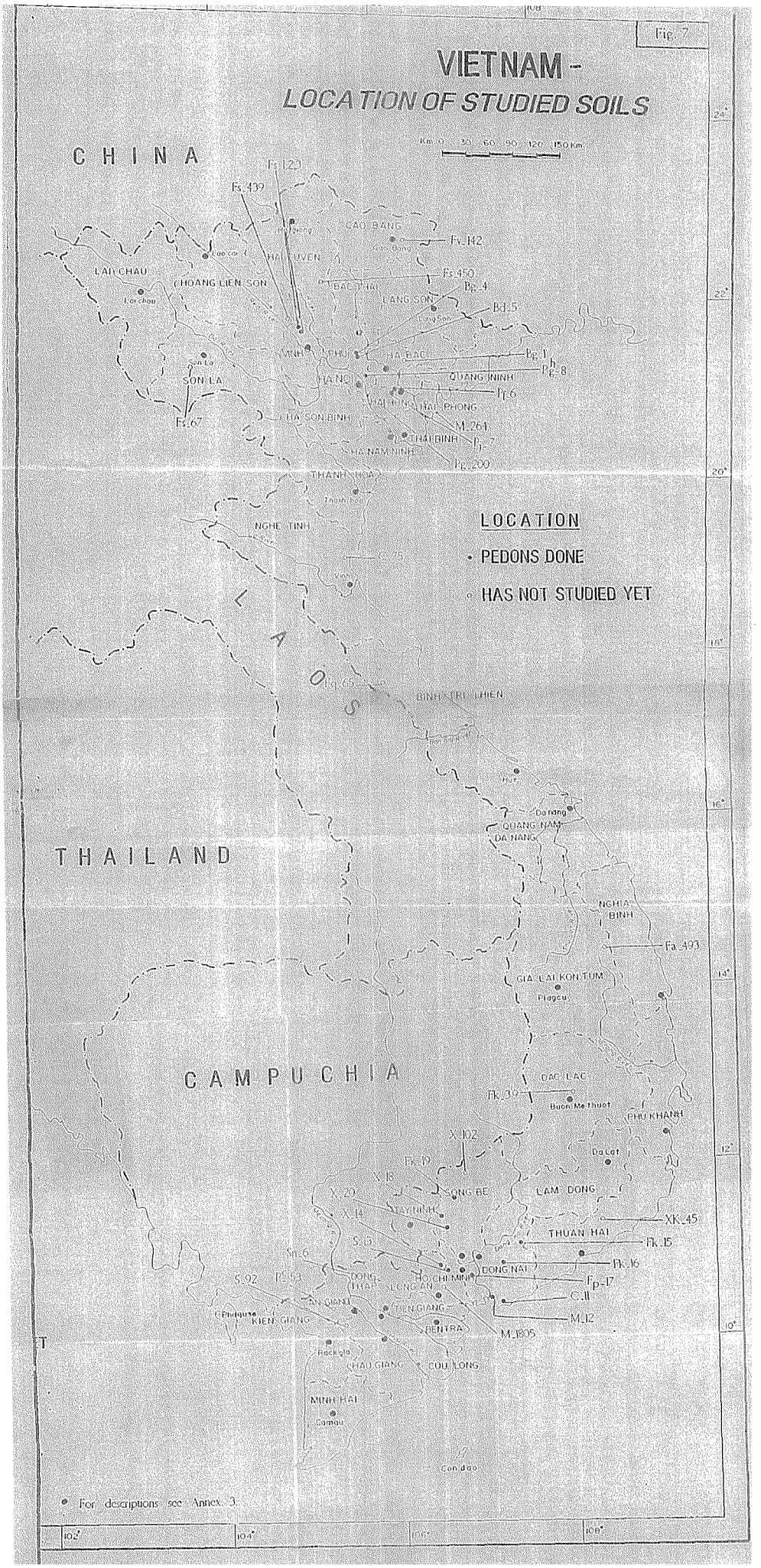


Fig. 7
VIETNAM -
LOCATION OF STUDIED SOILS
Km 0 30 60 90 120 150 Km
CHINA
Fs.123
Fs.439
CAO BANG
Fv.142
LAI CHAU
HOANG LIEN SON
Fs.450
Pg.4
LANG SON
Pf.5
Pg.1
Pf.8
SON LA
HA NOI
QUANG NINH
Pf.6
HAI HUNG
HAI PHONG
Fs.67
HA SON BINH
M.264
THAI BINH
Pf.7
HA NAM NINH
Pg.200
THANH HOA
NGHE TINH
C.75
LOCATION
• PEDONS DONE
◦ HAS NOT STUDIED YET
L A O S
BINH TRI THIEN
QUANG NAM
DA NANG
THAILAND
NGHIA BINH
Fa.493
GIA LAI KON TUM
Playcu
CAMPUCHIA
DAC LAC
Fk.39
Buon Me thuot
PHU KHANH
X.102
Da Lat
Fk.19
X.18
SONG BE
LAM DONG
X.20
TAY NINH
X.14
XK.45
THUAN HAI
Fk.15
S.16
Fk.16
DONG NAI
S.92
DONG THAP
HO CHI MINH
LONG AN
Fp-17
C.11
AN GIANG
TIEN GIANG
KIEN GIANG
M.12
BENTRA
M.1805
Rachgia
CHAU GIANG
CUU LONG
MINH HAI
Camau
Con dao
For descriptions see Annex 3.
102°
104°
106°
108°
24°
22°
20°
18°
16°
14°
12°
10°

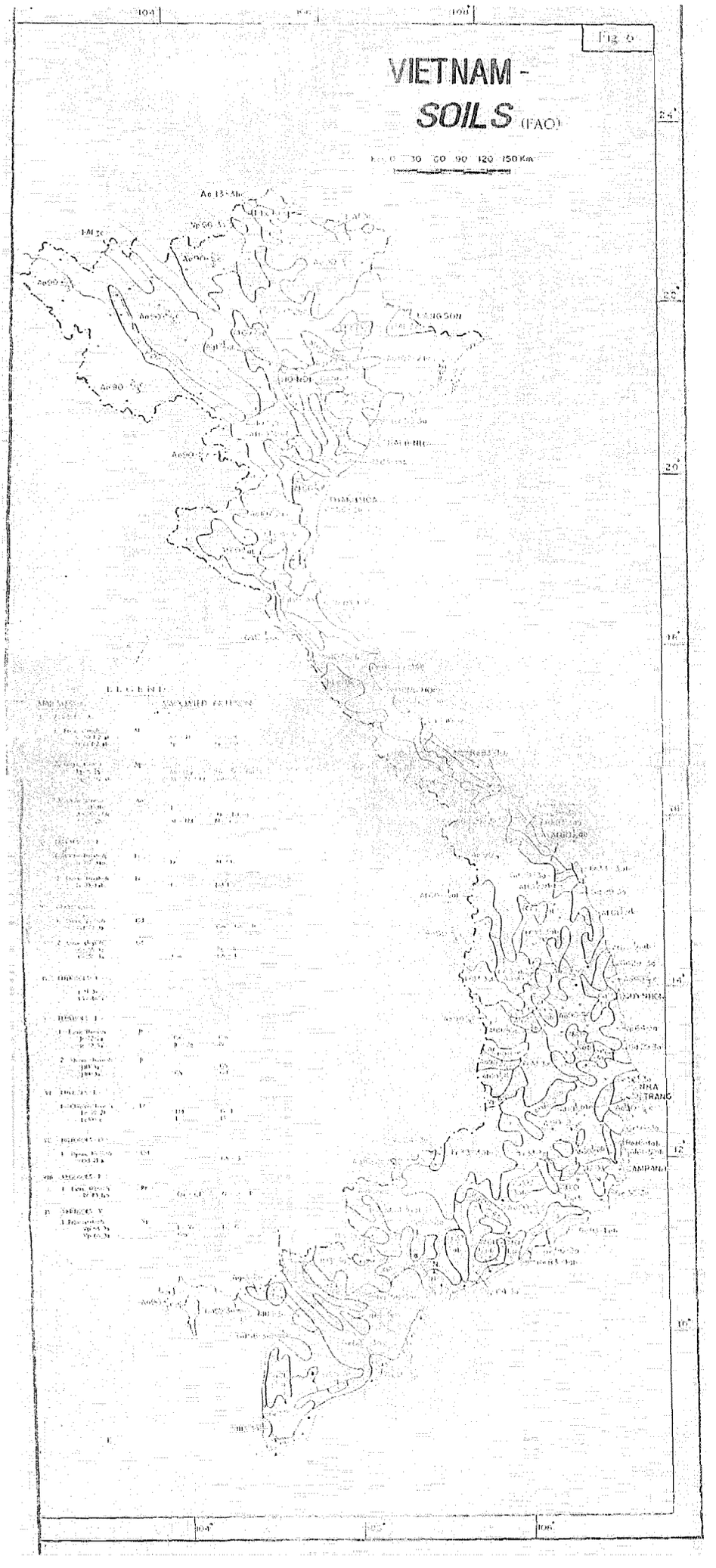


Fig. 6
VIETNAM -
SOILS (FAO)
0 30 60 90 120 150 Km
LEGEND
HANOI
HAIPHONG
VINH
HUE
NHA TRANG
AMPANG