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The WINAND STARING CENTRE for Integrated Land, Soil and Water Research

Detailed soil survey and land evaluation of the WARDA experimental area, Bouaké, Côte d'Ivoire

R.T.A. Hakkeling
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Report 22

Wageningen (The Netherlands), 1989

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ABSTRACT

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A detailed soil survey was carried out of a 1220 ha experimental area, belonging to the interior plains of West Africa. Three main physiographic units are distinguished: uplands, with shallow to deep, gravelly, usually clayey, well drained, soils; colluvial footslopes, with deep, sandy, usually imperfectly drained soils; bottomlands, with deep, clayey, very poorly drained soils.
A qualitative land evaluation is carried out for 'lowland rice', 'upland rice' and 'other dry land crops', using 8 land qualities, of which moisture availability, oxygen availability, nutrient availability and rootability are the most important. Furthermore, suitability of the individual mapping units for research trials is given.

Keywords: Soil Survey, Land Evaluation, Côte d'Ivoire, Ivory Coast, research suitability

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The WINAND STARING CENTRE is continuing the research of: Institute for Land and Water Management Research (ICW), Institute for Pesticide Research, Environment Division (IOB), Dorschkamp Research Institute for Forestry and Landscape Planning, Division of Landscape Planning (LB), and Soil Survey Institute (STIBOKA).

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HOW TO READ THIS REPORT

Nobody will argue that a report on a soil survey and land evaluation shows little resemblance to a novel. Relatively few people will be fascinated with its entire contents, whereas scores of people may consider it dull and technical. This is why this chapter is written. It serves to guide the reader who is only interested in parts of the contents, generally the agriculturist who is not too close to the soil.

The researcher with a superficial interest is referred to the Summary and Conclusions to grasp the contents of the report in a nutshell.

The non-soil scientist who needs to know the major findings of the survey is, in addition, referred to Chapter 5. This chapter gives a not too technical breakdown of the relevant properties of each mapping unit, including suitability for rice and dryland crops, and size and homogeneity of the unit within the survey area.

The highly-interested non-soil scientist may also wish to read Chapter 4, which elaborates on the criteria applied in the qualitative land evaluation. This chapter may also serve as a basis for later quantitative land evaluation studies as part of WARDA's research programme.

The soil scientist can easily select his chapters of interest. He may want to take notice of the environmental data in Chapter 2, and scrutinize Chapter 3, the rather technical description of the soils. Moreover, he may have a special interest in technical details, for example on the profile descriptions in Annex 2.

SUMMARY AND CONCLUSIONS

The present text reports on the soils and the physical setting of the new WARDA experimental site near Bouaké, Côte d'Ivoire. This description is followed by a physical land evaluation and an indication of the suitability of the different units on the soil map for research purposes.

Physical setting and soils
The site comprises 1220 ha of the catchment area of the river M'bé. Three major physiographic units are distinguished. They occur in a toposequential pattern, also known as the upland/ inland swamp continuum:

- **Uplands**: approximately 1 km wide, upper slopes 0-2%, middle and lower slopes 2-4%, comprising 69% of the total area; rainfall is the only water source;
- **Colluvial footslopes**: 20-200 m wide, slopes 1-4%, comprising 19% of the total area; in addition to rainfall, groundwater acts as a source of moisture to plants during part of the year (6-8 months);
- **Bottomlands**: on average 20-250 m wide, slopes <1%, comprising 12% of the total area; groundwater acts as main source of moisture to plants almost during the entire year (10-12 months), with submergence during some months.

The above subdivision is used as a first level in the legend to the soil map, which recognizes 17 units. Second and third level subdivisions in the legend are based on soil depth, gravel content, texture, external drainage and water control. The most important mapping units in terms of size are:

Uuvg: Upper upland slopes with very deep, gravelly, clayey soils
Umdg1: Middle upland slopes with deep, gravelly, clayey soils
Umdo1: Middle upland slopes with deep, non-gravelly, clayey soils
Umdo2: Middle upland slopes with moderately deep to deep, non-gravelly, loamy soils
Ummg : Middle upland slopes with moderately deep, gravelly, loamy soils
Umsg : Middle upland slopes with shallow, gravelly, loamy soils and ironstone outcrops
Fil : Footslopes with imperfectly to poorly drained, deep sandy soils
Bc1 : Bottomlands with deep, clayey soils (with water control)
Bc2 : Bottomlands with deep, clayey soils (without water control)

A part of the upland soils has a limited depth due to the presence of a massive compacted or even indurated lateritic layer ('carapace' and ironstone or 'cuirasse' respectively.)

A high gravel content is common in many upland soils, as old ironstone layers were broken up by river incision and erosion.

Drainage conditions vary during the year with the season, particularly in the colluvial footslopes. The soils that are closest to the bottomlands have the watertable in the root zone during part of the year.
Dam construction in the upper reaches of the M'bé has caused the formation of a sizeable reservoir, entailing water control in the M'bé bottomland, which covers 7% of the total area.

Land evaluation

A qualitative, physical land evaluation is carried-out, considering a number of land qualities, of which the most important ones are listed below. The land utilization types in this report are very broadly defined as 'lowland rice', 'upland rice' and 'other dryland crops'.

Moisture availability is assessed in terms of length of growing period, which is determined mainly by the length of the rainy season, the amount of stored soil moisture and the influence of groundwater.
Moisture availability is high in the bottomlands and in the imperfectly drained parts of the footslopes. It is low in the shallow loamy soils of the uplands and in the well drained parts of the footslopes.

Oxygen availability is mainly expressed in terms of external drainage. Well drained soils (uplands) have a high oxygen availability. It is moderate in imperfectly drained soils (mainly colluvial footslopes), and low in the (very) poorly drained soils (bottomlands).

Nutrient availability/inherent fertility is moderate to high in both the soils of the uplands and the bottomlands, but low in the colluvial footslopes. The latter soils have a very low organic matter content and they are low in phosphorus and potassium.

Rootability and adequacy for tuber expansion can be broadly assessed by the combined rating of the land characteristics 'effective soil depth' and 'bulk density'.
Effective soil depth is defined here as the depth to root-impeding layers. In the survey area, shallow or moderately deep carapace or cuirasse is limiting the soil depth in units **Ummg** and **Umsg.** A very high gravel content, as occurring locally in units **Uuvg** and **Umdg**, mostly goes together with high bulk density, and thus lower rootability.

Suitability indication

The suitability indication given below is based on the size and homogeneity of the mapping units and on the suitability of the soils for the defined land utilization types (lowland rice, upland rice and other dryland crops).

Uuvg and **Umdg**: total acreage 426 ha (35% of the total area). Six large and nine medium sized, relatively homogeneous polygons provide suitable experimental land. Still, before implementing any research, uniformity trials are needed on these tracts of land. The suitability for the cultivation of upland rice as well as many other dryland crops is high.

Umsg: total acreage 165 ha (13.5%). The unit is made up of 2 large, 6 medium and 14 small polygons, which all occur as elongated strips that follow the contours. Their suitability for any crop is low to very low, due to general shallowness and high variability of soil depth.

Fil: total acreage 178 ha (14.6%). The unit is made up of 2 large, 4 medium and 8 small polygons. There is ample research land, which, unless fertilized, has a low suitability for upland rice and other dryland crops, due to poor soil fertility. Moisture and oxygen availability vary during the year. In this respect, the position on the slope is of great importance. Any research should take into consideration the relative position of a plot on the toposequence.

Bc1 and **Bc2**: total acreage 135 ha (11.1%). The unit is made up of 3 large, 3 medium and 4 small polygons. Heterogeneity within the units is rather high, due to colluviation-alluviation processes and periodic submergence. The M'bé and Oundré bottomlands are suitable for lowland rice trials. Bottomlands of the other tributaries are not.

Umdo1 (6.7%), **Umdo2** (3.0%), and **Ummg** (3.0%) are of secondary importance, in terms of acreage. The remaining units are even smaller. 'Disturbed land' occupies 3.6% of the land surface.

RESUME ET CONCLUSIONS

Ce document décrit les conditions physiques qui prévalent dans le nouveau site expérimental de l'ADRAO, près de Bouaké, Côte d'Ivoire. Cette description est suivie d'une évaluation physique du terrain et d'une indication du degrée d'aptitude des différentes unités de la carte pédologique à des fins de recherche.

Le milieu physique et les sols
Le site comprend 1.220 ha du bassin versant de la rivière M'bé. On distingue trois unités physiographiques principales. Elles se présentent sous forme d'une toposéquence désignée sous l'appellation de continuum terrains exondés/bas-fonds.

- **Terrains exondés**: environ 1 km de large, haut de pente 0-2%, milieu et bas de pente 2-4%, couvrant 69% de la superficie totale; les précipitations constituent la seule source d'eau.

- **Bas de pente colluviaux**: 20-200 m de large, pente 1-4%, couvrant 19% de la superficie totale; en plus des pluies, la nappe phréatique assure l'alimentation hydrique des plantes durant une partie de l'année (5-10 mois).

- **Bas-fonds**: 20-250 m de large, pente <1%, couvrant 12% de la superficie totale; ici, la nappe phréatique constitue durant presque toute l'année (10-12 mois) la principale source d'alimentation hydrique des plantes, avec submersion pendant quelques mois.

La subdivision ci-dessus est utilisée dans la légende de la carte pédologique, qui reconnaît 17 unités. Les subdivisions aux deuxième et troisième niveaux de la légende sont basées sur la profondeur du sol, sa teneur en gravier, sa texture, le drainage externe et la maîtrise d'eau.
Les unités cartographiques les plus importantes en termes de superficie sont les suivantes:

Uuvg : Terrains exondés, haut de pente, avec des sols argileux gravileux très profonds
Umdg1: Terrains exondés, milieu de pente, avec des sols argileux gravileux profonds
Umdo1: Terrains exondés, milieu de pente, avec des sols argileux profonds, sans gravillons
Umdo2: Terrains exondés, milieu de pente, avec des sols limoneux profonds ou moyennement profonds, sans gravillons
Ummg : Terrains exondés, milieu de pente, avec des sols limoneux gravileux moyennement profonds
Umsg : Terrains exondés, milieu de pente, avec des sols limoneux gravileux peu profonds et des affleurements de cuirasse

Fi1 : Bas de pente colluviaux avec des sols sableux profonds imparfaitement drainés ou mal drainés

Bc1 : Bas-fonds avec des sols argileux profonds (avec de la maîtrise d'eau)

Bc2 : Bas-fonds avec des sols argileux profonds (sans maîtrise d'eau)

Une partie du terrains exondés a une profondeur limitée par suite de la présence d'une couche latéritique massive, compactée ou même indurée. Si elle n'est pas durcie, cette couche reçoit la dénomination de "carapace". Indurée, elle est appelée "cuirasse".

Une forte teneur en gravillons se retrouve communément dans beaucoup de terrains exondés, par suite de l'incision et de l'érosion des couches anciennes de la cuirasse.

Les conditions de drainage varient au cours de la saison, particulièrement en ce qui concerne les bas de pente colluviaux. Dans les sols les plus proches des bas-fonds, la nappe phréatique se trouve à la hauteur de la zone des racines durant une partie de l'année.

La construction d'un barrage en amont du M'bé a entraîné la formation d'un réservoir de bonnes dimensions, permettant la maîtrise de l'eau sur les terres situées en aval, qui couvrent 7% de la superficie totale.

Evaluation des terres

On a procédé à une évaluation physique qualitative des terres en prenant en considération un certain nombre de caractéristiques des terres. Dans ce résumé, seulement les caractéristiques les plus importants sont donnés. Les types d'utilization des terres sont, dans ce rapport, définis par les catégories très générales suivantes: "riz de bas-fonds", "riz pluvial" et "autres cultures sèches".

Les disponibilités en eau sont évaluées en termes de longueur de la période de croissance. Cette longueur est déterminée par la longueur de la saison de pluies, la quantité d'humidité résiduelle dans le sol et le niveau de la nappe phréatique. Les disponibilités en eau sont fortes dans les bas-fonds et dans les parties imparfaitement drainés des bas de pente colluviaux. Ils sont faibles dans les sols limoneux peu profonds et dans les parties bien drainées des bas de pente colluviaux.

Les disponibilités en oxygène sont exprimées en termes de drainage externe. Les sols bien drainés (sols exondés) présentent une forte disponibilité en oxygène. Cette disponibilité est moyenne dans les sols imparfaitement drainés (essentiellement les bas de pente colluviaux) et faible dans les sols mal (ou très mal) drainés (bas-fonds).

Les disponibilités en éléments nutritifs (fertilité intrinsèque) sont moyennes ou fortes dans les terrains exondés et dans les bas-fonds, mais faibles dans les bas de pente colluviaux. Ces derniers sols ont également une très faible teneur en matière organique, ainsi qu'en phosphore et en potassium.

La facilité d'enracinement et d'expansion des tubercules peut être estimée grosso modo par une évaluation combinée des caractéristiques des terres les suivants: "profondeur efficace du sol" et "densité apparente".
Par profondeur efficace du sol, on entend la profondeur jusqu'aux couches s'opposant à la pénétration des racines. Dans la zone étudiée, il s'agit des sols ayant une carapace ou une cuirasse à faible ou moyenne profondeur (**Ummg, Umsg**). Une très forte teneur en gravier, comme s'arrive localement dans les unités **Uuvg** et **Umdg**, est associée à une densité apparente élevée et, par conséquent, à une faible capacité de développement de racines.

Indication d'aptitude des unités cartographiques
Pour l'indication d'aptitude ci-dessous, on a pris en considération la dimènsion et l'homogénéité des unités cartographiques et l'aptitude des sols pour les types d'utilization des terres ("riz de bas-fonds", "riz pluvial" et "autres cultures sèches").

Uuvg et **Umdgl**: surface 426 ha (35% de la superficie totale). 6 grands polygones et 9 de dimensions moyennes, relativement homogènes, offrent des terres aptes à des fins expérimentales. Néanmoins, parce que les précédents culturaux sont différents, il faudra faire des essais d'uniformité sur ces terres. Elles sont tout à fait aptes pour la riziculture pluviale ainsi que pour beaucoup d'autres cultures sèches.

Umsg: surface 165 ha (13,5%). On trouve ici 2 grands polygones, 6 de taille moyenne et 14 petits, tous sous forme de bandes allongées qui suivent les contours de la pente. Leur aptitude est faible ou très faible, pour toute culture, en raison de la faible profondeur du sol et de la grande variabilité spatiale de cette profondeur.

Fil: surface 178 ha (14,6%). Cette unité est constituée par 2 grands polygones, 4 de dimensions moyennes et 8 petits. Ici, on trouve une superficie assez grande qui se prête à des expérimentations, mais sans fertilisation, elles ne seront que faiblement aptes à la riziculture pluviale et à d'autres cultures sèches, car la fertilité de ces sols est médiocre. Les disponibilités en eau et en oxygène varient selon la période de l'année. A cet égard, la position sur la pente revêt une grande importance. Toute recherche devra prendre en considération la position relative d'une parcelle sur la toposéquence.

Bc1 et **Bc2**: surface 135 ha (11,1%). Ces unités se composent de 3 grands polygones, 3 de taille moyenne et 4 petits, avec une hétérogénéité assez élevée par suite de processus de colluvionnement et alluvionnement et des phénomènes de submersion temporaire. Les bas-fonds des rivières M'bé et Oundré sont aptes pour des essais de riziculture de bas-fonds. Les bas-fonds des autres cours d'eau ne le sont pas.

Enfin, d'importance secondaire en termes de superficie, sont les unités suivantes: **Umdo1** (6,7%), **Umdo2** (3,0%), et **Ummg** (3,0%). Les unités restantes sont encore plus petites. Les "sols perturbés" occupent 3,6% de la superficie totale.

1 INTRODUCTION

The West Africa Rice Development Association (WARDA) is one of the thirteen member institutes of the Consultative Group of International Agricultural Research (CGIAR).
Until 1987, WARDA had its headquarters in Monrovia, Liberia. The then Netherlands Soil Survey Institute (STIBOKA), since 1989 merged into Winand Staring Centre, was involved in the listing of biophysical and infrastructural aspects to possibly base the institute in an other WARDA member state (Andriesse, 1987). Eventually the institute moved house, and the new main research station and administrative headquarters are now in Bouaké, Côte d'Ivoire.

The Government of Côte d'Ivoire tentatively pinpointed an area of 4000 ha, approximately 15 km northwest of Bouaké, to accommodate new buildings as well as trial fields in the upland/inland swamp continuum. An important technical advantage to settle down here is the presence of an artificial reservoir in the upper reaches of the river M'bé, ensuring year-round water control and irrigation facilities in the adjacent downstream lowlands.

Subsequently, WARDA forwarded a request to the Netherlands Government, Ministry of Foreign Affairs (DGIS - DPO/OT), to render assistance as to the actual demarcation and characterization of representative land within the 4000 ha. A site evaluation was carried out to this effect by STIBOKA (Smaling, 1988). This evaluation resulted in an advice to select approximately 1300 ha of land.

The present text reports on the next step in the characterization exercise, a detailed soil survey on a scale of 1 : 5000. The aim of this work is to provide WARDA researchers with a clear insight into the physical setting of the land available for experiments and the suitability for rice and other annual crops. Fieldwork took place in August and September 1989.

2 PHYSICAL SETTING OF THE SURVEY AREA

2.1 Location and extent

The survey area is located about 15 km northwest of Bouaké, in central Côte d'Ivoire (Figure 1). Coordinates (UTM) are 5°06'W 7°52'N.

The WARDA research area comprises 1220 ha of the catchment area of the M'bé river, which runs approximately west-east. Approximately 90% of the area is located on its right bank. It includes a part of the main tributary Oundré (Figure 2). Dams have been constructed in two tributaries. One has formed a sizable artificial reservoir, the second one has been completed recently and is gradually filling up.
The area has 10.8 km of motorable tracks. It is accessible from the tarmac road that connects Bouaké with Katiola. Alternatively, the station can be reached from Diabo, some 20 km to the north-west of Bouaké.

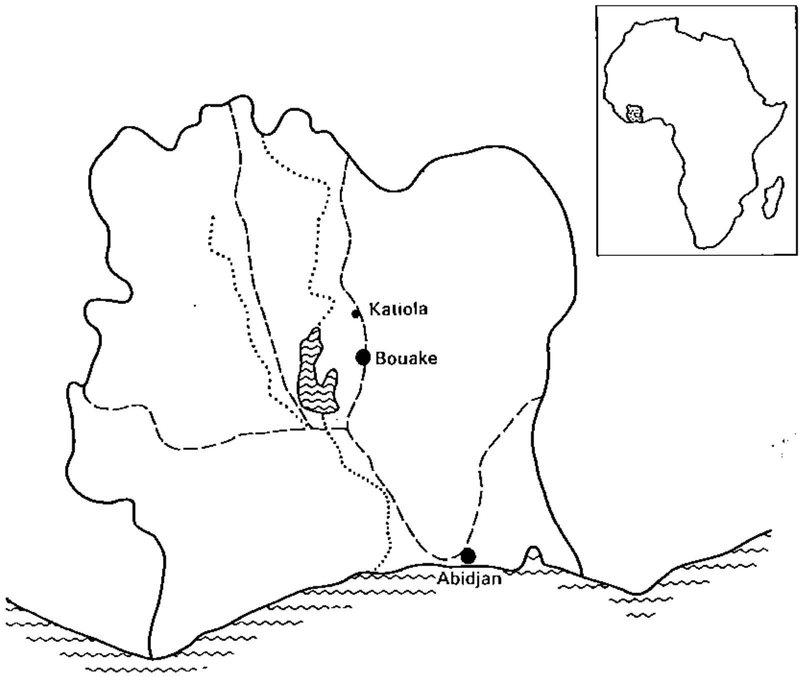

Figure 1. Location of Bouaké and Katiola in Côte d'Ivoire.

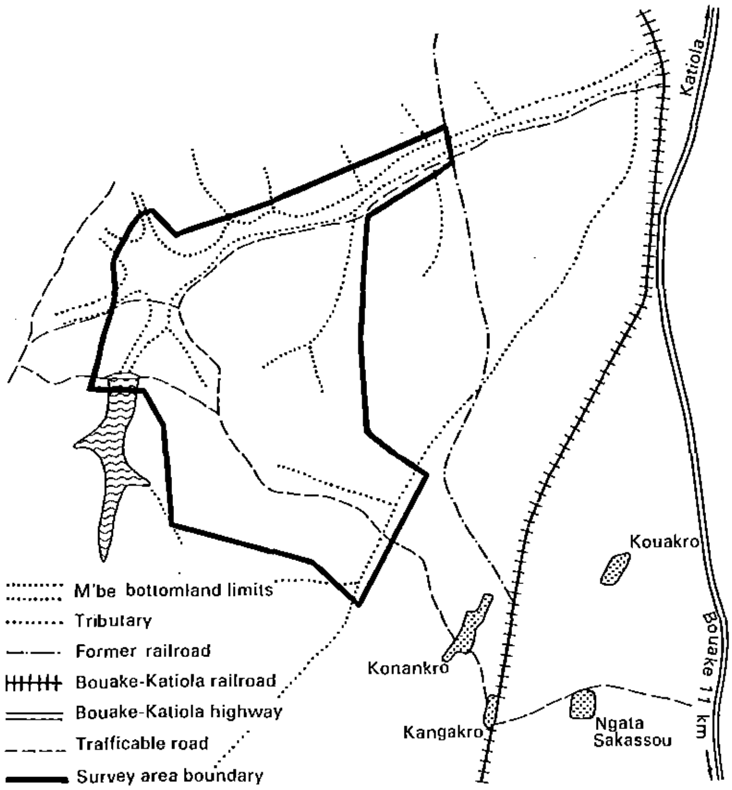

Figure 2. Location of the survey area.

2.2 Climate

The rainfall distribution pattern in the survey area is bimodal. Two humid periods occur each year, separated by a relatively dry period. The first humid period occurs in April-June, the second in September-October. As average figures can easily give too optimistic a picture of the real situation, due to very wet outliers, the 50% and 75% probability rainfall is also given. They represent the rainfall that is exceeded in 1 out of 2 years and 3 out of 4 years respectively. Data are given in Table 1 and Figure 3. Precipitation data for Bouaké Aero were obtained through WARDA (period 1951-1985).

Table 1. Precipitation, potential evapotranspiration and temperature recorded at Bouaké Aero.

Month	Precipitation (mm)			Pot. Evapot. (mm)	Temperature (°C)
	Average	50% prob.	75% prob.		
J	11	0	0	130	26.2
F	47	34	11	140	27.3
M	86	74	63	153	26.9
A	126	125	105	147	26.5
M	134	138	105	138	25.8
J	156	134	90	108	24.4
J	118	91	48	92	23.5
A	98	95	57	87	23.3
S	183	157	118	109	23.7
O	139	125	82	128	24.3
N	32	20	9	125	24.9
D	16	9	0	121	25.1
Total	1146			1478	

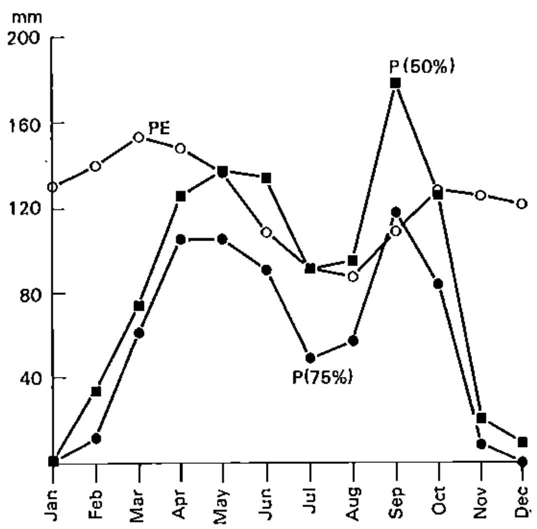

Figure 3. Monthly 50% and 75% probability rainfall (P (50%), P (75%)); monthly average potential evapotranspiration (PE).

Average monthly potential evapotranspiration and temperature have been listed too in Table 1. Temperature data were obtained through WARDA (period 1951-1985), evapotranspiration data from ORSTOM (1971; period not known). As temperature and evapotranspiration have a much lower variability as compared to precipitation, no probability figures are given.

The survey area is located in the bio-climatic zone of the Guinea Savanna (Hekstra and Andriesse, 1983). To define bio-climatic zones, the authors used the length of the period in which the average precipitation exceeds 0.5 x evapotranspiration. In the Guinea Savanna zone, this period is defined as 165 to 270 days. For the survey area, it is about 230 days.

2.3 Geology and landforms

The bedrock that underlies the soils of the survey area is made up of Precambrian granites and associated metamorphic rocks of the so-called Basement Complex, which covers large parts of West Africa (ORSTOM, 1971).
The parent material has undergone several weathering cycles. Meanwhile, the absence of significant tectonic activity in West-Africa has precluded any rejuvenation of natural resources. As a consequence, quartz is by far the predominant mineral in the surveyed soils. Feldspars and micas occur in low percentages, having weathered largely into kaolinite and sesquioxides.

Physiographically, the area belongs to the 'Interior Plains' of West Africa (Hekstra and Andriesse, 1983). These are nearly level to gently undulating (slopes 0-5%), slightly dissected peneplains with scattered inselbergs. The interior plains cover extensive parts of West Africa. The major part of the interior plains is underlain by metamorphic rocks, which also holds for the survey area.

Detailed soil surveys, comparable to the survey dealt with in the present report were carried out in the interior plains of Sierra Leone (Smaling et al., 1985a) and Nigeria (Smaling et al., 1985b). Although the physiography of these sites is comparable to the physiography of the survey area, other environmental aspects are not. Soils of the Sierra Leone site are derived from Basement Complex rocks, but the site is located in the Equatorial Forest zone. The Nigeria site is located in the Guinea Savanna zone, but it has soils which are derived from sandstones.

Poss (1982), in a morpho-pedologic survey near Katiola, describes 13 different toposequences. The toposequence resembling the situation in the survey area is defined as: 'paysage de collines gravillonaire convexes à plan convexes'. Predominant slopes and soils in this area near Katiola appear to be very similar to the slopes and soils in the survey area.

The toposequence of the survey area comprises three major physiographic units, which are described below. Relief intensity, which is defined as the average difference in height between the top and the bottom of a toposequence, is approximately 40 m.
In terminology of rice-based farming systems research in West Africa, the toposequence is known as the upland/inland swamp continuum.

- **Uplands**
  The uplands in the survey area comprise the interfluves, with flat to almost flat upper slopes (0-2%) and gentle middle and lower slopes (2-4%). The slopes are generally slightly convex.
  The distance between the top of the interfluves and the valleybottom is approximately 700 m. The uplands comprise about 69 percent of the total survey area.

- **Colluvial footslopes**
  The colluvial footslopes form a transitional zone, which is usually narrow (20 - 100 m). Near the head of a tributary it can be up to 200 m wide. Slopes are rectilinear to slightly concave and almost flat to gentle (1- 4%). They occupy 19 percent of the total acreage.

- **Bottomlands**
  The M'bé bottomland is flat and 100 to 250 m wide. It comprises 7% of the survey area. Tributaries are narrower (20-50 m) and flat to almost flat (slopes less then 1%). The bottomlands comprise 5% of the entire survey area.

2.4 Hydrology

The M'bé valley is a 'streamflow' valley as defined by Savvides (1981). It does not have a well-defined water course. According to Raunet (1985) the M'bé valley can be classified as a 'vallon à fond plat, à flancs concaves'. The tributaries can be classified as 'vallon concave à horizontale'.
According to Hekstra and Andriesse (1983) the drainage density of the interior plains in this part of West Africa is low to medium (0.3-1.2 km/km^2) and the drainage texture is coarse (0.5 $streams/km^2$). In the survey area, the drainage density is 1.0 km/km^2, and the drainage texture is about 0.4 $streams/km^2$. Both figures are well within the given range.

The physiographic legend applied in this soil survey follows the hydrosequential subdivision as suggested by Moormann et al. (1977). The two concepts are summarized in Table 2.

2.5 Vegetation and land use

The natural vegetation in the survey area consists of tall grasses with scattered trees (wooded grassland). Patches of forest are found on the upper upland slopes. Secondary forest covers most of the tributaries. This type of vegetation is common in the Guinea Savanna vegetation zone (ORSTOM, 1971). Bouaké is situated near the northern border of the Guinea Savanna vegetation zone. This is not in line with the reported position of Bouaké in the southern part of the Guinea Savanna

Table 2. Toposequential and hydrosequential subdivisions of the upland/inland swamp continuum in the survey area.

This report	Moorman et al (1977)	Main Water source
uplands	pluvial lands	rain is the only water source; no groundwater in the root zone
colluvial footslopes	phreatic lands	in addition to rainfall, groundwater acts as a source of water to plants during part of the year (5-10 months)
bottomlands	fluxial lands	(high) groundwater acts as main source of water to plants almost during the entire year (10-12 months); submergence occurs during some months; run-on; over-flow

bioclimatic zone (Hekstra and Andriesse, 1983; see section 2.2).

Cultivation of the uplands is practiced through traditional slash and burn techniques. After clearing the land, the plots are, generally, cultivated for two or three consecutive years. Yam is the main crop, grown in 40 cm high mounds. Other important crops are cassava, maize, groundnut and cotton. Upland rice is less commonly cultivated.
Extensive areas in the uplands remain fallow. 'Imperata' grasses mainly occupy the fallow land. They may reach heights of up to 3 meter on the deep soils of the upper upland slopes. Only 25-30% of the total upland area is cultivated annually. With a cultivation period of 2-3 years, this means that the average fallow period is 7-9 years. Land with shallow soils is not used at all.

The colluvial footslopes are more intensively cultivated, probably because of a more reliable water supply. All crops grown on the uplands are cultivated here as well. Yields however, seem to be lower, which is probably due to the lower soil fertility.

The bottomlands are mainly used for rice cultivation. The M'bé bottomland is entirely subdivided into small plots, separated by bunds. Facilities for irrigation were constructed in the seventies, but at the time of survey, they were in a neglected state. The artificial reservoir in the western part of the survey area provides water continuously. Hence, two crops of rice can be harvested per year.
The various tributaries have so far sporadically been used for rice cultivation.

3 SOILS

3.1 Survey and laboratory methods

Aerial photographs at a 1 : 20 000 scale were especially taken for the present survey, in May 1989.
Prior to fieldwork, an 'uncontrolled' mosaic of these photos at a 1 : 5 000 scale was prepared. It served as a base map in the field, and is used as a base for the final soil map.

Augerings in transects across the valleys and slopes constituted most of the first part of the fieldwork period. Hereafter, a draft legend was drawn up. The legend became definite during subsequent systematic observations. Some 650 augerings were made, to a depth of 120 cm, where possible. 22 profile pits were described, 16 of which were sampled. A map showing the location of the profile pits is included in the back pocket of the report.

Direction et Contrôle des Grands Travaux (DCGTx) in Bouaké analyzed the soil samples of representative profiles on texture (Robinson pipette method), organic carbon (Walkley & Black method), total nitrogen (Kjeldahl method), available phosphorus (Olsen method), exchangeable bases and cation exchange capacity (at pH 7.0, NH_4-acetate extraction).
In Wageningen, analyzes were done on 42 core samples for the determination of bulk density and moisture retention of the different soils (sandtable method, pressure membrane method).
Water samples were taken from various parts of the survey area. They were analyzed for iron content to check on possible iron toxicity (determination by AAS).

Profile descriptions with chemical and physical data are given in Annex 2.

3.2 Mapping unit symbols

The symbols on the soil map (in back cover) refer to the map legend, which is made up of 17 units.

Physiography is applied at the first level of subdivision:

Uu Uplands-upper slopes: approx. 500 m wide with 0-2% slopes
Um Uplands-middle slopes: 200 to 700 m wide, with 2-4% slopes, in places with ironstone outcrops
F Colluvial footslopes: 20-200 m wide, slopes 1-4%
B Bottomlands: 20-250 m wide, slopes less than 1%
D Disturbed land

For the upland soils (**Uu, Um**), second and third levels of subdivision are based on soil depth and gravel content respectively:

vg Very deep soils (>120 cm) with a high gravel content (15% or more by weight; mostly in the upper part of the profile)
dg Deep soils (80-120 cm) with a high gravel content (15% or more by weight; mostly in the upper part of the profile)
do Deep soils (80-120 cm) with a low gravel content (not exceeding 15% by weight in any part of the profile)
mg Moderately deep soils with a high gravel content, ironstone between 50 and 80 cm of the surface
sg Shallow soils with a high gravel content, ironstone within 50 cm of the surface

The subdivision of the soils of the footslopes (**F**) is based on external drainage:

i1 Deep sandy soils, groundwater within rooting zone during peak rains
i2 Deep clayey soils, undifferentiated
w1 Deep sandy soils, groundwater below rooting zone during peak rains
w2 Moderately deep sandy soils over ironstone

The subdivision of the soils of the bottomlands (**B**) is based on texture and water control:

c1 Deep clayey soils, with water control
c2 Deep clayey soils, without water control
s Deep sandy soils, in places with clay below 80 cm, no water control

Two units are distinguished with so-called disturbed lands (**D**). These units are not elaborated upon in the following chapters because they have a very high variability and do not occur elsewhere in the region. Physiographically, they belong to the uplands. They comprise 3.6% of the total area.

3.3 Brief description of the soils of the mapping units

In this section, brief descriptions are given of the different soils in the survey area. Annex 2 encompasses comprehensive descriptions of the representative soil profiles, including the results of chemical and physical soil analyses. Class limits used for the description of soils are given in Annex 1.

Many soils of the survey area have a limited depth due to a massive compacted lateritic layer, which is sometimes hard enough to be called ironstone. Such layers have developed from the irreversible hardening of plinthite. This is an iron-rich, humus-poor mixture of clay with quartz and other diluents.

Fresh plinthite commonly occurs as dark red mottles. It changes irreversibly to ironstone on exposure to repeated wetting and drying (Soil Survey Staff, 1985).
In the survey area, layers are encountered that are still rather soft. These massive, slightly indurated layers are known in francophone Africa as 'carapace'. Lozet and Mathieu (1986) define carapace as 'accumulation continue dans toute la masse de l'horizon, peu cimentée, se fragmente à la main ou sous un faible choc au marteau'.
Real ironstone is called 'cuirasse'. It occurs in bands, roughly following the contours, and as outcrops on the upper parts of the uplands. Roots will not penetrate, except through cracks. Lozet and Mathieu (1986) define cuirasse as 'horizon continu fortement induré et cimenté par un enrichement en sesquioxides de fer et/ou d'alumine'.
Many upland soils have a high gravel content. This is due to the disruption of old cuirasse layers under the influence of river incision and erosion.

In this text, soil depth classes refer to effective soil depth, i.e. depth to root-impeding layers, including abrupt textural changes, compacted soil horizons and ironstone. Thus, a soil may be described as 'shallow' or 'moderately deep' and still be genetically deep if deep soil formation has taken place.

Soil classification as described below, refers to the USDA Soil Taxonomy (Soil Survey Staff, 1985), the Revised Legend of the Soil Map of the World (FAO/Unesco/ISRIC, 1988) and the French classification system (CPCS, 1967).

Uu - Soils of the uplands (upper slopes)

- **Uuvg**
  Well drained, very deep, dark reddish brown, weak subangular blocky, sandy clay to clay, often overlying carapace below 120 cm. Ironstone gravel (30-60% by weight) occurs in the profile. Size and amount of the gravel decrease below 80 cm. The surface soil (15-30 cm thick) consists of sandy clay loam. Representative profiles: 1, 2, 3, 4
  Soil Taxonomy: Paleustults
  FAO: Rhodi-humic Acrisols
  CPCS: Sols ferrallitiques faiblement désaturés remaniés modals

- **Uusg**
  Well drained, shallow, weak subangular blocky, with strongly varying colour and texture, overlying ironstone within 50 cm. Ironstone gravel (30-60% by weight) occurs throughout the profile.
  Soil Taxonomy: Lithic Ustropepts
  FAO: Orthi-dystric Leptosols, petroferric phase
  CPCS: Sols ferrallitiques faiblement désaturés typiques indurés

Um - Soils of the uplands (middle slopes)

- **Umdg1**
  Well drained, deep, red to yellowish red, weak subangular blocky, sandy clay to clay, overlying carapace between 80 and 120 cm. Ironstone gravel (30-60% by weight) occurs in the upper half of the profile. Size and amount of the gravel decrease with depth. The surface soil (15-30 cm thick) consists of sandy clay loam. Representative profiles: 5, 6
  Soil Taxonomy: Paleustults
  FAO: Rhodi-humic Acrisols
  CPCS: Sols ferrallitiques faiblement désaturés remaniés indurés

- **Umdg2**
  Well drained, moderately deep to deep, red to yellowish red, weak subangular blocky, sandy clay to clay. Ironstone gravel (30-40% by weight) occurs throughout the profile. The surface soil (15-30cm thick) consists of sandy clay loam.
  Soil Taxonomy: Paleustults
  FAO: Rhodi-humic Acrisols
  CPCS: Sols ferrallitiques faiblement désaturés remaniés indurés

- **Umdo1**
  Well drained, deep, yellowish red, weak subangular blocky, sandy clay loam to clay. Fine manganese concretions occur in the lower part of the profile. The surface soil (20 cm thick) consists of sandy clay loam.
  Representative profiles: 7, 8
  Soil Taxonomy: Paleustults
  FAO: Chromi-haplic Acrisols (with inclusions of Rhodi humic Acrisols)
  CPCS: Sols ferrallitiques faiblement désaturés remaniés modals

- **Umdo2**
  Well drained, moderately deep to deep, reddish brown, weak subangular blocky, sandy loam. Locally ironstone gravel occurs below 50 cm. Ironstone or carapace is found at a depth between 70 and 120 cm. The surface soil (20 cm thick) consists of sandy loam.
  Representative profile: 9
  Soil Taxonomy: Paleustults
  FAO: Chromi-haplic Acrisols
  CPCS: Sols ferrallitiques faiblement désaturés remaniés modals

- **Ummg**
  Well drained, moderately deep, yellowish red, weak subangular blocky, loamy sand to sandy loam. Between 50 and 80 cm the soil is overlying ironstone. Ironstone gravel (about 50%

by weight) occurs in the subsoil. The surface soil (15 cm thick) consists of sandy loam. Representative profiles: 10, 11
Soil Taxonomy: Oxic Ustropepts
FAO: Orthi-ferralic Cambisols, petroferric phase
CPCS: Sols ferrallitiques faiblement désaturés typiques indurés

- **Umsg**
Well drained, shallow, dark brown to brown, weak subangular blocky, sandy loam. Between 0 and 50 cm the soil is overlying ironstone. Ironstone gravel occurs throughout the profile. The surface soil (15 cm thick) consists of sandy loam. Representative profile: 12
Soil Taxonomy: Lithic Ustropepts
FAO: Orthi-dystric Leptosols, petroferric phase
CPCS: Sols ferrallitiques faiblement désaturés typiques indurés

F - Soils of the colluvial footslopes

- **Fi1**
Imperfectly drained, deep, yellowish brown, weak subangular blocky, coarse (loamy) sand (finer textures downslope). Mottles occur throughout the profile. Surface soils also consist of coarse (loamy) sand. Actual watertable during peak rainfall (September 1989) was between 20 and 80 cm. Representative profiles: 13, 14, 15, 16.
Soil Taxonomy: Aquic Ustipsamments
FAO: Orthi-gleyic Arenosols
CPCS: Sols peu evolués d'apport colluvial hydromorphes

- **Fi2**
Imperfectly drained, deep, yellowish brown, sandy clay to clay. Mottles occur throughout the profile. The surface layer (10 to 30 cm) consists of loamy sand.
Soil Taxonomy: Tropaquents
FAO: Gleyi-eutric Fluvisols
CPCS: Sols peu evolués d'apport colluvial hydromorphes

- **Fw1**
Well drained to moderately well drained, deep, brown, weak subangular blocky, sand to loamy sand. The surface soil consists of coarse to medium sand. Representative profile: 17
Soil Taxonomy: Typic Ustipsamments
FAO: Orthi-luvic Arenosols
CPCS: Sols peu evolués d'apport colluvial modals

- **Fw2**
  Well drained, moderately deep, brown, sand to loamy sand, overlying ironstone at a depth of 50 to 80 cm. The surface soil consists of coarse to medium sand.
  Soil Taxonomy: Typic Ustipsamments
  FAO: Orthi-luvic Arenosols, petroferric phase
  CPCS: Sols peu evolués d'apport colluvial modals

B - Soils of the bottomlands

- **Bc1**
  Very poorly drained, deep, sandy clay loam to clay, with varying colours; in places stratified thin layers of loamy sand. The upper 50 cm of the soil is usually reduced, the lower part is mottled. The surface layer consists of clay.
  Representative profiles: 18, 19, 20
  Soil Taxonomy: Tropaquents
  FAO: Gleyi-eutric Fluvisols
  CPCS: Sols hydromorphes peu humifères à gley peu profond

- **Bc2**
  Poorly to very poorly drained, deep, gray, sandy clay loam to sandy clay, with thin layers of coarse sand to loamy sand. Mottles occur throughout the profile. Representative profile: 21
  Soil Taxonomy: Tropaquents
  FAO: Gleyi-eutric Fluvisols
  CPCS: Sols hydromorphes peu humifères à gley peu profond

- **Bs**
  Poorly to very poorly drained, moderately deep to deep, pale brown, coarse sand to loamy sand. Mottles occur throughout the profile. At a depth of 50 to 80 cm, this soil is overlying mottled clay. Representative profile: 22
  Soil Taxonomy: Tropaquents
  FAO: Areni-eutric Fluvisols
  CPCS: Sol hydromorphes peu humifères à gley peu profond

3.4 Cross sections

Figure 4 shows a schematic cross section of the toposequence in the study area. It provides information on:
- The occurrence and distribution of the most important mapping units
- Slope pattern and relief intensity
- Depth and texture profiles of the different soils

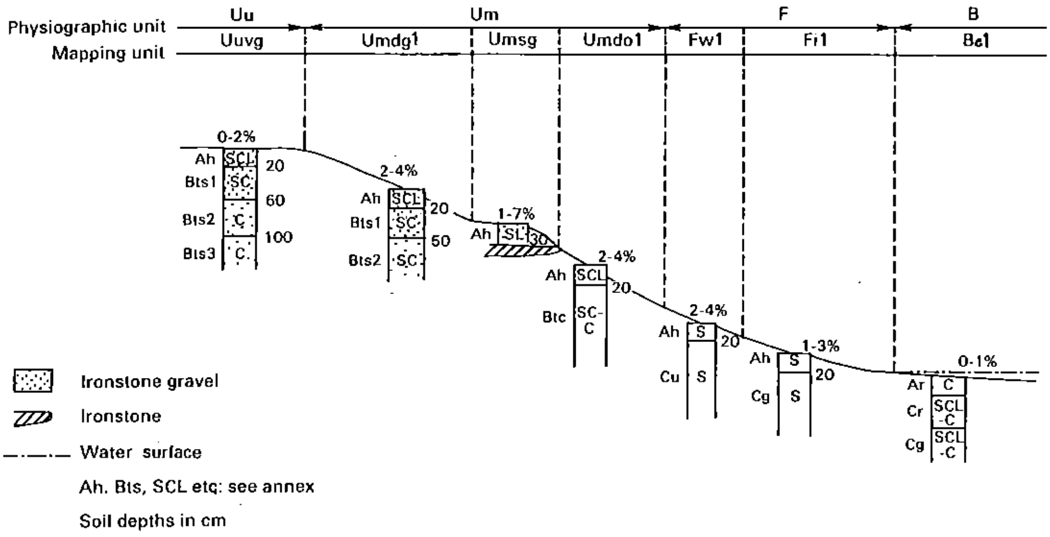

Figure 4. Schematic cross section of the toposequence in the survey area.

3.5 Soil chemical data

A summary of the chemical parameters of the soils of the different mapping units is given in Table 3. Table 4 shows iron contents of ground- and surface water samples taken at various sites in the survey area. The data shown in these tables are discussed and evaluated in Section 4.2.

Table 3. Chemical properties of the most important mapping units (averages).

parameter	depth (cm)	Uuvg/ Umdg (n=4)	Umdo (n=2)	Ummg/ Umsg (n=1)	Fil/Fw (n=2)	Bc (n=3)
organic	0-20	2.1	1.1	0.7*	0.3*	2.1
carbon (%)	20-40	1.0	0.8	0.7	-	0.7
total N	0-20	1.2	0.7	0.6	0.3	1.7
(%.)	20-40	0.8	0.6	0.5	-	0.6
C/N ratio	0-20	23**	16	13	10**	12
	20-40	13	14	13	-	10
pH-H_2O	topsoil	6.3	6.3**	6.2	6.0	5.8
(1:2.5)	subsoil	6.0	5.8	5.8	5.8	6.3
P-Olsen	topsoil	6***	18**	4	3	15
(ppm)	subsoil	-***	2	3	0.5	4**
Exch. Ca	topsoil	5.5	2.5	1.8	1.0	4.9
(me/100g)	subsoil	2.5	1.6	1.1	0.4	3.3
Exch. Mg	topsoil	1.9	1.0	0.6	0.3	3.4
(me/100g)	subsoil	0.8	0.6	0.4	0.1	2.9
Exch. K	topsoil	0.6	0.2**	0.2	0.1	0.3
(me/100g)	subsoil	0.2	0.1	0.1	0.1	0.1
Exch. Na	topsoil	0.06	0.04	0.04	0.02	0.4
(me/100g)	subsoil	0.04	0.04	0.04	0.02	0.4
CEC (pH 7)	topsoil	11.0	6.0	4.0	2.5	14.1
(me/100g)	subsoil	10.8	8.5	4.0	1.5	10.3

n = Number of profiles
* Figures were derived from 2 (Ummg/Umsg) and 5 (Fil/Fw) profiles.
** Figures were calculated from strongly varying individual data. They have a limited validity.
*** Laboratory results of two profiles were unrealistically high and have not been taken into account.
\- No data available

Table 4. Iron content of various ground- and surface water samples.

Location	Fe^{2+}(ppm)	pH
Groundwater in top of footslope	4.82	6.2
Groundwater in bottom of footslope	0.65	5.5
Seepagewater at boundary footslope/bottomland	2.35	6.3
Seepagewater in bottom footslope	0.50	6.5
Rain	0.05	6.3
Water of the lake	0,09	6.9

3.6 Soil physical data

The physical properties of the soils of the different mapping units are summarized in Table 5. The data shown in this table are discussed and evaluated in Section 4.2.

Table 5. Physical properties of the most important mapping units (averages).

parameter	depth	Uuvg/ Umdg (n=4)	Umdo (n=2)	Ummg/ Umsg (n=2)	Fil/Fw (n=5)	Bc (n=3)
Texture - % clay	topsoil	25	25	16	7	40
(<2mm) % silt		14	10	8	5	23
% sand		61	65	76	88	37
% gravel (>2mm)		11	0	14	0	0
Texture - % clay	subsoil	47	49	19	7	33
(<2mm) % silt		13	10	10	6	21
% sand		40	41	71	87	45
% gravel (>2mm)		43	3	51	0	0
Porosity	topsoil	55	48	46	39	-
(vol.%)	subsoil	46*	40	-	34	-
Water content	topsoil	29	21	17	12	-
pF 2.0 (vol.%)	subsoil	23*	31	-	10	-
Water content	topsoil	12	7	4	2	-
pF 4.2 (vol.%)	subsoil	9*	15	-	2	-
Bulk density	topsoil	1.3	1.4	1.5	1.6	-
(g/cm^3)	subsoil	1.5*	1.4	-	1.6	-

n = Number of profiles
* Figures were derived from 1 profile.
\- No data available
Texture was not determined on the same samples as porosity, water content and bulk density.

4 QUALITATIVE LAND EVALUATION

Land evaluation is the process of assessing land performance for specified purposes (FAO, 1976, 1983). It involves the execution and interpretation of surveys and studies of soils, vegetation, climate and other aspects of land.
In this chapter a qualitative, physical land evaluation is carried out for 'lowland rice', 'upland rice' and 'other dryland crops'. First of all, a broad overview is given of land qualities that limit crop production on the soils of the different mapping units.

4.1 Review of land qualities related to crop productivity

Land qualities are complex attributes of land which act in a distinct manner in their influence on the suitability of land for a specific use (FAO, 1976, 1983). Land qualities are composed of a set of land characteristics. These are land attributes that can be measured and quantified easily, like slope steepness, texture, drainage, pH, etc. Land qualities, on the other hand, are mostly rated in terms of 'high', 'low', 'severe', 'slight', etc. Land qualities that are considered relevant to the survey area are:

a) Moisture availability
b) Oxygen availability
c) Nutrient availability
d) Nutrient retention capacity
e) Soil toxicity
f) Rootability
g) Ease of cultivation
h) Risk of erosion

Also relevant, but not discussed in this text, are:
i) Occurrence of pests and soil-borne diseases
j) Climatic hazards other than moisture stress or excess moisture
k) Risk of flooding

a) Moisture availability

Moisture availability is assessed as the combined effect of input (precipitation, irrigation water, groundwater, seepage) and output (evapotranspiration, run-off, deep percolation, flow discharge) of the waterbalance.

Precipitation and evapotranspiration are relevant to all mapping units in the survey area. Run-off and deep percolation

occur in uplands and the upper parts of the footslopes. Seepage is relevant only to the lower part of the footslopes and to the bottomlands. Irrigation water and flow discharge are only relevant to the bottomlands. The balance between input and output is modified by the moisture stored by the various soils.
In the uplands the groundwater table is permanently below the root zone. In the footslopes and the bottomlands the groundwater table reaches up to the root zone during the rainy season. In the bottomlands, the groundwater table can even reach above the soil surface, causing temporary waterlogged conditions.

Water that is retained in the soil between field capacity (pF 2.0) and permanent wilting point (pF 4.2) is considered plant-available (water retention capacity). It is higher in the better structured, fine-textured soils (units **Uuvg, Umdg, Umdo, Bc**) than in the coarse-textured soils (units **Ummg, Umsg, Fil, Fw, Bs**, see Table 5).
During dry spells and at the end of the rainy season, crops on upland soils largely depend on the moisture stored in the soil.
The total soil moisture storage is not only dependant on the water retention capacity of the soil, but also on the soil depth and the depth that can be reached by the plant roots. For rice, the latter depth is set at 60 cm, for other upland crops at 80 cm.

The soil moisture storage can have an important impact on the length of the growing season, which is here defined as the period in which the 50%-probability rainfall (P(50%)) exceeds the potential evapotranspiration (PE), plus an additional period in which the stored soil moisture is consumed. For the survey area the period in which P(50%) exceeds PE is 140-160 days (May to October, Figure 3). Assuming a precipitation deficit of 3 mm/day at the end of the rainy season, the growing period of a soil with a total moisture storage of X mm is prolonged by X/3 days. Crops on soils with a high moisture storage capacity are thus better capable of surviving dry spells within and at the end of the growing season. Table 6 lists soil moisture storage for the most important units.

Table 6. Soil moisture storage (mm) for the most important map units, calculated for rice and other dryland crops.

crop	rooting depth	Uuvg/ Umdg	Umdo	Ummg	Umsg	Fil/Fw	Bc
soil depth		>80	>80	50-80	0-50	>80	>80
rice	60 cm	91	91	55-65	0-55	51	n.r.
other dryland crops	80 cm	119	123	55-85	0-55	67	n.r.

n.r. not relevant

It can now be calculated that, for units **Uuvg, Umdg and Umdo**, 91/3=30 days can be added on top of the 140-160 days mentioned above (for rice). Similarly, for unit **Umsg**, only 0 to 18 days can be added.

The soils of the mapping units **Fi1** have a low moisture storage capacity, but this is more than offset by the occurrence of shallow groundwater during the larger part of the year. It is estimated that for the lower parts of these units an extra 30-60 days can be added to the growing season. The upper part of these units have an estimated growing period topping-up of 20-30 days.

In the bottomlands seepage is an additional water accumulation factor to those relevant to the uplands and footslopes. It is hard to estimate its effect on moisture availability. A rough estimate is an extra 60-100 days for unit **Bs**, and 100-150 days for unit **Bc2**. For the M'bé bottomland (unit **Bc1**), water balance measurements are less relevant, since water is available throughout the year, from the reservoir.

b) Oxygen availability

The land quality 'oxygen availability' is expressed in terms of external drainage and porosity. Well drained soils have a high oxygen availability, imperfectly drained soils a moderate, and (very) poorly drained soils have a low oxygen availability. Furthermore, soils with a high porosity have a higher oxygen availability than soils with a low porosity.

Oxygen availability is a limiting factor to cultivation of dryland crops on the imperfectly and poorly drained soils of the footslopes and the bottomlands. It is however not limiting on the well drained uplands.
For upland rice, the lower oxygen availability in units **Fi** is not constraining.
For lowland rice, the low oxygen availability is not a limiting factor in the bottomlands.

The data in Table 5 indicate that in the uplands and colluvial footslopes, porosity is always sufficiently high to ensure a good oxygen availability.

c) Nutrient availability

Chemical properties of the soils of the different mapping units are listed in Table 3. These data can be grouped into nutrient availability/inherent fertility classes (Table 8) according to the ranges given in Table 7. The ratings are based on literature and experience in similar environments.

Further validation is necessary, which can only be done through field research, establishi‿g relationships between fertility parameters, crop nutrient withdrawal and crop yields. Such data are, however, not yet available for the survey area. Recent reviews revealed that rice withdraws on average 34 kg N, 4 kg P and 30 kg K per ton harvested product. For yam, these values are 5 kg N, 0.5 kg P and 6 kg K (Cooke, 1982; Pieri, 1985).

Table 7. Nutrient availability classes and rating tables for chemical parameters (0-20 cm).

	class		
..eter	high	moderate	low
Total N (%.)	> 1.0	1.0-0.6	< 0.6
$pH-H_2O$	> 5.8	5.2-5.8	< 5.2
P-Olsen (ppm)	> 6.0	4.0-6.0	< 4.0
Ca-exch (me/100g)	> 1.0	0.6-1.0	< 0.6
Mg-exch (me/100g)	> 0.5	0.3-0.5	< 0.3
K-exch (me/100g)	> 0.3	0.2-0.3	< 0.2

The nutrient availability ratings for the different soils of the survey area are given in Table 8.

Table 8. Nutrient availability ratings for the different soils of the survey area.

parameter	depth	Uuvg/ Umdg	Umdo	Ummg	Fil/Fw	Bc
Total N	0-20	high	mod.	low	low	high
	20-40	mod.	low	low	-	low
$pH-H_2O$	topsoil	high	high	high	high	mod.
	subsoil	high	mod.	mod.	mod.	high
P-Olsen	topsoil	mod.	high	mod.	low	high
	subsoil	-	low	low	low	mod.
Ca-exch	topsoil	high	high	high	mod.	high
	subsoil	high	high	high	low	high
Mg-exch	topsoil	high	high	high	mod.	high
	subsoil	high	high	mod.	low	high
K-exch	topsoil	high	mod.	mod.	low	mod.
	subsoil	mod.	low	low	low	low

- No data available

Since the root volume is mainly confined to the topsoil, nutrient availabilities for this part of the soil are the most important.

The ratings of Table 8 can be summarized as follows:

- the soils of mapping units **Uuvg** and **Umdg** have a high fertility
- the soils of units **Umdo** have a moderate fertility, but with low subsoil contents of N, P and K
- the soils of unit **Ummg** have a low to moderate fertility
- the coarse-textured soils of the footslopes (**Fi**, **Fw**) are very poor: they have low contents of N, P, and K
- the clayey soils of the bottomlands (**Bc**) have a high fertility as far as the topsoil is concerned.

Van der Poel (1989) collected nutrient availability data for some 60 bottomland soils in the Equatorial Forest zone and the Guinea Savanna zone of West Africa. In comparison, the soils of the M'bé bottomland rate among the better (Table 9).

Table 9. Means and ranges of nutrient availability for bottomland soils in the Equatorial Forest zone, the Guinea Savanna zone (Van de Poel, 1989) and the survey area (M'bé bottomland).

Parameter	depth	Equatorial Forest Zone		Guinea Savanna Zone		M'bé bottomland
		mean	range	mean	range	mean
organic	0-20	1.7	0.6-6.7	1.1	0.1-2.8	2.1
carbon (%)	20-50	0.5	0.1-1.2	0.5	0.1-0.9	0.7
Total N	0-20	1.3	0.1-6.0	0.8	0.1-1.9	1.7
(%.)	20-50	0.5	0.1-0.8	0.3	0.1-0.8	0.6
$pH-H2^{0}$	0-20	4.9	3.8-6.6	5.8	4.6-6.7	5.8
	20-50	5.1	4.1-6.6	5.8	4.7-7.0	6.3
Ca-exch	0-20	0.87	0.08-5.7	2.5	0.6-13.5	4.9
(me/100g)	20-50	0.48	0.06-9.5	2.9	0.3-21.0	3.3
Mg-exch	0-20	0.43	0.06-3.8	1.0	0.1-10.8	3.4
(me/100g)	20-50	0.82	0.03-7.0	1.1	0.1-18.8	2.9
K-exch	0-20	0.10	0.01-0.5	0.2	0.02-0.9	0.3
(me/100g)	20-50	0.05	0.01-0.4	0.2	0.03-0.5	0.1
Na-exch	0-20	0.06	0.01-0.4	0.1	0.02-0.3	0.4
(me/100g)	20-50	0.05	0.01-0.4	0.1	0.01-0.4	0.4
CEC	0-20	7.1	2.6-17.2	7.3	1.5-24.7	14.1
(me/100g)	20-50	3.7	1.6-22.3	6.5	1.7-31.2	10.3

Three remarks can be made on the appraisal of soil fertility:

- As soils become submerged, electrochemical changes due to reduction result in slightly better nutrient availability as compared to aerobic conditions (Ponnamperuma, 1978). This applies to the cultivation of lowland rice on the poorly drained soils of the bottomlands. For this particular land utilization type, availability ratings of phophorus availability and exchangeable bases as given in Table 7, should be upgraded by one class.

- Nitrogen in the soil is susceptible to various loss mechanisms, including leaching, denitrification and volatilization. These loss mechanisms act most strongly in alternatingly wet and dry environments as is the case in the footslopes and the bottomlands (Moormann et al., 1977). Proper land management may reduce losses.
- Continuous cultivation without fertilizer application will cause a rapid decline of nutrient availability, particularly on the uplands. As long as the present cultivation/fallow ratio (2-3 years cultivation followed by 7-9 years fallow) is maintained, nutrient levels will remain at a reasonable level.

d) Nutrient retention capacity

Some soils (units **Ummg, Umsg, Fi1, Fw**) have a low cation exchange capacity (Table 3). This is the result of low organic matter content, low clay content and unfavourable clay mineralogy. In such soils nutrient retention is very low and, as leaching losses are high, a low recovery of applied fertilizer must be expected. Under such conditions, application of fertilizer should go hand in hand with proper timing and management in order to be effective (De Datta, 1978).
The fine-textured soils of the study area (**Uuvg, Umdg, Umdo, Fi2, Bc**) have a more favourable nutrient retention capacity.

e) Soil Toxicity

Strongly orange-coloured ground- and surfacewater, a symptom of high ferric iron content, was observed at various places in the footslopes and bottomlands of the survey area. Incidence of iron (Fe^{2+}) toxicity to rice in poorly drained soils is frequently reported in literature (Van Breemen and Moormann, 1978; IITA, 1983). At Fe^{2+}-contents of 50-100 ppm rice is considered to start showing toxicity symptoms (bronzing).

Table 4 shows iron contents of water samples taken at various sites in the survey area. Iron levels do not reach levels reported to be toxic in literature, although strong orange colouring was observed. These data do not mean that there is no risk of iron-toxicity, since little is known on the variability in time. Heavy rainfall may have diluted the iron contents of the samples taken. A monitoring programme may throw a better light on this important land quality.

Secondary effects of excess Fe^{2+} are that it induces deficiencies of Zn and Cu and that it competes with K, Mg, Ca and NH4 for adsorption sites at the exchange complex, thereby enhancing leaching losses of valuable nutrients.

f) Rootability

Rootability and adequacy for tuber expansion can be broadly assessed by rating the land characteristics 'effective soil depth' and 'texture'.
Effective soil depth is defined here as the depth to root-impeding layers. These include: hard rock (not relevant to the survey area), ironstone (as in units **Ummg** and **Umsg**), massive compacted layers (in units **Umdg** and **Umdo**) abrupt textural changes (as in unit **Bs**) and shallow or moderately deep groundwater (in poorly drained and imperfectly drained soils of the footslopes and the bottomlands).

A high gravel content usually causes a high bulk density, and thus low rootability. However, the gravelly clays of units **Uuvg** and **Umdg** do not seem to hinder root penetration. On the contrary, roots seem to enter deeper than in the non-gravelly clays of the **Umdo** units.
However, where the gravel content is very high (>50% by volume), the rootability is indeed lower.

Bulk density in the topsoils in the survey area ranges from 1.3 (uplands) to 1.6 (colluvial footslopes). For tuber crops, bulk density of the subsoil may be too high for adequate growth. Therefore, these crops are mostly grown in large mounds (about 40 cm high). This is at the same time a means to avoid excessive wetness.

g) Ease of cultivation

'Ease of manual cultivation' of the soils in the survey area is, in a strict sense, mostly high, because of the low plasticity and the absence of stones and rock at the surface.

When considering 'ease of mechanized cultivation', slope steepness is a relevant land characteristic and areas with slopes over 5% rank 'moderate' for this land quality. However, such areas occur only in unit **Umsg**, where they are associated with ironstone outcrops, and therefore not suitable for mechanized cultivation.

h) Risk of erosion

Because of prevailing gentle slopes, the erosion hazard in the survey area is rather low.
Some evidence of rainsplash erosion is visible on the mounds which are made for yam and cassava: large amounts of larger gravel are exposed on the surfaces, indicating an outwash of the finer material to the depressions between the mounds. However, accelerated downslope transport has not been observed.

Kalms (1977), in an erosion study near Bouaké, measured erosion losses of up to 50 tonnes/ha for plots on 4% slopes with a low gravel content in the topsoils. This indicates a moderate erosion hazard for **Umdo** units. Erosion losses on plots with gravelly topsoils are much lower, probably because the infiltration capacity of these soils is significantly higher.

Downslope tracks in the field are another cause of erosion in the **Umdo** units. They can easily turn into waterways during peak rains and small to moderate gullies can develop.

4.3 Summary

Tables 10, 11 and 12 list the land evaluation ratings for the land qualities discussed in this chapter for lowland rice, upland rice and other upland crops respectively. Crop requirements are derived from surveys in Sierra Leone (FAO/UNDP, 1979, 1980) and from more general studies (FAO, 1983 and 1985).

Table 10. Qualitative suitability rating of map units in the survey area, for lowland rice.

Map unit	moisture availab.	oxygen availab.	nutrient availab.	nutrient retention	soil tox.	root-ability	ease of cultivation		erosion hazard	general suitability
							manual	mechanized		
Uuvg	-	p	-	-	-	x	x	-	-	non
Uusg	(xx)	p	(xx)	(xx)	-	xxx	xx	p	-	non
Umdg1	-	p	-	-	-	x	x	-	-	non
Umdg2	-	p	-	-	-	-	-	-	-	non
Umdo1	-	p	x	x	-	-	-	-	x	non
Umdo2	-	p	(xx)	(xx)	-	-	-	-	x	non
Ummg	x	p	xx	xx	-	-	-	xx	-	non
Umsg	xx	p	(xx)	(xx)	-	xx	-	p	-	non
Fi1	-	xxx	xxx	xx	x	-	-	-	-	very low
Fi2	-	p	(-)	(-)	-	x	x	-	-	non
Fw1	xx	p	xxx	xx	-	-	-	-	-	non
Fw2	(xx)	p	(xxx)	(xx)	-	-	-	-	-	non
Bc1	-	-	-	-	x	-	x	-	-	high
Bc2	-	-	-	-	x	-	x	-	-	high
Bs	-	-	(x)	(x)	x	-	-	-	-	moderate

- no constraint
x slight constraint
xx moderate constraint
xxx severe constraint
p prohibitive
( ) not measured, estimated from comparable soils in the survey area

Table 11. Qualitative suitability rating of map units in the survey area, for upland rice.

Map unit	moisture availab.	oxygen availab.	nutrient availab.	nutrient retention	soil tox.	root-ability	ease of cultivation manual	ease of cultivation mechanized	erosion hazard	general suitability
Uuvg	-	-	-	-	-	x	x	-	-	high
Uusg	(xx)	-	(xx)	(xx)	-	xxx	xx	p	-	very low
Umdg1	-	-	-	-	-	x	x	-	-	high
Umdg2	-	-	-	-	-	-	-	-	-	high
Umdo1	-	-	x	x	-	-	-	-	x	moderate
Umdo2	-	-	(xx)	(xx)	-	-	-	-	x	low
Ummg	x	-	xx	xx	-	-	-	xx	-	low
Umsg	xx	-	(xx)	(xx)	-	xx	-	p	-	very low
Fi1	-	-	xxx	xx	x	-	-	-	-	low
Fi2	-	-	(-)	(-)	-	x	x	-	-	moderate
Fw1	xx	-	xxx	xx	-	-	-	-	-	very low
Fw2	(xx)	-	(xxx)	(xx)	-	-	-	-	-	very low
Bc1	-	xx	-	-	x	-	x	-	-	low
Bc2	-	xx	-	-	x	-	x	-	-	low
Bs	-	xx	(x)	(x)	x	-	-	-	-	low

- no constraint
x slight constraint
xx moderate constraint
xxx severe constraint
p prohibitive
( ) not measured, estimated from comparable soils in the survey area

Table 12. Qualitative suitability rating of map units in the survey area, for other dryland crops (yam, cassave, maize, cotton; based on average requirements).

Map unit	moisture availab.	oxygen availab.	nutrient availab.	nutrient retention	soil tox.	root-ability	ease of cultivation manual	ease of cultivation mechanized	erosion hazard	general suitability
Uuvg	-	-	-	-	n.r.	x	x	-	-	high
Uusg	xx	-	(xx)	(xx)	n.r.	xxx	xx	p	-	very low
Umdg1	-	-	-	-	n.r.	x	x	-	-	high
Umdg2	-	-	-	-	n.r.	-	-	-	-	high
Umdo1	-	-	x	x	n.r.	-	-	-	x	moderate
Umdo2	-	-	(xx)	(xx)	n.r.	-	-	-	x	low
Ummg	x	-	xx	xx	n.r.	x	-	xx	-	low
Umsg	xx	-	(xx)	(xx)	n.r.	xx	-	p	-	very low
Fi1	-	x	xxx	xx	n.r.	-	-	-	-	low
Fi2	-	-	(-)	(-)	n.r.	x	x	-	-	moderate
Fw1	xx	-	xxx	xx	n.r.	-	-	-	-	very low
Fw2	xx	-	(xxx)	(xx)	n.r.	-	-	-	-	very low
Bc1	-	p	-	-	n.r.	-	x	-	-	non
Bc2	-	p	-	-	n.r.	-	x	-	-	non
Bs	-	p	(x)	(x)	n.r.	-	-	-	-	non

no constraint
x slight constraint
xx moderate constraint
xxx severe constraint
p prohibitive
( ) not measured, estimated from comparable soils in the survey area

5 THE MAPPING UNITS AND THEIR SUITABILITY FOR RESEARCH ON RICE AND DRYLAND CROPS

In this chapter, the preceding facts and interpretations are summarized for each mapping unit. Furthermore, recommendations are given concerning the suitability of the mapping units for research trials. These recommendations are mainly based on unit distribution and soil homogeneity.
Absolute and relative acreages and unit distributions are given as well. Unit distribution is given as the number of large (>25 ha), medium (5-25 ha), small (2-5 ha) and very small (<2 ha) units.

Map Symbol : **Uuvg**

Acreage (ha) : 141 (11.6%)
Unit distribution : 2 large, 2 medium
Brief description : Upper upland slopes with very deep gravelly clay soils
Slope (%) : 0-2
Present land use : shifting cultivation

Moisture availab. : high
Oxygen availab. : high
Nutrient availab. : high
Rootability : high

Suitability for
- lowland rice : not suitable
- upland rice : high
- other crops : high

Recommendation : because of the size and the relative homogeneity of the polygons, this unit is very suitable for research trials. Uniformity trials may be necessary (see remarks).

Remarks:
The horizon immediately underlying the topsoil can be extremely gravelly and somewhat compacted, thus limiting the rootability.

Part of this unit is covered by termite mounds, either active or abandonned. This affects homogeneity, since the soils of the termite mounds have a higher fertility and a different texture.

Map Symbol	: **Uusg**
Acreage (ha)	: 18 (1.5%)
Unit distribution	: 1 medium, 1 small, 2 very small
Brief description	: Upper upland slopes with shallow gravelly soils
Slope (%)	: 0 - 2
Present land use	: forest
Moisture availab.	: strongly varying
Oxygen availab.	: high
Nutrient availab.	: strongly varying
Rootability	: high in deeper pockets
Suitability for	
lowland rice	: not suitable
upland rice	: very low
other crops	: very low
Recommendation	: to remain under forest

Remarks:
The surface is partly often covered by large ironstone boulders. Pockets of deeper soils occur in patches.

Map Symbol	: **Umdgl**
Acreage (ha)	: 285 (23.4%)
Unit distribution	: 4 large, 7 medium
Brief description	: Middle upland slopes with deep gravelly clay soils
Slope (%)	: 2 - 4
Present land use	: shifting cultivation
Moisture availab.	: high
Oxygen availab.	: high
Nutrient availab.	: high
Rootability	: high
Suitability for	
lowland rice	: not suitable
upland rice	: high
other crops	: high
Recommendation	: very suitable for research trials, uniformity trials may be necessary (see remarks).

Remarks:
A significant part of the surface of this unit is covered by termite mounds, either active or abandonned. This affects homogeneity, since the soils of the termite mounds have a higher fertility, and a different texture.

Map Symbol	: **Umdg2**
Acreage (ha)	: 22 (1.8%)
Unit distribution	: 2 medium, 1 very small
Brief description	: Middle upland slopes with moderately deep to deep gravelly clay soils
Slope (%)	: 2 - 4
Present land use	: shifting cultivation
Moisture availab.	: high
Oxygen availab.	: high
Nutrient availab.	: high
Rootability	: high
Suitability for	
lowland rice	: not suitable
upland rice	: high
other crops	: high
Recommendation	: soils are homogeneous; where the polygons are large enough, they can be used for research trials.

Map Symbol	: **Umdol**
Acreage (ha)	: 81 (6.7%)
Unit distribution	: 1 large, 3 medium, 5 small, 4 very small
Brief description	: Middle upland slopes with deep, non gravelly clay soils
Slope (%)	: 2 - 4
Present land use	: shifting cultivation
Moisture availab.	: high
Oxygen availab.	: high
Nutrient availab.	: moderate (subsoil deficient in N, P, K)
Rootability	: high
Suitability for	
lowland rice	: not suitable
upland rice	: moderate
other crops	: moderate
Recommendation	: where polygons are sufficiently large, this unit can be used for research trials

Infiltration capacity of these soils is not very high, causing a moderate erosion hazard. Some downslope tracks have developed into gullies. Management practices must include anti-erosion measures.

Map Symbol	: **Umdo2**
Acreage (ha)	: 36 (3.0%)
Unit distribution	: 4 medium
Brief description	: Middle upland slopes with moderately deep to deep non-gravelly sandy loam soils
Slope (%)	: 2 - 4
Present land use	: shifting cultivation, high percentage fallow
Moisture availab.	: moderate to high
Oxygen availab.	: high
Nutrient availab.	: low to moderate
Rootability	: high
Suitability for	
lowland rice	: not suitable
upland rice	: low
other crops	: low
Recommendation	: when sufficiently large, this unit can be used for research trials.

Map Symbol	: **Ummg**
Acreage (ha)	: 36 (3.0%)
Unit distribution	: 3 medium, 5 small, 2 very small
Brief description	: Middle upland slopes with moderately deep gravelly sandy loam soils
Slope (%)	: 1 - 8
Present land use	: shifting cultivation
Moisture availab.	: moderate
Oxygen availab.	: high
Nutrient availab.	: low (deficient in N, P)
Rootability	: high
Suitability for	
lowland rice	: not suitable
upland rice	: low
other crops	: low
Recommendation	: because of the limited size of the polygons and the high heterogeneity of the soil depth caused by the irregular ironstone surface, this unit has limited suitability for research trials.

Map Symbol	**: Umsg**
Acreage (ha)	: 165 (13.5%)
Unit distribution	: 2 large, 6 medium, 8 small, 6 very small, all in narrow bands along the contours
Brief description	: Middle upland slopes with shallow gravelly sandy loam soils and associated ironstone outcrops
Slope (%)	: 1 - 8
Present land use	: mainly fallow
Moisture availab.	: low
Oxygen availab.	: high
Nutrient availab.	: low (deficient in N, P)
Rootability	: low
Suitability for	
lowland rice	: not suitable
upland rice	: very low
other crops	: very low
Recommendation	: not suitable for research trials because of strong heterogeneity of the soil depth.

Map Symbol	**: Fil**
Acreage (ha)	: 178 (14.6%)
Unit distribution	: 2 large, 4 medium, 3 small, 5 very small
Brief description	: Footslopes with imperfectly to poorly drained deep sandy soils
Slope (%)	: 1 - 3
Present land use	: shifting cultivation
Moisture availab.	: high
Oxygen availab.	: low
Nutrient availab.	: low (highly deficient in N, P, Mg, K)
Rootability	: moderate
Suitability for	
lowland rice	: very low
upland rice	: low
other crops	: low
Recommendation	: when sufficiently large, this unit can be used for research trials.

Remarks:
Where this unit is very narrow, ironstone may occur in the subsoil (below 80 cm). Near the upper boundary, the soils may locally be very gravelly.

In the lower parts of this unit, the groundwater reaches the surface during the wet season, possibly causing iron toxicity.

Map Symbol	: **Fi2**
Acreage (ha)	: 10 (0.8%)
Unit distribution	: 3 small, 3 very small
Brief description	: Footslopes with imperfectly drained deep clay soils (located along the Oundre river)
Slope (%)	: 1 - 2
Present land use	: forest
Moisture availab.	: high
Oxygen availab.	: low
Nutrient availab.	: moderate
Rootability	: moderate
Suitability for	
lowland rice	: not suitable
upland rice	: moderate
other crops	: moderate
Recommendation	: to remain under forest.

Map Symbol	: **Fw1**
Acreage (ha)	: 24 (1.5%)
Unit distribution	: 2 medium, 2 small, 2 very small
Brief description	: Footslopes with well to moderately well drained deep sandy soils
Slope (%)	: 2 - 4
Present land use	: shifting cultivation, high percentage fallow
Moisture availab.	: low
Oxygen availab.	: high
Nutrient availab.	: very low (highly deficient in N, P, Mg, K)
Rootability	: high
Suitability for	
lowland rice	: not suitable
upland rice	: very low
other crops	: very low
Recommendation	: larger mapping units are suitable for research trials.

Map Symbol	: **Fw2**
Acreage (ha)	: 19 (1.6%)
Unit distribution	: 1 medium, 2 small, 1 very small
Brief description	: Footslopes with well drained moderately deep sandy soils
Slope (%)	: 2 - 4
Present land use	: mainly fallow
Moisture availab.	: low
Oxygen availab.	: high
Nutrient availab.	: very low (highly deficient in N, P, Mg, K)
Rootability	: high
Suitability for	
lowland rice	: not suitable
upland rice	: very low
other crops	: very low
Recommendation	: Not very representative and thus less suitable for research trials.

Map Symbol	: **Bc1**
Acreage (ha)	: 83 (6.8%)
Unit distribution	: 1 large
Brief description	: Bottomlands with deep clayey soils (with water control)
Slope (%)	: 0 - 1
Present land use	: lowland rice
Moisture availab.	: high
Oxygen availab.	: low
Nutrient availab.	: high
Rootability	: low
Suitability for	
lowland rice	: high
upland rice	: low
other crops	: not suitable
Recommendation	: Suitable for lowland rice trials; irrigation and drainage system must be rehabilitated.

Remarks:
Locally, sandy or sandy loam subsoils occur, reflecting old sedimentation patterns. Similar soils occur in narrow bands (about 10 m) along the fringes of the unit. Topsoils always consist of a puddled layer of at least 20 cm sandy clay to clay, with a high organic matter content. This very firm layer largely precludes vertical water movement through the soil.

Extreme iron colouring was observed at the sides of the valley. Here, iron-rich seepage water from the higher slopes enters the bottomland. Towards the centre of the valley, drainage becomes much better and no iron colouring occurs.

Map Symbol : **Bc2**

Acreage (ha) : 52 (4.3%)
Unit distribution : 2 medium, 3 small, 4 very small
Brief description : Bottomlands with deep clay soils, without water control
Slope (%) : 0 - 1
Present land use : lowland rice and forest

Moisture availab. : high
Oxygen availab. : low
Nutrient availab. : high
Rootability : low

Suitability for
lowland rice : high
upland rice : low
other crops : not suitable

Recommendation : Oundre bottomland is suitable for research trials. Bottomlands of smaller tributaries are usually too small and should remain under forest.

Map Symbol : **Bs**

Acreage (ha) : 16 (1.3%)
Unit distribution : 2 medium, 1 small, 2 very small
Brief description : Bottomlands with moderately deep to deep, sandy soils
Slope (%) : 0 - 1
Present land use : forest

Moisture availab. : high
Oxygen availab. : low
Nutrient availab. : low
Rootability : high

Suitability for
lowland rice : moderate
upland rice : low
other crops : not suitable

Recommendation : to remain under forest.

Map Symbol : **D1**

Acreage (ha) : 29 (2.3%)
Unit distribution : 1 medium
Brief description : Disturbed soils, probably connected with ancient village
Slope (%) : varying
Present land use : shifting cultivation

Moisture availab. : high
Oxygen availab. : high
Nutrient availab. : moderate
Rootability : high

Suitability for
- lowland rice : not suitable
- upland rice : variable
- other crops : variable

Recommendation : variability is too high and representativeness is too low to be suitable for research trials.

Remarks:
The unit consists of a system of artificial ridges and depressions with a height difference of about 2 meters. Soils are dark brown throughout, charcoal and pottery fragments are found up to a depth of 120 cm. Pottery fragments can be observed in yam and cassava mounds all over this unit, sometimes in abundant amounts.

No termite mounds are found in this area, although they are very frequent in comparable positions in the landscape, which are not influenced by human activity.

Map Symbol : **D2**

Acreage (ha) : 16 (1.3%)
Unit distribution : 2 medium, 1 very small
Brief description : Disturbed soils connected with the construction of the dam
Slope (%) : 5 - 10
Present land use : mainly fallow

Moisture availab. : not determined
Oxygen availab. : not determined
Nutrient availab. : not determined
Rootability : not determined

Suitability for
- lowland rice : not suitable
- upland rice : variable
- other crops : variable

Recommendation : not suitable for research trials.

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ANNEX 1 KEY TO SOIL DESCRIPTION CLASSES

Classes from 'Guidelines for soil profile description' (FAO, 1977) and Soil Survey Manual (Soil Survey Staff, 1984)

HORIZON SYMBOL

A - topsoil
B - weathered subsoil
C - Non-weathered subsoil

SUFFIXES

c - concretions
g - oxidation mottles, gleying
h - humus
m - cementation
r - reduction
s - sequioxides
t - clay illuviation
u - unspecified

TOPOGRAPHY

Flat or almost flat	Slopes not steeper than 2%
Undulating	Steepest slopes between 2% and 8%

SLOPE CLASS

Flat to almost flat	0-2%
Gently sloping	2-6%
Sloping	6-13%

EXTERNAL DRAINAGE

Well drained	Water is removed readily
Moderately well drained	Water is removed somewhat slowly, soil is wet for small part of the year
Imperfectly drained	Water is removed slowly, soil is wet for significant part of the year
Poorly drained	Water is removed slowly, soils is wet for large part of the year
Very poorly drained	Water is removed very slowly, water table at surface for larger part of the year

SOIL COLOUR: Colours used in the Munsell Color charts (moist colour)

EFFECTIVE SOIL DEPTH

Shallow	0-50 cm
Moderately deep	50-80 cm
Deep	80-120 cm
Very deep	>120 cm

TEXTURE < 2mm

S - sand
LS - loamy sand
SL - sandy loam
SCL - sandy clay loam
CL - clay loam
SC - sandy clay
C - clay
For sand: f - fine m - medium c - coarse

TEXTURE >2mm

sGR - slightly gravelly	2-15% gravel
GR - gravelly	15-50% gravel
vGR - very gravelly	50-90% gravel

STRUCTURE

<u>grade</u>

Weak	Poorly formed, indistinct peds
Moderate	Well formed, distinct peds

<u>size</u>

Fine	5-10 mm
Medium	10-20 mm
Coarse	20-50 mm

<u>type</u>

SAB - subangular blocky
AB - angular blocky

CONSISTENCE

<u>moist</u>

Loose	Non-coherent
Very friable	Soil material crushes under very gentle pressure
Friable	Soil material crushes easily under gentle to moderate pressure
Firm	Soil material crushes under moderate pressure

<u>wet</u>

nST - non-sticky	Practically no soil material adheres to fingers
sST - slightly sticky	Soil material adheres to fingers, but comes off rather cleanly
ST - sticky	Soil material adheres to fingers and tends to stretch and pull apart
nPL - non-plastic	No wire is formable
sPl - slightly plastic	Wire formable but soil mass easily deformable
PL - plastic	Wire formable and much pressure required for deformation of soil mass
Very fluid	When squeezed in hand, material flows easily between fingers

MOTTLES

abundance

Few	<2% of exposed surface
Common	2-20% of exposed surface
Many	>20% of exposed surface

size

Fine	< 5 mm diameter
Medium	5-15 mm diameter
Coarse	>15 mm diameter

contrast

Faint
Distinct
Prominent

ROOTS

abundance

Few
Common
Many

size

Fine
Medium
Large

BOUNDARY

distinction

Abrupt
Clear
Gradual
Diffuse

regularity

Smooth
Wavy
Irregular
Broken

CUTANS

quantity

Patchy	Small scattered patches of cutans
Broken	Cutans cover much but not all of ped faces

thickness

Thin
Moderately thick

ANNEX 2 DESCRIPTION AND ANALYTICAL RESULTS OF REPRESENTATIVE PROFILES

PROFILE NUMBER: 1 LAND USE/VEGETATION: FALLOW, IMPERATA GRASSES
MAPPING UNIT : Uuvg

SLOPE (%) : 2-3
DRAINAGE : WELL DRAINED
FLOODING : NONE
WATERTABLE:

CLASSIFICATION
- SOIL TAXONOMY : PALEUSTULT
- FAO : RHODI-HUMIC ACRISOL
- CPCS : SOL FERRALLITIQUE FAIBLEMENT DESATURE REMANIE MODAL

PROFILE DESCRIPTION

Horizon Symbol - - - - Depth	Colour moist	Texture < 2mm - - - - > 2mm	Structure (grade, size, type)	Consistence moist - - - - - wet	Mottles (abundance, size, contrast)	Roots (grade, size, type)	Hor.boundary (distinction, regularity)	Other features (concretions, cutans, krotovinas, crystals)
Ah - - - - 0-22	10YR2/2	SL - - - -	WEAK FINE SAB	FRIABLE - - - - - sST/sPL		MANY FINE, MED,CRS	CLEAR WAVY	
BA - - - - 22-35	7.5YR3/2	SC - - - - GR	WEAK MEDIUM SAB	FIRM - - - - - ST/PL		COMMON FINE, MEDIUM	DIFFUSE SMOOTH	KROTOVINAS AND STRONG TERMITE ACTIVITY
Bts1 - - - - 35-60	2.5YR3/6	SC - - - - GR	WEAK COARSE SAB	FIRM - - - - - ST/sPL		COMMON FINE, MEDIUM	CLEAR SMOOTH	
Bts2 - - - - 60-90	2.5YR4/6	C - - - - vGR	WEAK COARSE AB	FIRM - - - - - ST/sPL		FEW FINE, MEDIUM	GRADUAL SMOOTH	
Bts3 - - - - 90-140	2.5YR4/6	C - - - - GR	WEAK COARSE AB	FIRM - - - - - ST/sPL				

REMARKS:

LABORATORY DATA

Horizon	Sample depth(cm)	Texture (%) clay	silt	sand	gravel	pH H2O	KCl	C org (%)	N tot (‰)	C/N	P-Olsen (ppm)	Exch. Cations (meq/100g) Ca	Mg	K	Na	CEC (pH 7) (meq/100g)	Base sat.(%)
Ah	0-22	18	9	73	10	6.1	5.5	1.72	1.26	14	206	5.17	1.11	0.32	0.06	10.0	67
BA	22-35	40	13	47	30	6.1	5.3	0.98	0.73	14	163	3.30	0.74	0.18	0.04	8.2	53
Bts1	35-60	37	15	48	19	6.2	5.4	0.62	0.56	11	97.0	2.60	0.45	0.22	0.04	7.4	45
Bts2	60-90	53	12	35	38	6.3	5.5	0.45	0.45	10	54.3	2.40	0.41	0.22	0.04	8.6	36
Bts3	90-140	54	14	32	16	6.4	5.7	0.41	0.28	15	20.7	3.13	0.41	0.22	0.04	10.0	38

Horizon	Sample depth(cm)	Bulk density (g/cm3)	Water content (volume %) pF0.0	pF1.0	pF2.0	pF2.7	pF4.2	Water retention capacity (mm/m)
Ah	5-10	1.30	54	40	29	23	13	160

PROFILE NUMBER: 2
MAPPING UNIT : Uuvg

LAND USE/VEGETATION: FALLOW, IMPERATA GRASSES

SLOPE (%) : 0-1
DRAINAGE : WELL DRAINED
FLOODING : NONE
WATERTABLE:

CLASSIFICATION
- SOIL TAXONOMY : PALEUSTULT
- FAO : RHODI-HUMIC ACRISOL
- CPCS : SOL FERRALLITIQUE FAIBLEMENT DESATURE REMANIE MODAL

PROFILE DESCRIPTION

Horizon Symbol / Depth	Colour moist	Texture < 2mm / > 2mm	Structure (grade, size, type)	Consistence moist / wet	Mottles (abundance, size, contrast)	Roots (abund. size, distr)	Hor.boundary (distinction, regularity)	Other features (concretions, cutans, krotovinas, crystals)
Ah / 0-23	5YR2/2	SCL / sGR	WEAK COARSE SAB	FRIABLE / ST/sPL		MANY FINE, MEDIUM	CLEAR SMOOTH	
AB / 23-40	5YR3/3	SC / GR	WEAK COARSE SAB	vFRIABLE / ST/sPL		MANY FINE, MED,CRS	CLEAR SMOOTH	
Bts1 / 40-89	2.5YR3/4	SC / vGR	WEAK MEDIUM SAB	FRIABLE / ST/sPL		COMMON FINE, MEDIUM	GRADUAL SMOOTH	CUTANS: BROKEN, MOD.THICK IRONSTONE BLOCK OF 12cm DIAMETER OCCURS
Bts2 / 89-130	2.5YR3/6	C / GR	WEAK MEDIUM SAB	FRIABLE / ST/sPL		FEW FINE, MEDIUM		CUTANS: BROKEN, MOD.THICK

REMARKS:

LABORATORY DATA

Horizon	Sample depth(cm)	Texture (%) clay	silt	sand	gravel	pH H2O	pH KCl	C org (%)	N tot (%.)	C/N	P-Olsen (ppm)	Exch. Cations (meq/100g) Ca	Mg	K	Na	CEC (pH 7) (meq/100g)	Base sat.(%)
Ah	0-23	30	21	49	7	6.4	6.0	3.15	1.90	17	239	8.40	2.62	1.00	0.08	16.4	74
AB	23-40	38	12	50	31	6.0	5.6	1.36	0.90	15	141	3.70	1.03	0.26	0.04	9.8	51
Bts1	40-89	43	7	50	58	6.0	5.6	0.58	0.56	10	65.2	2.58	0.82	0.16	0.04	12.0	30
Bts2	89-130	43	15	42	37	6.1	5.9	0.23	0.41	6	9.1	2.03	0.55	0.16	0.04	10.8	26

Horizon	Sample depth(cm)	Bulk density (g/cm3)	Water content (volume %) pF0.0	pF1.0	pF2.0	pF2.7	pF4.2	Water retention capacity (mm/m)
Ah	2-7	1.34	48	43	35	29	14	210
Bts1	83-88	1.51	46	31	23	17	9	140

PROFILE NUMBER: 3 LAND USE/VEGETATION: FALLOW
MAPPING UNIT : Uuvg

SLOPE (%) : 1-2
DRAINAGE : WELL DRAINED
FLOODING : NONE
WATERTABLE:

CLASSIFICATION
- SOIL TAXONOMY : PALEUSTULT
- FAO : RHODI-HUMIC ACRISOL
- CPCS : SOL FERRALLITIQUE FAIBLEMENT DESATURE REMANIE MODAL

PROFILE DESCRIPTION

Horizon Symbol / Depth	Colour moist	Texture < 2mm / > 2mm	Structure (grade, size, type)	Consistence moist / wet	Mottles (abundance, size, contrast)	Roots (abund. size, distr)	Hor.boundary (distinction, regularity)	Other features (concretions, cutans, krotovinas, crystals)
Ah / 0-16	7.5YR3/2	SCL / GR	WEAK MEDIUM SAB	FRIABLE / sST/nPL		MANY FINE, MED,CRS	CLEAR SMOOTH	
Bts1 / 16-36	5YR4/6	C / vGR	WEAK MEDIUM SAB	FRIABLE / sST/nPL		FEW FINE, MEDIUM	CLEAR SMOOTH	CUTANS: BROKEN, MOD.THICK
Bts2 / 36-75	2.5YR4/6	C / vGR	WEAK COARSE SAB	FRIABLE / sST/nPL		FEW FINE, MEDIUM	GRADUAL SMOOTH	CUTANS: BROKEN, MOD.THICK
Bts3 / 75-110	2.5YR4/6	C / GR	WEAK MEDIUM SAB	FRIABLE / nST/nPL		FEW FINE, MEDIUM	CLEAR SMOOTH	CUTANS: BROKEN, MOD.THICK
Bm / 110-123	2.5YR4/6	C / sGR	WEAK MEDIUM SAB	vFRIABLE / mST/nPL				

REMARKS:

LABORATORY DATA

Horizon	Sample depth(cm)	Texture (%) clay	silt	sand	gravel	pH H20	KCl	C org (%)	N tot (%.)	C/N	P-Olsen (ppm)	Exch. Cations (meq/100g) Ca	Mg	K	Na	CEC (pH 7) (meq/100g)	Base sat.(%)
Ah	0-16	28	12	62	22	6.5	6.3	1.95	1.18	17	9.1	4.72	2.69	0.54	0.04	9.6	83
Bts1	16-36	43	15	42	63	5.5	5.0	0.85	0.78	11	2.2	1.46	0.89	0.22	0.02	5.8	45
Bts2	n.d.																
Bts3	n.d.																
Bm	n.d.																

Horizon	Sample depth(cm)	Bulk density (g/cm3)	Water content (volume %) pF0.0	pF1.0	pF2.0	pF2.7	pF4.2	Water retention capacity (mm/m)
Ah	3-8	1.23	55	37	24	17	8	160

PROFILE NUMBER: 4 LAND USE/VEGETATION: YAM, FALLOW
MAPPING UNIT : Uuvg

SLOPE (%) : 2
DRAINAGE : WELL DRAINED
FLOODING : NONE
WATERTABLE:

CLASSIFICATION
- SOIL TAXONOMY : PALEUSTULT
- FAO : RHODI-HUMIC ACRISOL
- CPCS : SOL FERRALLITIQUE FAIBLEMENT DESATURE REMANIE MODAL

PROFILE DESCRIPTION

Horizon Symbol ---- Depth	Colour moist	Texture < 2mm ---- > 2mm	Structure (grade, size, type)	Consistence moist ----- wet	Mottles (abundance, size, contrast)	Roots (abund. size, distr)	Hor.boundary (distinction, regularity)	Other features (concretions, cutans, krotovinas, crystals)
Ah ---- 0-10	7.5YR3.2	SL ----	WEAK MEDIUM SAB	vFRIABLE ----- ST/PL		MANY FINE, MED,CRS	SMOOTH CLEAR	
BA ---- 10-20	5YR4/4	SC ---- sGR	WEAK COARSE SAB	vFRIABLE ----- ST/PL		MANY FINE, MED,CRS		
Bts1 ---- 20-80	5YR4/6	C ---- vGR	WEAK MEDIUM SAB	FRIABLE ----- ST/PL		COMMON FINE, MED,CRS		
Bts2 ---- 80-125	2.5YR4/6	C ---- GR	WEAK MEDIUM SAB	FRIABLE ----- ST/PL		COMMON FINE, MEDIUM		
Bm ---- 125-130	AGGREGATE	MASSIVE, COMPACTED, POROUS						

REMARKS:

PROFILE NUMBER: 5
MAPPING UNIT : Umdgl

LAND USE/VEGETATION: FALLOW, IMPERATA GRASSES

SLOPE (%) : 3
DRAINAGE : WELL DRAINED
FLOODING : NONE
WATERTABLE:

CLASSIFICATION
- SOIL TAXONOMY : PALEUSTULT
- FAO : RHODI-HUMIC ACRISOL
- CPCS : SOL FERRALLITIQUE FAIBLEMENT DESATURE REMANIE INDURE

PROFILE DESCRIPTION

Horizon Symbol / Depth	Colour moist	Texture < 2mm / > 2mm	Structure (grade, size, type)	Consistence moist / wet	Mottles (abundance, size, contrast)	Roots (abund. size, distr)	Hor.boundary (distinction, regularity)	Other features (concretions, cutans, krotovinas, crystals)
Ah / 0-20	10YR3/2	SL / sGR	WEAK MEDIUM SAB	vFRIABLE / sST/sPL		MANY FINE, MED,CRS	CLEAR SMOOTH	
Bts1 / 20-40	7.5YR4/4	SCL / sGR	WEAK MEDIUM SAB	FRIABLE / ST/sPL		MANY FINE, MEDIUM	CLEAR WAVY	CUTANS: BROKEN, THIN
Bts2 / 40-70	5YR5/6	SC/C / GR	WEAK MEDIUM SAB	FRIABLE / ST/sPL		COMMON FINE	GRADUAL SMOOTH	CUTANS: BROKEN, MOD.THICK
Bts3 / 70-102	5YR5/6	SC/C / GR	WEAK MEDIUM SAB	FRIABLE / ST/sPL		COMMON FINE	CLEAR SMOOTH	CUTANS: BROKEN, THIN
Bm / 102-125	MASSIVE, COMPACTED, POROUS					vFEW FINE		

REMARKS:

LABORATORY DATA

Horizon	Sample depth(cm)	Texture (%) clay	silt	sand	gravel	pH H2O	KCl	C org (%)	N tot (%.)	C/N	P-Olsen (ppm)	Exch. Cations (meq/100g) Ca	Mg	K	Na	CEC (pH 7) (meq/100g)	Base sat.(%)
Ah	0-20	25	13	62	9	6.2	5.9	1.51	0.34	44	2.6	3.80	1.19	0.42	0.04	7.0	78
Bts1	20-40	33	14	53	15	6.0	5.7	0.83	0.67	12	0.43	2.30	0.86	0.10	0.04	5.8	57
Bts2	40-70	43	13	44	39	6.0	5.6	0.55	0.45	12	0.43	2.03	0.98	0.08	0.04	5.6	56
Bts3	70-100	53	12	35	35	6.0	5.6	0.48	0.56	9	0.43	1.75	1.09	0.08	0.04	7.0	42
Bm	102-125	38	18	44	0	6.1	5.7	0.23	0.28	8	0.43	1.55	1.09	0.06	0.04	6.8	40

PROFILE NUMBER: 6
MAPPING UNIT : Umdg1

LAND USE/VEGETATION: FALLOW, COTTON

SLOPE (%) : 2-4
DRAINAGE : WELL DRAINED
FLOODING : NONE
WATERTABLE:

CLASSIFICATION
- SOIL TAXONOMY : PALEUSTULT
- FAO : RHODI-HUMIC ACRISOL
- CPCS : SOL FERRALLITIQUE FAIBLEMENT DESATURE REMANIE INDURE

PROFILE DESCRIPTION

Horizon Symbol / Depth	Colour moist	Texture < 2mm / > 2mm	Structure (grade, size, shape)	Consistence moist / wet	Mottles (abundance, size, contrast)	Roots (abund. size-distr)	Hor.boundary (distinction, regularity)	Other features (concretions, cutans, krotovinas, crystals)
Ah / 0-25	10YR3/2	SL / ----	WEAK COARSE SAB	vFRIABLE / sST/sPL		MANY FINE, MED,CRS	CLEAR SMOOTH	STRONG TERMITE ACTIVITY
AB / 25-36	7.5YR4.2	SCL / sGR	WEAK MEDIUM SAB	FRIABLE / sST/nPL		COMMON FINE, MEDIUM	CLEAR SMOOTH	
Bts / 36-53	5YR4/6	SC / GR	WEAK COARSE SAB	FRIABLE / sST/nPL		COMMON FINE, MEDIUM	CLEAR IRREGULAR	CUTANS: BROKEN, MOD.THICK
2Bts / 53-82	5YR5/6	SC / GR	WEAK MEDIUM SAB	FRIABLE / sST/nPL		FEW FINE	CLEAR SMOOTH	CUTANS: BROKEN, MOD.THICK
2Bm / 82-105	AGGREGATE	SC / sGR	WEAK MEDIUM SAB	FIRM / sST/nPL		vFEW FINE		CUTANS: BROKEN, MOD.THICK

REMARKS:

PROFILE NUMBER: 7
MAPPING UNIT : Umdol

LAND USE/VEGETATION: FALLOW, IMPERATA GRASSES

SLOPE (%) : 0-2
DRAINAGE : WELL DRAINED
FLOODING : NONE
WATERTABLE:

CLASSIFICATION
- SOIL TAXONOMY : PALEUSTULT
- FAO : RHODI-HUMIC ACRISOL
- CPCS : SOL FERRALLITIQUE FAIBLEMENT DESATURE REMANIE MODAL

PROFILE DESCRIPTION

Horizon Symbol / Depth	Colour moist	Texture < 2mm / > 2mm	Structure (grade, size, type)	Consistence moist / wet	Mottles (abundance, size, contrast)	Roots (abund. size, distr)	Hor. boundary (distinction, regularity)	Other features (concretions, cutans, krotovinas, crystals)
Ah 0-20	10YR2/2	SCL	WEAK COARSE SAB	FRIABLE sST/sPL		MANY FINE, MED,CRS	CLEAR SMOOTH	
BA 20-45	5YR3/4	SC	WEAK COARSE SAB	FRIABLE ST/PL		COMMON FINE, MED,CRS	CLEAR SMOOTH	HIGH BIOLOGICAL ACTIVITY
Bt1 45-60	2.5YR3/4	SC sGR	WEAK COARSE SAB	FIRM ST/PL		COMMON FINE	GRADUAL SMOOTH	CUTANS: PATCHY, THIN
Bt2 60-100	2.5YR3/6	C sGR	WEAK COARSE SAB	FRIABLE/FIRM ST/PL		COMMON FINE, MEDIUM	DIFFUSE SMOOTH	CUTANS: BROKEN, THIN
Bt3 100-126	2.5YR46	C sGR	WEAK COARSE SAB	FRIABLE ST/sPL		COMMON FINE MEDIUM		CUTANS: BROKEN,THIN

REMARKS:

LABORATORY DATA

Horizon	Sample depth(cm)	Texture (%) clay	silt	sand	gravel	pH H2O	pH KCl	C org (%)	N tot (%.)	C/N	P-Olsen (ppm)	Exch. Cations (meq/100g) Ca	Mg	K	Na	CEC (pH 7) (meq/100g)	Base sat.(%)
Ah	0-20	25	13	62	0	6.4	5.8	1.13	0.78	15	9.1	3.33	1.03	0.34	0.04	8.0	59
BA	20-45	38	10	52	0	5.9	5.2	0.91	0.67	14	2.2	2.43	0.74	0.20	0.04	9.6	36
Bt1	45-60	45	8	47	4	5.9	5.1	0.58	0.56	10	1.3	1.35	0.53	0.08	0.04	9.4	21
Bt2	60-100	55	7	38	6	6.0	5.3	0.56	0.50	11	3.9	1.53	0.49	0.08	0.04	11.8	18
Bt3	100-126	58	10	32	5	6.0	5.4	0.38	0.39	10	1.7	2.10	0.74	0.08	0.04	11.8	25

Horizon	Sample depth(cm)	Bulk density (g/cm3)	Water content (volume %) pF0.0	pF1.0	pF2.0	pF2.7	pF4.2	Water retention capacity (mm/m)
Ah	5-10	1.34	49	39	20	25	8	120
Bt2	65-70	1.46	43	38	31	26	14	170

PROFILE NUMBER: 8
MAPPING UNIT : Undol

LAND USE/VEGETATION: FALLOW, LOW GRASSES

SLOPE (%) : 4
DRAINAGE : WELL DRAINED
FLOODING : NONE
WATERTABLE:

CLASSIFICATION
- SOIL TAXONOMY : PALEUSTULT
- FAO : CHROMI-HAPLIC ACRISOL
- CPCS : SOL FERRALLITIQUE FAIBLEMENT DESATURE REMANIE MODAL

PROFILE DESCRIPTION

Horizon Symbol / Depth	Colour moist	Texture < 2mm / > 2mm	Structure (grade, size, type)	Consistence moist / wet	Mottles (abundance, size, contrast)	Roots (grade, size, type)	Hor.boundary (distinction, regularity)	Other features (concretions, cutans, krotovinas, crystals)
Ah / 0-21	10YR4/2	SCL	WEAK MEDIUM SAB	FRIABLE / sST/sPL		MANY FINE, MEDIUM	CLEAR WAVY	
Bt1 / 21-39	7.5YR4/4	SC	WEAK MEDIUM SAB	FIRM / ST/PL		COMMON FINE, MEDIUM	CLEAR WAVY	
Bt2 / 39-75	5YR5/8	C	WEAK MEDIUM SAB	FIRM / ST/sPL		COMMON FINE	GRADUAL SMOOTH	CUTANS: BROKEN, THIN
Btc / 75-125	5YR5/8	C	WEAK MEDIUM SAB	FIRM / nST/nPL		FEW FINE	ABRUPT SMOOTH	CUTANS: BROKEN, THIN CONCRETIONS: MANY, SMALL, DISTINCT
Bm / 125-140		C	MASSIVE			vFEW FINE		CONCRETIONS: MANY, MEDIUM, PROMINENT

REMARKS:

LABORATORY DATA

Horizon	Sample depth(cm)	Texture (%) clay	silt	sand	gravel	pH H2O	KCl	C org (%)	N tot (%.)	C/N	P-Olsen (ppm)	Exch. Cations (meq/100g) Ca	Mg	K	Na	CEC (pH 7) (meq/100g)	Base sat.(%)
Ah	0-21	25	8	67	0	5.8	5.4	0.99	0.62	16	27	1.78	0.98	0.08	0.04	4.2	69
Bt	21-39	37	11	52	0	5.6	5.2	0.67	0.50	14	3.0	1.35	0.74	0.08	0.04	5.4	41
Bt2	39-75	47	11	42	0	5.6	5.2	0.55	0.45	12	0.43	1.10	0.66	0.08	0.04	6.4	29
Btc	75-125	50	13	37	0	5.7	5.5	0.41	0.45	9	0.86	1.58	0.82	0.08	0.04	7.4	34
Bm	125-140	45	13	42	0	5.8	5.7	0.32	0.34	9	0.86	1.54	0.74	0.08	0.04	6.4	38

Horizon	Sample depth(cm)	Bulk density (g/cm3)	Water content (volume %) pF0.0	pF1.0	pF2.0	pF2.7	pF4.2	Water retention capacity (mm/m)
Ah	5-10	1.44	46	33	22	16	6	160
Bt2	39-44	1.57	38	35	31	27	16	150

PROFILE NUMBER: 9
MAPPING UNIT : Umdo2

LAND USE/VEGETATION: FALLOW

SLOPE (%) : 2-4
DRAINAGE : WELL DRAINED
FLOODING : NONE
WATERTABLE:

CLASSIFICATION
- SOIL TAXONOMY : PALEUSTULT
- FAO : CHROMI-HAPLIC ACRISOL
- CPCS : SOL FERRALLITIQUE FAIBLEMENT DESATURE REMANIE

PROFILE DESCRIPTION

Horizon Symbol ---- Depth	Colour moist	Texture < 2mm ---- > 2mm	Structure (grade, size, type)	Consistence moist ----- wet	Mottles (abundance, size, contrast)	Roots (abund. size, distr)	Hor.boundary (distinction, regularity)	Other features (concretions, cutans, krotovinas, crystals)
Ah ---- 0-25	10YR3/4	LS ----	WEAK MEDIUM SAB	vFRIABLE ----- sST/nPL		MANY FINE, MED,CRS	CLEAR SMOOTH	
BA ---- 25-42	7.5YR4/2	SL ----	WEAK COARSE SAB	vFRIABLE ----- nST/nPL		COMMON FINE, MED,CRS	CLEAR SMOOTH	
Bt ---- 42-73		cSL ----	WEAK COARSE SAB	FRIABLE ----- sST/sPL		COMMON FINE, MED,CRS	ABRUPT IRREGULAR	TERMITE CELLS
2Bts ---- 73-85	5YR4/4	SL ---- vGR	WEAK COARSE SAB	FRIABLE ----- sST/sPL		FEW FINE, MED,CRS	SMOOTH CLEAR	CUTANS: BROKEN, THICK
Bm ---- 85-120		cSCL ----	WEAK COARSE SAB	FRIABLE ----- sST/sPL		FEW FINE, MEDIUM		

REMARKS:

PROFILE NUMBER: 10
MAPPING UNIT : Umng

LAND USE/VEGETATION: FALLOW

SLOPE (%) : 2
DRAINAGE : WELL DRAINED
FLOODING : NONE
WATERTABLE:

CLASSIFICATION
- SOIL TAXONOMY : OXIC USTROPEPT
- FAO : ORTHI-FERRALIC CAMBISOL, PETROFERRIC PHASE
- CPCS : SOLS FERRALLITIQUE FAIBLEMENT DESATURE TYPIQUE INDURE

PROFILE DESCRIPTION

Horizon Symbol / Depth	Colour moist	Texture (< 2mm / > 2mm)	Structure (grade, size, shape)	Consistence moist / wet	Mottles (abundance, size, contrast)	Roots (abund. size-distr)	Hor. boundary (distinction, regularity)	Other features (concretions, cutans, krotovinas, crystals)
Ah / 0-15	10YR3/4	fS / sGR	WEAK MEDIUM SAB	vFRIABLE / nST/nPL		MANY FINE, MED,CRS	CLEAR SMOOTH	
BA / 15-25	7.5YR4/2	LS / GR	WEAK MEDIUM SAB	LOOSE / nST/nPL		MANY FINE, MED,CRS	CLEAR SMOOTH	
Bts / 25-64	5YR4/6	LS / vGR	WEAK MEDIUM SAB	vFRIABLE / nST/nPL		FEW FINE		

REMARKS:

PROFILE NUMBER: 11
MAPPING UNIT : Ummg

LAND USE/VEGETATION: FALLOW, IMPARATA GRASS

SLOPE (%) : 4
DRAINAGE : WELL
FLOODING : NONE
WATERTABLE:

CLASSIFICATION
- SOIL TAXONOMY : OXIC USTROPEPT
- FAO : ORTHI-FERRALIC CAMBISOL, PETROFERRIC PHASE
- CPCS : SOL FERRALLITIQUE FAIBLEMENT DESATURE TYPIQUE INDURE

PROFILE DESCRIPTION

Horizon Symbol ---- Depth	Colour moist	Texture < 2mm ---- > 2mm	Structure (grade, size, type)	Consistence moist ----- wet	Mottles (abundance, size, contrast)	Roots (abund. size distr)	Hor.boundary (distinction, regularity)	Other features (concretions, cutans, krotovinas, crystals)
Ah ---- 0-15	10YR3/4	SL ---- sGR	WEAK MEDIUM SAB	vFRIABLE ----- mST/nPL		MANY FINE, MED,CRS	GRADUAL SMOOTH	
BA ---- 15-24	5YR3/4	SL ---- vGR	WEAK MEDIUM SAB	vFRIABLE ----- sST/nPL		COMMON FINE, MEDIUM	GRADUAL SMOOTH	TERMITE NESTS
Bts ---- 24-40	5YR4/6	SL ---- vGR	WEAK MEDIUM SAB	vFRIABLE ----- sST/nPL		FEW FINE	CLEAR WAVY	SOME CUTANS ON GRAVEL
Bm ---- 40-70		MASSIVE, STRONGLY COHERENT, PERMEABLE						
----		----		-----				

REMARKS:

LABORATORY DATA

Horizon	Sample depth(cm)	Texture (%) clay	silt	sand	gravel	pH H2O	pH KCl	C org (%)	N tot (%.)	C/N	P-Olsen (ppm)	Exch. Cations (meq/100g) Ca	Mg	K	Na	CEC (pH 7) (meq/100g)	Base sat.(%)
Ah	0-15	18	9	73	10	6.2	5.8	0.74	0.56	13	3.9	1.83	0.57	0.20	0.04	4.0	66
BA/Bts	15-40	19	10	71	51	5.8	5.2	0.66	0.50	13	3.0	1.07	0.37	0.08	0.04	4.0	39
Bm	n.d.																

Horizon	Sample depth(cm)	Bulk density (g/cm3)	Water content (volume %) pF0.0	pF1.0	pF2.0	pF2.7	pF4.2	Water retention capacity (mm/m)
Ah	5-10	1.43	49	34	17	12	4	130

PROFILE NUMBER: 12
MAPPING UNIT : Umsg

LAND USE/VEGETATION: UPLAND RICE

SLOPE (%) : 2-4
DRAINAGE : MOD.WELL DRAINED
FLOODING : NONE
WATERTABLE:

CLASSIFICATION
- SOIL TAXONOMY : LITHIC USTROPEPT
- FAO : DYSTRIC LEPTOSOL, PETROFERRIC PHASE
- CPCS : SOL FERRALLITIQUE FAIBLEMENT DESATURE TYPIQUE INDURE

PROFILE DESCRIPTION

Horizon Symbol / Depth	Colour moist	Texture < 2mm / > 2mm	Structure (grade, size, shape)	Consistence moist / wet	Mottles (abundance, size, contrast)	Roots (abund. size-distr)	Hor.boundary (distinction, regularity)	Other features (concretions, cutans, krotovinas, crystals)
Ah / 0-11	10YR3/2	cSL / GR	WEAK COARSE SAB	vFRIABLE / nST/nPL		COMMON FINE, MEDIUM	CLEAR SMOOTH	
AB / 11-22	10YR3/3	cSL / vGR		-----		FEW FINE, MEDIUM	CLEAR WAVY	
Bts / 22-49	7.5YR4/4	cSL / vGR		-----		FEW MEDIUM		

REMARKS:

LABORATORY DATA

Horizon	Sample depth(cm)	Texture (%) clay	silt	sand	gravel	pH H2O	KCl	C org (%)	N tot (%.)	C/N	P-Olsen (ppm)	Exch. Cations (meq/100g) Ca	Mg	K	Na	CEC (pH 7) (meq/100g)	Base sat.(%)
Ah-AB	3-18	15	7	78	18			0.72									
Bts	n.d.																

Horizon	Sample depth(cm)	Bulk density (g/cm3)	Water content (volume %) pF0.0	pF1.0	pF2.0	pF2.7	pF4.2	Water retention capacity (mm/m)
Ah	5-10	1.55	42	27	17	12	4	130

PROFILE NUMBER: 13
MAPPING UNIT : Fi1

LAND USE/VEGETATION: UPLAND RICE

SLOPE (%) : 2-4
DRAINAGE : IMPERFECTLY DRAINED
FLOODING : NONE
WATERTABLE: - 65 cm

CLASSIFICATION
- SOIL TAXONOMY : AQUIC USTIPSAMMENT
- FAO : ORTHI-GLEYIC ARENOSOL
- CPCS : SOL PEU EVOLUE D'APPORT COLLUVIAL HYDROMORPHE

PROFILE DESCRIPTION

Horizon Symbol / Depth	Colour moist	Texture < 2mm / > 2mm	Structure (grade, size, shape)	Consistence moist / wet	Mottles (abundance, size, contrast)	Roots (abund. size-distr)	Hor.boundary (distinction, regularity)	Other features (concretions, cutans, krotovinas, crystals)
Ah / 0-15	10YR3/2	LS	WEAK COARSE SAB	vFRIABLE / nST/nPL		MANY FINE	CLEAR SMOOTH	
Cg / 15-65	10YR5/4	S	WEAK COARSE SAB	vFRIABLE / nST/nPL	COMMON COARSE DISTINCT	MANY FINE, MEDIUM		

REMARKS:

LABORATORY DATA

Horizon	Sample depth(cm)	Texture (%) clay	silt	sand	gravel	pH H2O	KCl	C org (%)	N tot (‰)	C/N	P-Olsen (ppm)	Exch. Cations (meq/100g) Ca	Mg	K	Na	CEC (pH 7) (meq/100g)	Base sat.(%)
Ah	0-15	10	7	83	0	6.1	5.4	0.19	0.34	6	3.0	0,95	0,36	0.08	0.02	2.0	71
Cg	35-50	7	5	88	0	5.9	5.2	0.12	0.22	5	0.43	0.40	0.14	0.06	0.02	1.6	39

Horizon	Sample depth(cm)	Bulk density (g/cm3)	Water content (volume %) pF0.0	pF1.0	pF2.0	pF2.7	pF4.2	Water retention capacity (mm/m)
Ah	5-10	1.55	38	29	13	8	2	110

PROFILE NUMBER: 14 LAND USE/VEGETATION: UPLAND RICE
MAPPING UNIT : Fi1

SLOPE (%) : 2-4
DRAINAGE : IMPERFECTLY DRAINED
FLOODING : NONE
WATERTABLE: - 57 cm

CLASSIFICATION
- SOIL TAXONOMY : AQUIC USTIPSAMMENT
- FAO : ORTHI-GLEYIC ARENOSOL
- CPCS : SOLS PEU EVOLUE D'APPORT COLLUVIAL HYDROMORPHE

PROFILE DESCRIPTION

Horizon Symbol / Depth	Colour moist	Texture < 2mm / > 2mm	Structure (grade, size, shape)	Consistence moist / wet	Mottles (abundance, size, contrast)	Roots (abund. size-distr)	Hor.boundary (distinction, regularity)	Other features (concretions, cutans, krotovinas, crystals)
Ah / 0-14	10YR3/2	S	WEAK COARSE SAB	vFRIABLE / nST/nPL		MANY FINE, MED,CRS	CLEAR SMOOTH	
Cg / 14-57	10YR5/4	S	WEAK COARSE SAB	vFRIABLE / nST/nPL	MANY COARSE PROMINENT	COMMON FINE, MEDIUM		

REMARKS:

LABORATORY DATA

Horizon	Sample depth(cm)	Texture (%) clay	silt	sand	gravel	pH H2O	pH KCl	C org (%)	N tot (%.)	C/N	P-Olsen (ppm)	Exch. Cations (meq/100g) Ca	Mg	K	Na	CEC (pH 7) (meq/100g)	Base sat.(%)
Ah	0-14	6	4	90	0			0.55									
Cg	35-50	6	5	89	0			0.35									

Horizon	Sample depth(cm)	Bulk density (g/cm3)	Water content (volume %) pF0.0	pF1.0	pF2.0	pF2.7	pF4.2	Water retention capacity (mm/m)
Ah	5-10	1.59	40	34	12	8	3	90
Cg	45-50	1.58	36	32	10	5	2	80

PROFILE NUMBER: 15
MAPPING UNIT : F11

LAND USE/VEGETATION: UPLAND RICE

SLOPE (%) :
DRAINAGE : IMPERFECTLY DRAINED
FLOODING : NONE
WATERTABLE: - 20 cm

CLASSIFICATION
- SOIL TAXONOMY : AQUIC USTIPSAMMENT
- FAO : ORTHI-GLEYIC ARENOSOL
- CPCS : SOL PEU EVOLUE D'APPORT COLLUVIAL HYDROMORPHE

PROFILE DESCRIPTION

Horizon Symbol / Depth	Colour moist	Texture < 2mm / > 2mm	Structure (grade, size, shape)	Consistence moist / wet	Mottles (abundance, size, contrast)	Roots (abund. size-distr)	Hor.boundary (distinction, regularity)	Other features (concretions, cutans, krotovinas, crystals)
Ah / 0-20	10YR3/2	LS	WEAK COARSE SAB	vFRIABLE / nST/nPL		MANY FINE, MED,CRS		

REMARKS:

LABORATORY DATA

Horizon	Sample depth(cm)	Texture (%) clay	silt	sand	gravel	pH H2O	pH KCl	C org (%)	N tot (%.)	C/N	P-Olsen (ppm)	Exch. Cations (meq/100g) Ca	Mg	K	Na	CEC (pH 7) (meq/100g)	Base sat.(%)
Ah	0-15	7	5	88	0			0.74									

Horizon	Sample depth(cm)	Bulk density (g/cm3)	Water content (volume %) pF0.0	pF1.0	pF2.0	pF2.7	pF4.2	Water retention capacity (mm/m)
Ah	5-10	1.64	37	30	13	9	2	110

PROFILE NUMBER: 16
MAPPING UNIT : Fil

LAND USE/VEGETATION: UPLAND RICE

SLOPE (%) :
DRAINAGE : IMPERFECTLY DRAINED
FLOODING : NONE
WATERTABLE: - 15 cm

CLASSIFICATION
- SOIL TAXONOMY : AQUIC USTIPSAMMENT
- FAO : ORTHI-GLEYIC ARENOSOL
- CPCS : SOL PEU EVOLUE D'APPORT COLLUVIAL HYDROMORPHE

PROFILE DESCRIPTION

Horizon Symbol / Depth	Colour moist	Texture < 2mm / > 2mm	Structure (grade, size, shape)	Consistence moist / wet	Mottles (abundance, size, contrast)	Roots (abund. size-distr)	Hor. boundary (distinction, regularity)	Other features (concretions, cutans, krotovinas, crystals)
Ah / 0-15	10YR3/2	LS	WEAK COARSE SAB	vFRIABLE / nST/nPL		MANY FINE, MED,CRS		

REMARKS:

LABORATORY DATA

Horizon	Sample depth(cm)	Texture (%) clay	silt	sand	gravel	pH H2O	KCl	C org (%)	N tot (%.)	C/N	P-Olsen (ppm)	Exch. Cations (meq/100g) Ca	Mg	K	Na	CEC (pH 7) (meq/100g)	Base sat.(%)
Ah	0-15	12	5	83	0			0.97									

Horizon	Sample depth(cm)	Bulk density (g/cm3)	Water content (volume %) pF0.0	pF1.0	pF2.0	pF2.7	pF4.2	Water retention capacity (mm/m)
Ah	5-10	1.63	37	33	21	12	2	190

PROFILE NUMBER: 17 LAND USE/VEGETATION: FALLOW
MAPPING UNIT : Fw1

SLOPE (%) : 2-4
DRAINAGE : WELL DRAINED
FLOODING : NONE
WATERTABLE: - 125 cm

CLASSIFICATION
- SOIL TAXONOMY : TYPIC USTIPSAMMENT
- FAO : ORTHI-LUVIC ARENOSOL
- CPCS : SOL PEU EVOLUE D'APPORT COLLUVIAL MODAL

PROFILE DESCRIPTION

Horizon Symbol / Depth	Colour moist	Texture < 2mm / > 2mm	Structure (grade, size, shape)	Consistence moist / wet	Mottles (abundance, size, contrast)	Roots (abund. size-distr)	Hor.boundary (distinction, regularity)	Other features (concretions, cutans, krotovinas, crystals)
Ah / 0-20	10YR3/2	S	WEAK MEDIUM SAB	LOOSE / nST/nPL		MANY FINE, MED,CRS	CLEAR SMOOTH	
AC / 20-35	10YR3/3	S	WEAK COARSE SAB	LOOSE / nST/nPL		MANY FINE, MED,CRS	CLEAR SMOOTH	
Cu / 35-100	7.5YR4/4	LS	WEAK MEDIUM SAB	LOOSE / nST/nPL		COMMON FINE, MED,CRS	CLEAR SMOOTH	
Cg1 / 100-115	7.5YR5/4	LS	WEAK MEDIUM SAB	LOOSE / nST/nPL	COMMON MEDIUM DISTINCT	FEW FINE, MEDIUM	CLEAR SMOOTH	
Cg2 / 115-125	7.5YR5/4	LS	WEAK MEDIUM SAB	LOOSE / nST/nPL	COMMON MEDIUM DISTINCT	FEW FINE, MEDIUM		

REMARKS:

LABORATORY DATA

Horizon	Sample depth(cm)	Texture (%) clay	silt	sand	gravel	pH H2O	pH KCl	C org (%)	N tot (%.)	C/N	P-Olsen (ppm)	Exch. Cations (meq/100g) Ca	Mg	K	Na	CEC (pH 7) (meq/100g)	Base sat.(%)
Ah	0-20	7	3	90	0	6.0	5.8	0.45	0.34	13	3.5	0.95	0.26	0.08	0.02	3.0	44
AC	n.d.																
Cu	50-80	6	8	86	0	5.7	5.2	0.19	0.22	9	0.43	0.40	0.15	0.10	0.01	1.4	47
Cg1	n.d.																
Cg2	n.d.																

Horizon	Sample depth(cm)	Bulk density (g/cm3)	Water content (volume %) pF0.0	pF1.0	pF2.0	pF2.7	pF4.2	Water retention capacity (mm/m)
Ah	3-8	1.40	42	35	9	5	1	80
Cu	75-80	1.56	31	26	10	6	2	80

PROFILE NUMBER: 18
MAPPING UNIT : Bc1

LAND USE/VEGETATION: NON-USED RICE FIELD

SLOPE (%) : 0-1
DRAINAGE : VERY POOR
FLOODING : FREQUENT
WATERTABLE: + 40 cm

CLASSIFICATION
- SOIL TAXONOMY : TROPAQUENT
- FAO : GLEYI-EUTRIC FLUVISOL
- CPCS : SOL HYDROMORPHE PEU HUMIFERE A GLEY PEU PROFOND

PROFILE DESCRIPTION

Horizon Symbol / Depth	Colour moist	Texture < 2mm / > 2mm	Structure (grade, size, type)	Consistence moist / wet	Mottles (abundance, size, contrast)	Roots (abund. size, distr)	Hor. boundary (distinction, regularity)	Other features (concretions, cutans, krotovinas, crystals)
Ar / 0-8	2.5Y3/0	C		vST/vPL				
Ag / 8-22	2.5Y3/0	C		vST/vPL	FEW FINE DISTINCT			
Cg1 / 22-60	5Y4/1	CL		vST/vPL	MANY COARSE PROMINENT			
Cr / 60-73	5Y3/1	SCL		ST/sPL	COMMON FINE FAINT			
Cg2 / 73-110	2.5Y5/0	SCL		sST/sPL	MANY MEDIUM PROMINENT			

REMARKS: BECAUSE OF VERY STRONG MICRO-VARIABILITY IN DEPTH OF THE OXIDATION/REDUCTION BOUNDARY, COLOURS AND TEXTURE, SAMPLES ARE TAKEN IN 20cm LAYERS

LABORATORY DATA

Horizon	Sample depth(cm)	Texture (%) clay	silt	sand	gravel	pH H2O	pH KCl	C org (%)	N tot (%.)	C/N	P-Olsen (ppm)	Exch. Cations (meq/100g) Ca	Mg	K	Na	CEC (pH 7) (meq/100g)	Base sat.(%)
	0-20	42	20	38	0	5.8	5.0	1.08	0.90	12	9.5	4.53	3.65	0.26	0.36	15.0	59
	20-40	38	18	44	0	6.0	5.1	0.66	0.62	11	3.9	4.10	3.36	0.10	0.44	13.8	58
	40-60	32	28	40	0	6.4	5.3	0.40	0.39	10	1.7	3.43	2.83	0.08	0.48	10.4	66
	60-80	28	18	54	0	6.6	5.5	0.18	0.17	10	0.4	2.83	2.38	0.08	0.48	9.2	63

PROFILE NUMBER: 19
MAPPING UNIT : Bc1

LAND USE/VEGETATION: POORLY MAINTAINED RICE FIELD

SLOPE (%) : 0-1
DRAINAGE : POORLY DRAINED
FLOODING : FREQUENT
WATERTABLE: + 40cm

CLASSIFICATION
- SOIL TAXONOMY : TROPAQUENT
- FAO : GLEYI-EUTRIC FLUVISOL
- CPCS : SOL HYDROMORPHE PEU HUMIFERE A GLEY PEU PROFOND

PROFILE DESCRIPTION

Horizon Symbol ---- Depth	Colour moist	Texture < 2mm ---- > 2mm	Structure (grade, size, shape)	Consistence moist ----- wet	Mottles (abundance, size, contrast)	Roots (abund. size-distr)	Hor.boundary (distinction, regularity)	Other features (concretions, cutans, krotovinas, crystals)
Ar ---- 0-13		C ----		----- vFLUID				
A/C ---- 15-24		SCL ----		----- vFLUID				
Cr ---- 24-51		SCL ----		-----				
Cg ---- 51-100		SCL ----		-----				
----		----		-----				

REMARKS: BECAUSE OF VERY STRONG MICRO-VARIABILITY IN DEPTH OF THE OXIDATION/REDUCTION BOUNDARY, COLOURS AND TEXTURE, SAMPLES ARE TAKEN IN 20cm LAYERS

LABORATORY DATA

Horizon	Sample depth(cm)	Texture (%) clay	silt	sand	gravel	pH H_2O	KCl	C org (%)	N tot (‰)	C/N	P-Olsen (ppm)	Exch. Cations (meq/100g) Ca	Mg	K	Na	CEC (pH 7) (meq/100g)	Base sat.(%)
	0-20	41	23	36	0	5.8	5.4	3.38	2.30	15	17.0	5.25	3.36	0.40	0.40	14.4	65
	20-40	25	20	55	0	6.0	5.3	0.89	0.78	11	16.5	2.50	2.13	0.10	0.24	7.4	67
	40-60	27	21	52	0	6.0	5.0	0.22	0.34	6	6.1	2.30	2.17	0.08	0.24	6.4	75
	60-80	35	20	45	0	5.6	5.4	0.16	0.28	6	2.2	2.80	3.12	0.08	0.32	12.0	53

PROFILE NUMBER: 20
MAPPING UNIT : Bc1

LAND USE/VEGETATION: WELL MAINTAINED RICE FIELD

SLOPE (%) : 0-1
DRAINAGE : POORLY DRAINED
FLOODING : FREQUENT
WATERTABLE: ± 30 cm

CLASSIFICATION
- SOIL TAXONOMY : TROPAQUENT
- FAO : GLEYI-EUTRIC FLUVISOL
- CPCS : SOL HYDROMORPHE PEU HUMIFERE A GLEY PEU PROFOND

PROFILE DESCRIPTION

Horizon Symbol / Depth	Colour moist	Texture < 2mm / > 2mm	Structure (grade, size, shape)	Consistence moist / wet	Mottles (abundance, size, contrast)	Roots (abund. size-distr)	Hor.boundary (distinction, regularity)	Other features (concretions, cutans, krotovinas, crystals)
Ar / 0-20		CL		vFLUID				
Cg1 / 20-52		CL		vFLUID				
Cg2 / 52-100		CL						

REMARKS: BECAUSE OF VERY STRONG MICRO-VARIABILITY IN DEPTH OF THE OXIDATION/REDUCTION BOUNDARY, COLOURS AND TEXTURES, SAMPLES ARE TAKEN IN LAYERS OF 20cm THICK

LABORATORY DATA

Horizon	Sample depth(cm)	Texture (%) clay	silt	sand	gravel	pH H2O	pH KCl	C org (%)	N tot (%.)	C/N	P-Olsen (ppm)	Exch. Cations (meq/100g) Ca	Mg	K	Na	CEC (pH 7) (meq/100g)	Base sat.(%)
	0-20	37	27	36	0	5.7	5.2	1.83	1.79	10	19.1	5.05	3.20	0.22	0.28	13.8	63
	20-40	36	21	43	0	6.5	5.8	0.40	0.45	9	1.7	3.50	2.94	0.08	0.30	9.6	71
	40-60	39	21	40	0	6.7	5.9	0.26	0.34	8	0.87	4.30	3.32	0.08	0.40	11.2	72
	60-80	37	24	29	0	6.9	5.7	0.24	0.34	7	0.87	4.40	3.60	0.10	0.36	11.4	74

PROFILE NUMBER: 21
MAPPING UNIT : Bc2

LAND USE/VEGETATION: RICE FIELD

SLOPE (%) : 0-1
DRAINAGE : POORLY DRAINED
FLOODING : PERIODICALLY
WATERTABLE: + 20 cm

CLASSIFICATION
- SOIL TAXONOMY : TROPAQUENT
- FAO : GLEYI-EUTRIC FLUVISOL
- CPCS : SOL HYDROMORPHE PEU HUMIFERE A GLEY PEU PROFOND

PROFILE DESCRIPTION

Horizon Symbol ---- Depth	Colour moist	Texture < 2mm ---- > 2mm	Structure (grade, size, shape)	Consistence moist ----- wet	Mottles (abundance, size, contrast)	Roots (abund. size-distr)	Hor.boundary (distinction, regularity)	Other features (concretions, cutans, krotovinas, crystals)
---- 0-5		RECENT GRAVEL FROM ADJACENT SLOPES					————	
Ah ---- 5-15	2.5Y4/0	LcS ----		----- nS/nPL			————	
Cg ---- 15-29	2.5YR5/0	SCL ----		----- ST/PL	MANY MEDIUM DISTINCT		————	
2Cg ---- 29-48	2.5Y5/0	LS ----		----- ST/sPL	FEW MEDIUM FINE		————	
3Cg ---- 48-85	5Y5/1	SC ----		----- ST/PL	COMMON MEDIUM DISTINCT		————	

REMARKS:

PROFILE NUMBER: 22
MAPPING UNIT : Bs

LAND USE/VEGETATION: GRASSLAND

SLOPE (%) : 0-1
DRAINAGE : POORLY DRAINED
FLOODING : PERIODICAL
WATERTABLE:

CLASSIFICATION
- SOIL TAXONOMY : TROPAQUENT
- FAO : ARENI-EUTRIC FLUVISOL
- CPCS : SOL HYDROMORPHE PEU HUMIFERE A GLEY PEU PROFOND

PROFILE DESCRIPTION

Horizon Symbol / Depth	Colour moist	Texture < 2mm / > 2mm	Structure (grade, size, shape)	Consistence moist / wet	Mottles (abundance, size, contrast)	Roots (abund. size-distr)	Hor.boundary (distinction, regularity)	Other features (concretions, cutans, krotovinas, crystals)
Ah / 0-10	10YR4/1	LS	WEAK MEDIUM SAB	FRIABLE / nST/nPL		FINE, MED,CRS	CLEAR SMOOTH	
A/C / 10-20	10YR6/1	LS	WEAK MEDIUM SAB	FRIABLE / nST/nPL	vFEW FINE	FINE MEDIUM	DIFFUSE CLEAR	
Cg / 20-60	10YR6/3	cS	WEAK MEDIUM SAB	vFRIABLE / nST/nPL	COMMON FINE	FINE	ABRUPT WAVY	
2Cg1 / 60-80	10YR6/4	cS/C	WEAK MEDIUM SAB	FRIABLE/FIRM	MANY LARGE PROMINENT	FINE	ABRUPT WAVY	
2Cg2 / 80+	2.5Y7/0	C	SAB	vFIRM	MANY LARGE PROMINENT			

REMARKS:

Detailed Soil Map of the WARDA Experimental area, Bouaké, Côte d' Ivoire
LOCATION OF SOIL PROFILE PITS

This map is part of: 'Detailed Soil Survey and Land Evaluation of the WARDA Experimental Area, Bouaké, Côte d' Ivore' (Hakkeling, Smaling, Diatta, 1989. Report 22 Winand Staring Centre, P.O. Box 125, 6700 AC Wageningen, The Netherlands)