Landscape Ecological Survey (1:100,000) of the Bipindi-Akom II-Lolodorf Region Southwest Cameroon

B.S. van Gemerden
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Tropenbos-Cameroon Documents 1

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ABSTRACT

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In Southwest Cameroon a reconnaissance scale survey of landforms, soils and vegetation was carried out. The survey area covered some 167 000 ha. The altitudinal range was 40 to 1 000 m.a.s.l. Landforms discerned are: mountains, complexes of hills, isolated hills, hilly and rolling uplands, dissected erosional plains, and floodplains. Four soil types were described, ranging from well drained very clayey soils (in the mountain area) to very poorly to poorly drained soils (on valley bottoms). The seven main vegetation types include four types of primary to old secondary rain forest (bound to different altitudinal zones), young secondary forest, swamp forest, and secondary shrubland. The patterns of landforms, soil types, and vegetation types are integrated into one `landscape ecological' map (scale 1 : 100 000). The legend has a hierarchical structure. It is based primarily on a subdivision in four altitudinal zones, secondly on landform, and finally on the degree of disturbance of the natural vegetation by shifting cultivation.

Keywords: Africa, reconnaissance survey, rain forest, landforms, tropical soils, vegetation, altitudinal zonation.

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PREFACE

ABOUT TROPENBOS

The Tropenbos Foundation was established in 1988 by the Government of The Netherlands with the objectives to contribute to the conservation and wise use of tropical rain forest by generating knowledge and developing methodologies, and to involve and strengthen local research institutions and capacity in relation to tropical rain forests.

The Tropenbos Programme carries out research on moist tropical forest land at various locations around the world. At present (semi-) permanent research sites are located in Colombia, Guyana, Indonesia, Côte d'Ivoire and Cameroon. At the different locations, research programmes follow an interdisciplinary and common overall approach, with the aim to exchange data and make results mutually comparable.

About the Tropenbos-Cameroon Programme and ITTO Project PD 26/92

The present publication has been produced in the framework of ITTO Project PD 26/92, which is an integral part of the Tropenbos-Cameroon Programme (TCP). The research on which this publication is based, was financed by the International Tropical Timber Organization (ITTO), the Common Fund for Commodities (CFC), the Directorate General for International Cooperation of The Netherlands' Ministry of Foreign Affairs (DGIS), the Tropenbos Foundation and the implementing agencies mentioned below.

The Tropenbos-Cameroon Programme was established in 1992 by the Cameroonian Ministry of Environment and Forests (MINEF) and the Tropenbos Foundation. The general objective of TCP is to develop methods and strategies for natural forest management directed at sustainable production of timber and other forest products and services. These methods have to be ecologically sound, socially acceptable and economically viable (Foahom & Jonkers, 1992). TCP consists of fourteen interrelated projects in the fields of ecology, forestry, economy, social sciences, agronomy and soil science. In 1994, ITTO and CFC decided to co-finance six of these projects, which together form ITTO project PD 26/92. The 'Office National de Développement des Forêts' (ONADEF) is the agency responsible towards ITTO and CFC for the implementation of the Project PD 26/92.

The implementing agencies involved in the present study are the Winand Staring Centre for Integrated land, Soil and Water Research (SC-DLO), the 'Institut de la Recherche Agricole pour le Développement' (IRAD) and Wageningen Agricultural University (WAU).

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The National Herbarium of Cameroon (Dr. Onana, Dr. Achoungdong, Dr. Sonké Asongonyi and Mr. Mezili), the Limbé Botanic Garden (Mr. Peguy Mbatchou), the Department of Plant Taxonomy of the Wageningen Agricultural University (Dr. Breteler and Dr. Jongkind) and Dr. Duncan Thomas have helped with plant species identification. Mr. Tchuenteu of the IRAD Ekona soil laboratory has conducted the majority of soil analyses. Mr. van Reeuwijk of the International Soil Reference and Information Centre (ISRIC) carried out the clay mineralogy and reference analyses.

SUMMARY

This report presents the results of the reconnaissance scale landscape ecological survey of the Tropenbos-Cameroon Programme (TCP) research area in Southwest Cameroon conducted by the Forest Land Inventory and Land Evaluation project (Lu1). The main objective of the Lu1 project is to provide a scientific framework for sustainable land use planning in the TCP research area. Moreover, the Lu1 project provides a basis for all ecologically oriented research activities within the TCP area and allows for the extrapolation of the research results from sample areas to larger areas in South Cameroon.

In its first phase a survey of landforms, soils and vegetation is conducted at scale 1 : 100 000 of the Bipindi - Akom II - Lolodorf region (167 000 ha). Some 250 soil augerings, 45 soil pits and 125 vegetation relevés have been described, covering the most important landscapes. The results of the analysis of landform, soil and vegetation data are presented in this report and on the landscape ecological map. The second phase of the project entails the development of a land evaluation methodology for tropical moist forests in South Cameroon.

Landforms discerned in the TCP research area are mountains, complexes of hills, isolated hills, hilly and rolling uplands, dissected erosional plains, and floodplains. They are classified on basis of slope steepness, slope length, relief intensity and number of interfluves. The mountains, complexes of hills and isolated hills have very steep slopes and high relief intensities, whereas both the uplands and the dissected erosional plains have gentle to moderately steep slopes and low relief intensities. The first landform group is therefore more vulnerable to erosion than the latter.

The following four soil types are dominating in the research area:
- well drained very clayey soils: *Nyangong* soils;
- well drained clayey soils: the *Ebom* soils;
- moderately well to well drained sandy loam to sandy clay soils: the *Ebimimbang* soils;
- very poorly to poorly drained soils: the *Valley Bottom* soils.

The Nyangong and Ebom soils are deeply weathered yellowish brown to strong brown tropical clay soils, low in weatherable minerals and with cation exchange capacities in the (ferralic) B-horizons of less than 16 me/100 g clay. Their dominant clay minerals are kaolinite. The Nyangong soils have 50-80% clay in the subsoils; the Ebom soils are less heavy with 35-60% clay. Moreover, topsoils of the latter are lighter (20-50% clay) than the subsoils. The Nyangong soils classify as Xanthic Ferralsols, the Ebom soils as Acri-xanthic Ferralsols. The Ebimimbang soils are moderately deep to very deep, yellowish brown, sandy clay loams to sandy clays with lighter textured topsoils. They are classified as Plinthudults and typic Paleudults. The very poorly to poorly drained soils are developed in unconsolidated, stratified, recent alluvium. They are characterized by high groundwater tables, periodic flooding and locally greyish colours. In the FAO-Unesco classification they are classified as Dystric Fluvisols and Gleyic Cambisols.

All soils in the TCP research area have low pHs and are chemically poor. Their physical characteristics are good. Removal of the forest vegetation, e.g. by intensive logging or agriculture, will result in the physical degradation of the soil (decrease in organic matter) and the loss of nutrients stored in the forest vegetation.

Seven distinct `plant communities' have been identified using a phytosociological approach;

the analysis of plot data was carried out with the computer programme TWINSPAN. All vegetation types are defined by floristic composition and the (external) foliage coverage of the species. Interpretation of successional status, overall physiognomy and general site descriptors reveals a strong correlation of the plant communities with altitude and disturbance. The communities discerned are: submontane forest (altitude > 700 m asl), three types of lowland evergreen forest (< 350 m asl; 350-500 m asl; 500-700 m asl), swamp forest, young secondary forest and thicket on recently abandoned agricultural fields.

The legend of the 1 : 100 000 landscape ecological map is based on altitude, landform, soil and vegetation, and has a hierarchical structure. A total of 14 main mapping units has been discerned. These 14 units have been further subdivided according to vegetation characteristics brought about by human influences (shifting cultivation) into 34 units. The landscape ecological map presents the landscape in its complexity of landforms, soils and vegetation. Cross reference of the inventory data reveals a strong relationship between vegetation, altitude and soils. This supports the notion that natural vegetation can be seen as a response variable to environmental factors such as climate and soil. Since vegetation proves to be correlated with altitude, which is assumed to be related to climatic factors, the latter has been taken as the highest entry of the map legend. On this basis, the TCP research area is divided into five ecological zones (A - E).

The overall orientation of the ecological zones is NNE-SSW and follows the general orientation of the geological structures in Southwest Cameroon. The landscape of the TCP research area changes considerably from west to east. Altitude rises from approximately 40 to over 1000 m asl. Dissected erosional plains, hilly and rolling uplands dominate the western part of the area whereas complexes of hills and mountains are found solely in the east. Going from west to east the soils change from Ebimimbang to Ebom and Nyangong thereby increasing in clay content. Valley bottoms are found throughout the area but are more frequent and wider in the west. The natural vegetation changes from low altitude evergreen forest with many littoral species to a submontane vegetation with characteristics of cloud forest. Human activities have influenced this gradient by logging and shifting cultivation. Along the main access roads and in the vicinity of villages mosaics are found of actual fields, thickets on recently abandoned fields, young secondary forest and residual patches of tropical moist forest.

1 INTRODUCTION

1.1 FOREST LAND INVENTORY AND LAND EVALUATION PROJECT (LU1)

The Tropenbos Cameroon Programme (TCP) coordinates fourteen interrelated projects in the fields of ecology, forestry, economy, social sciences, agronomy and soil science. This report presents the results of the reconnaissance scale land inventory carried out in the first phase of the research project Lu1, titled `Forest Land Inventory and Land Evaluation' (Lu1).

1.2 RESEARCH OBJECTIVES

Detailed and up-to-date information on the abiotic and biotic environment of the TCP research area is a prerequisite for the formulation of a management plan. This information, however, is either non-existent (e.g. hydrology and erosion aspects) or not detailed enough for the present needs (e.g. climate, landforms, soils, land use, vegetation, and wildlife). The Lu1 project is aimed at filling those gaps which is essential for sound land use planning.

The general objective of Lu1 is to provide a scientific framework for sustainable land use planning for the TCP research area. This will be realized through the development of a land evaluation methodology for tropical moist forests. Moreover, the Lu1 project provides a basis for all ecologically oriented research activities within the TCP and permits the extrapolation of the results of TCP research to other areas in South Cameroon.

The first phase of the Lu1 project entails an integrated reconnaissance scale (1 : 100 000) survey on landforms, soils and vegetation. The present report is the result of this integrated survey, delimitating and describing the major landscape ecological units of the TCP area. In the second phase of the Lu1 project a qualitative ecological land evaluation will be conducted, investigating the suitability of each of the landscape ecological units for a number of relevant land-uses.

1.3 COURSE OF THE STUDY

Preliminary work on the interpretation of aerial photographs, including a five-week mission to the study area, was carried out by Mr. Luc Touber of the DLO- Winand Staring Centre for Integrated Land, Soil and Water Research (SC-DLO) (Touber 1993a; 1993b).

The Directorate General for International Cooperation of The Netherlands' Ministry of Foreign Affairs (DGIS) contracted two associate experts for the Lu1 project. Mr. G.W. Hazeu, soil scientist, started his work in Cameroon in March 1995. His contract expired in September 1997. In March 1995, DGIS appointed Mr. Barend S. van Gemerden as vegetation surveyor whose contract expired in December 1997.

The fieldwork for the landform, soil and vegetation survey was carried out between March 1995 and May 1996. Ms. A. Stoffels carried out the field survey of the northern part in the period April-October 1997.

Overall supervision of the Lu1 project was provided by senior soil and vegetation experts of SC-DLO. Additional assistance was given by a senior GIS expert of the same institute. A total of four backstopping missions were carried out by SC-DLO during the first phase of the project (Bregt and van Kekem, 1995, Hommel, 1995; Hommel and van Kekem, 1996, 1997).

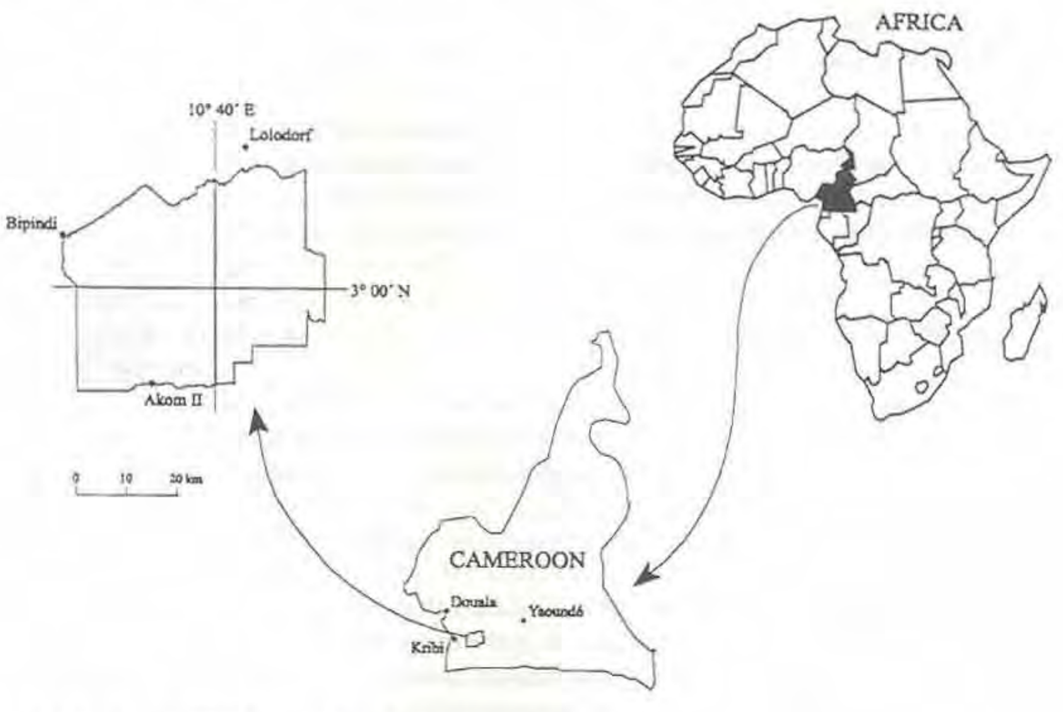

Figure 1.1 Location of TCP research area in Southwest Cameroon

1.4 REPORT OUTLINE

The climate, hydrology, geology, geomorphology, soils, vegetation and land use in South-West Cameroon are described in Chapter 2. The information presented is mostly derived from national or regional studies and merely gives a general overview of the physical environment of the TCP area.

To meet the needs of the qualitative ecological land evaluation more detailed information on landforms, soils and vegetation in the TCP area has been collected. Chapter 3 describes the methods used. Special emphasis is placed on the integration of the landform, soil and vegetation survey into what can be described as a broad landscape ecological approach (e.g. Zonneveld, 1995). In Chapters 4, 5 and 6 the results of respectively the landform, soil and vegetation survey are presented.

In Chapter 7 the landscape ecological map of the TCP research area (Annex I) is discussed and its units are described as characteristic combinations of landforms, soils and vegetation types.

2 STUDY AREA

2.1 LOCATION AND INFRASTRUCTURE

The TCP research area is situated in Southwest Cameroon at approximately 80 km East of Kribi, between 2°47_-3°14_ N 10°24_-10°51_ E. The area is delimitated by the villages of Bipindi, Akom II and Lolodorf (Fig. 1.1). From an administrative point of view the TCP research area is part of the South Province of the Republic of Cameroon and is subdivided into the Departments Océan and Ntem. The TCP area covers about 1700 km^2 which to a large extent coincides with a concession of the Dutch logging company of Wijma-Douala S.A.R.L. (GWZ).

All roads leading to and within the TCP area are dirt roads. Two governmental roads delimit the TCP research area, the Kribi-Bipindi-Lolodorf-Ebolowa road in the northwest and the Kribi-Akom II-Ebolowa road in the south. Within the area three principal roads are present, two of which having approximately a W-E direction and one a SW-NE direction. In addition many smaller exploitation roads have been constructed. Accessibility of these, however, is variable as maintenance is carried out by the logging companies and ceases once their activities are transferred to other regions. Footpaths connecting villages are found throughout the area. Transport by boat over the rivers is not possible due to the presence of rapids and waterfalls.

2.2 CLIMATE

The climate of Southwest Cameroon is equatorial. Although rainfall occurs throughout the year, two distinct minima and maxima can be distinguished in the annual pattern which are associated with the N-S movements of the Intertropical Convergence Zone over the area. The humid seasons extend from September to November and from April to May, whereas the drier seasons extend from December to March and from June to August. According to the classification system of Köppen (1936), the climate of the area is classified as humid tropical (Aw). Such a climate has a mean temperature in the coldest month above 18°C, an average annual temperature of around 25°C with little variation between years, and at least one distinct dry season.

Table 2.1 Summary of climatic data for selected stations in Southwest Cameroon (Olivry, 1986)

Climatic data	Weather station		
	Kribi	Lolodorf	Ebolowa
Altitude (m asl)	13	440	609
Mean annual temperature (°C)	26.4	24.6	24.0
Mean annual relative humidity (%)	73-94	n.a.	68-97
Mean annual vapour pressure (mbar)	29.3	n.a.	24.6
Mean annual rainfall (mm)	2836 (±393)	2096 (±286)	1719 (±195)
Wind speed below 4 m s^{-1} (% of time)	98	n.a.	n.a.
Main wind direction	SW	n.a.	W

Kribi n= 45 years; Lolodorf n= 25 years; Ebolowa n= 48 years; n.a. = data not available.

A summary of climatic data of selected stations in the region is presented in Table 2.1. The long term annual mean temperature decreases from West to East, corresponding with an increase in altitude (Olivry, 1986).

Long-term monthly averages of the minimum relative humidity values show little variation, ranging from 70% (March) to 78% (September) at Kribi and from 62% (February) to 74% (August) at Ebolowa (Olivry, 1986).

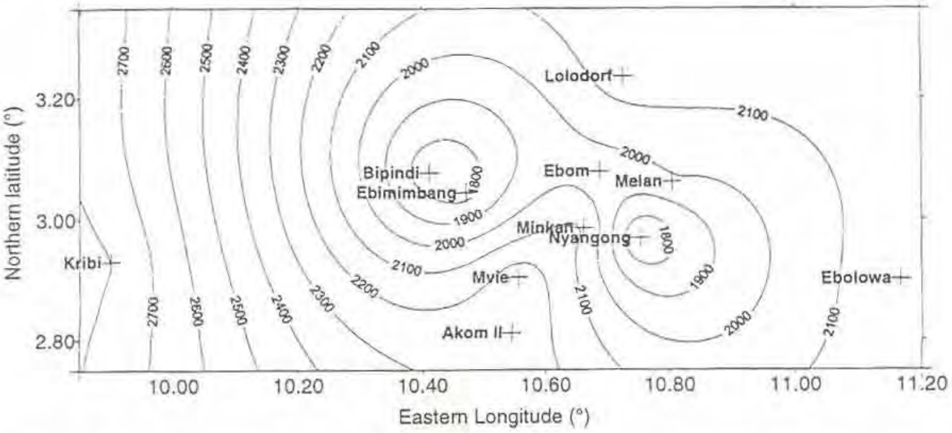

Figure 2.1 Rainfall distribution in Southwest Cameroon in the September 1995-August 1996 period (Waterloo *et al.*, 1997).

Annual rainfall totals tend to decrease with increasing distance from the coast. In Fig. 2.1 the results of one year (September 1995-August 1996) observations by the TCP hydrology team are summarized (Waterloo *et al.*, 1997). Observed mean maximum daily rainfall totals decrease correspondingly from 205 mm (n = 33 years) at Kribi to 115 mm (n = 9 years) and 113 mm (n = 34 years) at Lolodorf and Ebolowa, respectively (Franqueville, 1973; Olivry, 1986).

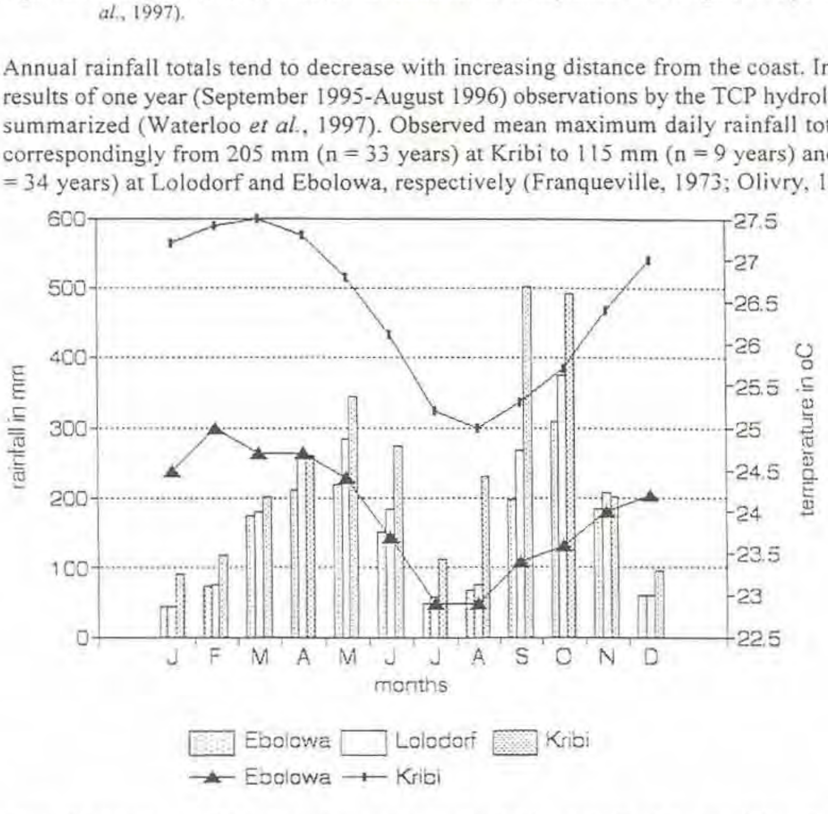

Figure 2.2 Monthly rainfall and temperature averages for Kribi, Lolodorf and Ebolowa (after Olivry, 1986). Kribi n= 45 years; Lolodorf n= 25; Ebolowa n= 48

Long-term averages of monthly rainfall totals of the Kribi, Lolodorf and Ebolowa stations are presented in Figure 2.2. Due to the geographic position of the TCP research area, the rainfall pattern in the area is likely to resemble those at Lolodorf and Ebolowa, rather than that at Kribi.

Wind speeds are generally low and the direction is predominantly W-SW throughout the year (Dolman & Waterloo, 1995).

The duration of bright sunshine has not been measured at any of the weather stations in South Cameroon. However, the mean daily value of 3.4 h day^{-1} observed at the weather station in Douala is a fair approximation (Dolman & Waterloo, 1995).

2.3 HYDROLOGY

The hydrography of Southwest Cameroon is characterized by a high drainage density as a result of a humid climate and the low permeability of the crystalline rock formations (Franqueville, 1973). The main rivers draining the TCP research area are the Lokoundjé, Tchangué, Kienké, Moungué, Biwome, Sonkwé and Messambe. Their flow direction is generally NNE-SSW, following the regional pattern of faulting. Smaller streams have a flow direction essentially perpendicular to the main rivers, resulting in a drainage pattern that has both dendritic and trellised characteristics.

Swampy areas are commonly found in the valleys of the smaller rivers. The soils in these areas remain waterlogged even during dry periods due to a continuous supply of groundwater from the hill slopes and due to relatively thin valley soils underlain by massive rock of low permeability.

Prior to 1995, hydrological studies have not been carried out at any location within the TCP research area. Hydrometric stations of the `Centre de Recherches Hydrologiques' of the `Institute de Recherche Géologique et Minière' (CRH-IRGM) were located in Lolodorf in the Lokoundjé river (draining the area north of the TCP research area) and in the Kienké river (partly draining the TCP research area) and the Lobé river (draining the area south of the TCP research area) at Kribi. However, all stations in South Cameroon have been abandoned since 1987 (pers. comm. J.C. Ntonga, 1996).

The discharge patterns of the rivers correspond to the seasonal rainfall pattern with maxima in October and May and minima in August and February (Olivry, 1986). Figure 2.2 shows the monthly discharges of the Lokoundjé, Kienké and Lobé rivers for the 1953 -1977 period.

The average annual discharge of the Lokoundjé river (at Lolodorf) amounted to 773 mm, whereas those of the Kienké and Lobé rivers amounted to 1082 mm and 1397 mm, respectively. Rainfall on the Lokoundjé basin and the Kienké and Lobé basins could be estimated at 1880 mm and 2425 mm, respectively, resulting in runoff coefficients varying between 41% for the Lokoundjé basin and 45% and 58% for the Kienké and Lobé basins (Olivry, 1986).

Annual evaporation rates obtained with the water balance method varied between 1107 mm for the Lokoundjé basin and 1345 mm and 1025 mm for the Kienké and Lobé basins (Olivry, 1986). The electric conductivity of stream water in the TCP research area is extremely low and varies between 13 $\mu S\ cm^{-1}$ and 28 $\mu S\ cm^{-1}$ in the dry season (Dolman & Waterloo, 1995). On the basis of data collected in one rainy season two EC zones can be discerned, the eastern part of the area with low EC values, i.e. 15-30 μS cm^{-1}, and slightly higher EC values, i.e. 30-50 μS cm^{-1}, in the west (M.J. Waterloo, pers. comm., 1996). The low EC values may be an indication for low soil nutrient levels in the area.

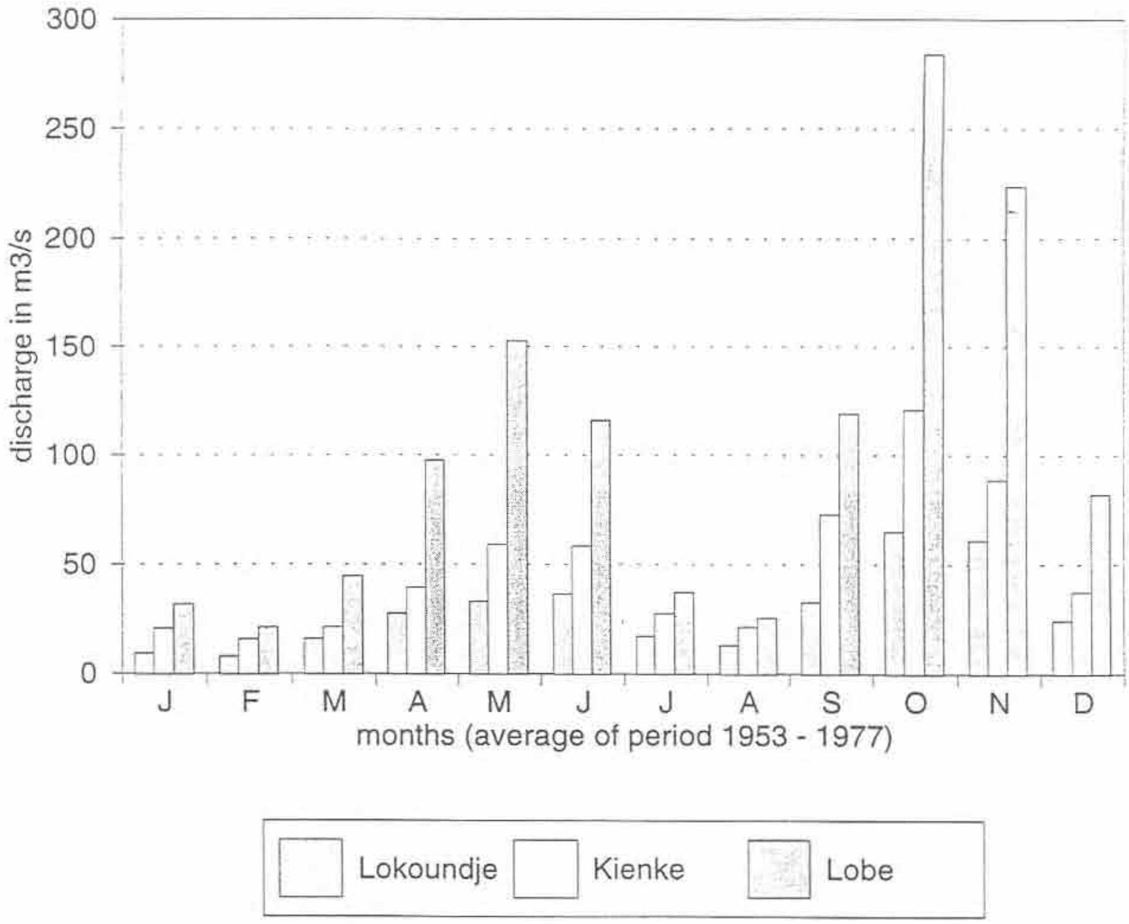

Figure 2.3 Mean monthly discharge patterns of the Lobé, Kienke and Lokoundjé rivers for the period 1953 - 1977 (after Olivry, 1986)

2.4 GEOLOGY

The most detailed information on the geology of Southwest Cameroon is provided by the 'Carte Géologique de Réconnaissance' at a scale of 1:500,000 (Champetier de Ribes, 1953; sheet Yaoundé East). Later publications, e.g. Franqueville (1973), seem to have been derived from the former without significant additional ground surveys (Touber, 1993a). More recent geological research in the region was carried out by the IRGM to establish a possible relation between Cameroon, the western part of the Congo craton and the São Francisco craton of Brazil (Toteu *et al.*, 1994). A geological map of South Cameroon was published recently but does not cover the TCP research area (MINREST and ORSTOM, 1995).

The Precambrian shield is the most important geological structure in Cameroon, and consists for a large part of metamorphic and old volcanic rocks (Franqueville, 1973). The metamorphic rocks consist mainly of gneisses, migmatites, schists and quartzites. Rocks formed in the period between Precambrian and Cretaceous are not found. Sedimentary rocks of Cretaceous or Tertiary-Quaternary age can be found in the Douala basin and alongside the Benoue river in North Cameroon. Tertiary-quaternary volcanic activity is restricted to West and Central Cameroon. In these regions basalts and andesites are present (Franqueville, 1973).

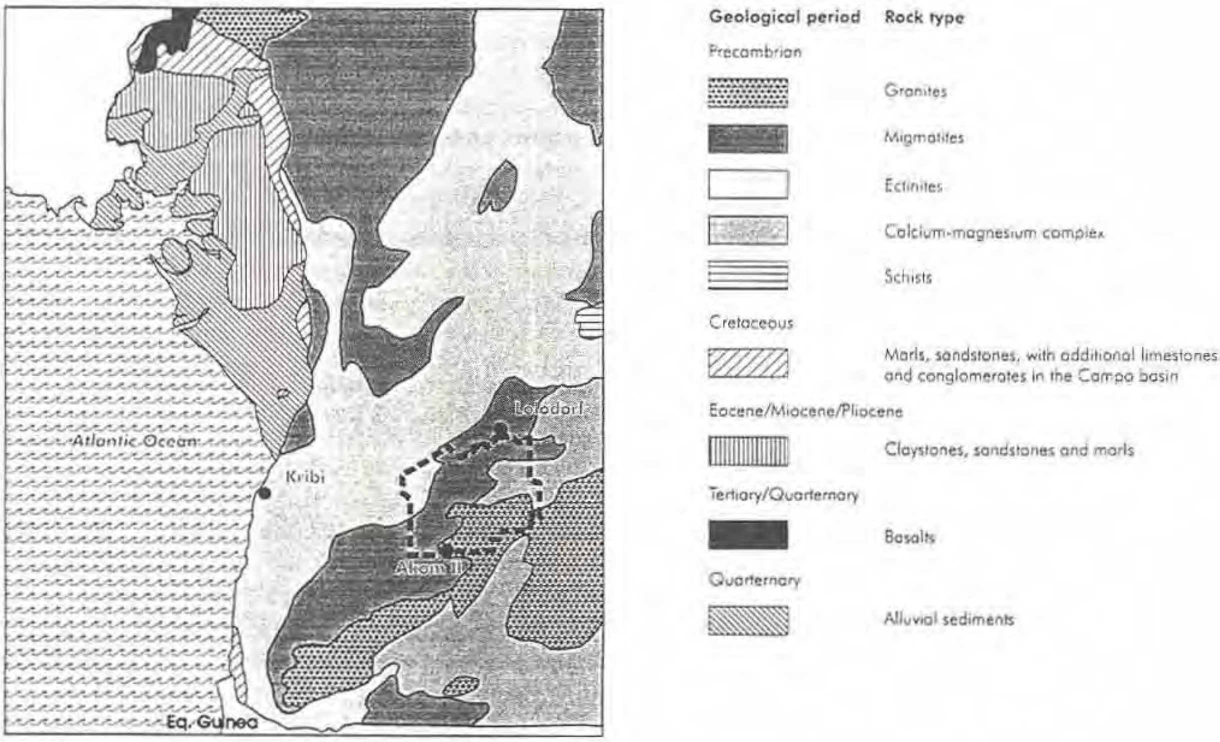

Figure 2.4 Geology of Southwest Cameroon; scale 1:200.000 (after Franqueville, 1973)

The rocks in the TCP area are all belonging to the Precambrian Basement complex (Franqueville, 1973). In the northeastern part gneisses and granites with high pyroxene contents occur. These rocks belong to the Calcium-Magnesium complex (Bilong, 1992 after Champetier de Ribes, 1956). In the northwestern part, ectinites (including gneisses, micaschist and quartzites) are found. In the western and central part of the area migmatites occur and granites are present in the southeast (see Fig. 2.4).

More recent studies on the geology of southwest Cameroon (Toteu *et al.*, 1994; Bilong 1992) discern two rock suites within the TCP research area: the Ntem complex and the Nyong series.

The Ntem complex is comparable to the Calcium-magnesium complex. The Nyong series consist of meta-sedimentary rocks which are composed of migmitates, gneiss, quartzites and amphibolites. In addition, in the Lolodorf region, some small lenses of ferro-magnesian rocks are found, such as amphibolites, diorites and gabbros, forming discontinuous bands with a general NE-SW direction.

During the present survey, mainly gneisses of various composition were found, as well as locally granites, migmatites, amphibolites, diorites and gabbros. Soils developed under a humid tropical climate on these metamorphic and igneous rocks will be composed of clay minerals (mainly kaolinite) with quartz sand and iron(hydr)oxides. These soils are acid and have low nutrient contents.

The overall tectonic direction in the Basement complex is NNE-SSW. Two synclinal zones and one anticlinal zone can be distinguished in South Cameroon. The first synclinal zone coincides essentially with the Sanaga valley, the second occupies Cameroon's southern border and disappears under the coastal basins. The anticlinal structure is composed of the metamorphic complex of Ntem which forms an extension of the Ebolowa-Ambam granite zone (Franqueville, 1973). Mineral resources of the geological formations in this part of the country are not economically exploitable (Franqueville, 1973

2.5 GEOMORPHOLOGY

The Atlantic coast of Southwest Cameroon is characterized by large swampy areas in the Douala basin while southwards a rocky coastline is present. Going eastward, the landscape changes from low altitude sedimentary plains to erosional plains and plateaus of the Precambrian shield with altitudes between 600 and 1000 m asl. The interface between the sedimentary plain and the Precambrian shield is only revealed by a few rapids in the larger rivers. Within the Precambrian shield four erosional plateaus, corresponding with 100, 200-300, 400-500 and 600-800 m asl, can be distinguished. The plateaus at 200-300 and 600-800 m asl respectively, correspond with the erosion surfaces African II and I (Franqueville, 1973).

Fluvial processes have shaped the landforms in the recent past. Eolian, glacial or periglacial processes did not affect the Cameroonian Precambrian shield.

The TCP research area is on the transition between the coastal plain and the Precambrian shield forming the interior plateau (Segalen, 1967). As a result the TCP research area is geomorphologically diverse. In the western part plains dominate whereas the eastern part is mountainous. The altitude ranges from 40 m asl in the western part to more than 1000 m asl in the eastern part. The central area is intermediate in both landform and altitude. A more elaborate literature review on landforms in the TCP research area is presented in section 4.1.

2.6 SOILS

The soils of Southwest Cameroon have been described and mapped at scale 1 : 2 000 000 and 1 : 1 000 000 (Segalen, 1957; Martin & Segalen, 1966). Three major soil types are distinguished. The deep, moderately well to well drained, yellowish brown tropical clay soils; `les sols ferrallitiques jaunes sur les roches acides (gneiss)' in the original French denomination, are the most widespread. These soils have high contents of sesquioxides (iron and aluminum) and are low in exchangeable bases.

The deep, well drained, reddish brown tropical clay soils; `les sols ferrallitiques rouges sur les roches acides' are restricted to the eastern part of Southwest Cameroon. The gneisses and granites of the `Complexe Calco-magnésien' coincide with this soil type (Touber, 1993a). The chemical properties are similar to the yellowish brown tropical clay soils.

The third soil type are the alluvial soils which are restricted to alluvial plains and valley bottoms. Although not covering large surfaces, this soil type is very distinct. It is often mapped in association with the yellowish brown and reddish brown tropical clay soils. The alluvial soils are characterized by greyish colours or mottling due to permanently high or variable groundwater levels. Texture varies with depth.

The soils in Southwest Cameroon are generally acid, have no weatherable minerals and the cation retention by the mineral soil fraction is low, leading to chemically poor soils. The soil fertility mainly depends on the organic matter that is concentrated in the upper 50 cm of the profile. Removal of the biomass and erosion of the topsoil seriously reduces the fertility (Driessen & Dudal, 1989). The soils are prone to strong phosphorus fixation and aluminum toxicity.

The physical properties of the soils are favourable for agriculture: deep soils with high permeability and a stable microstructure. With exception of the shallow and sandy soil types the soils are hardly susceptible to erosion. Their friable consistence under most conditions makes them easy to work. The well-drained tropical clay soils may in times be droughty because of their low water storage capacity (Driessen & Dudal, 1989). The physical characteristics, i.e. soil structure, permeability and infiltration, deteriorate by forest exploitation (e.g. on account of the use of heavy machinery).

A more elaborate literature review on soils in the TCP research area is presented in section 5.1.

2.7 VEGETATION

Southwest Cameroon forms part of the Guineo-Congolian domain which consists of dense humid evergreen forests. The area forms a belt along the Bay of Biafra. The width of the belt increases from 100-150 km in the north to 200-250 km in the south (Letouzey, 1985). The Guineo-Congolian domain is divided by altitude in a submontane zone (altitudes between 800 and 2200 m asl) and a zone with low and medium altitudes (between sea level and 800 m asl).

The submontane part of the Guineo-Congolian domain is almost completely restricted to the Mount Cameroon area and only very small surfaces are found scattered throughout Southwest Cameroon on individual upheavals surpassing 800 m asl. Most submontane forests have been degraded as a result of shifting cultivation and logging activities.

In Southwest Cameroon, the lower part of the Guineo-Congolian domain can be divided into four districts; the Littoral Atlantic district, the Biafran Atlantic district and the Central-oriental Atlantic district with humid evergreen forests, and one district with semi-deciduous humid forests (Letouzey 1968; 1985). In Figure 2.5 the location of the different districts is roughly indicated.

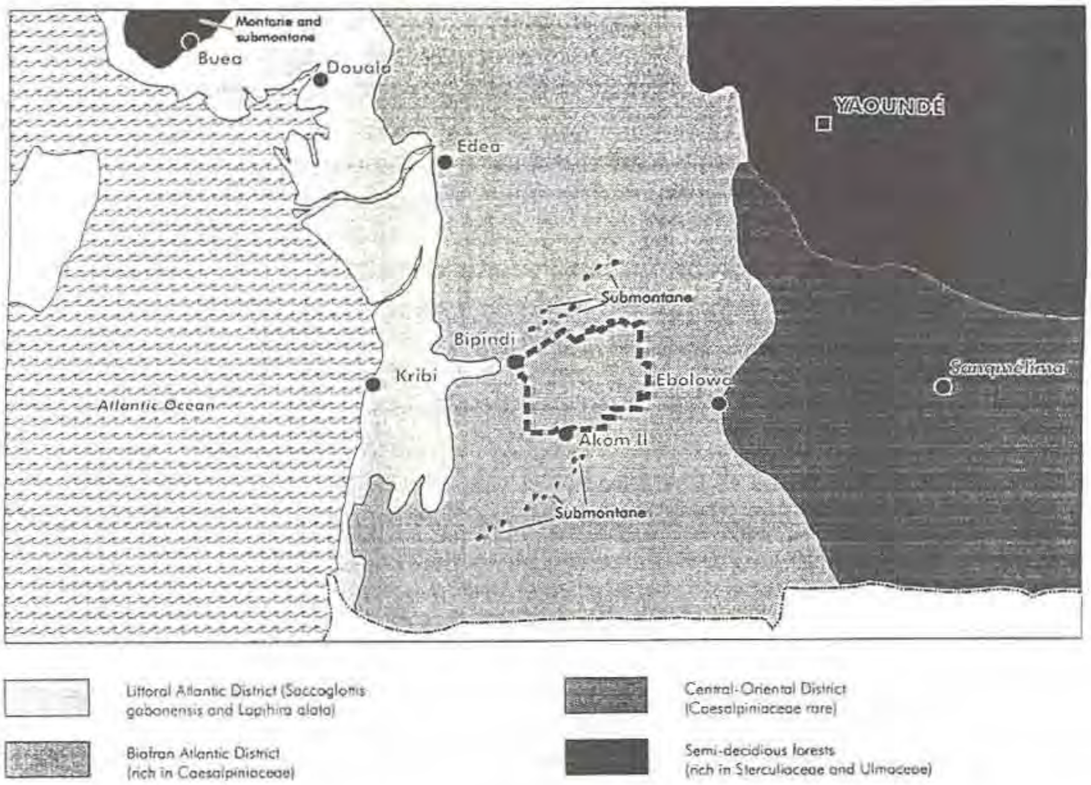

Figure 2.5 Phytogeographical map of Southwest Cameroon (after Letouzey, 1985)

The Littoral Atlantic district is restricted to a zone of 50 -100 km along the coast and altitudes are between 50-100 m asl. Annual rainfall in this region is generally well above 2000 mm. The Littoral Atlantic forest with *Lophira alata* and *Saccoglottis gabonensis* is the most important forest type in this district (Letouzey, 1985). Although the general appearance of the forest is that of a primary vegetation, Letouzey (1968) and others state that these forests were established after extensive forest clearing for human occupation by probably the Bassa in the eighteenth century. Their view is based on historical research and the ecological characteristics of *Lophira alata*. Nearly all the vegetation in this district has recently been subject to degradation due to human activities such as shifting cultivation, industrial plantations of oil palm, rubber and bananas, commercial logging, road construction and urbanization (Letouzey, 1985).

The Biafran Atlantic district is found at altitudes between (100) 200-500 m asl, and is located between the Littoral Atlantic district along the coast, and the Central-oriental Atlantic district and the semi-deciduous forests in the East. The climate is moist with annual rainfall figures of about 2000 mm. The vegetation in this district is (co-)dominated by species of the *Caesalpiniaceae* family. The forests of the Biafran Atlantic district are suffering degradation due to human activities (Letouzey, 1968; 1985).

The Central-oriental Atlantic district is found to the east of the Biafran Atlantic district. The vegetation is essentially an evergreen forest poor in *Caesalpiniaceae*. This district gradually merges towards the Northeast in the semi-deciduous forests with many members of the *Sterculiaceae* and *Ulmaceae*. The boundaries of both districts with the Biafran Atlantic district are gradual.

Because of the various human activities mentioned above, the vegetation in large parts of Southwest Cameroon has changed drastically. Forests in different stages of degradation are found close to towns and villages, along access roads, and in logged forest. The floristic composition of the secondary vegetation is very distinct and incorporates many species which can be characterized as `pioneer species' and which are found in disturbed vegetation throughout the Guineo-Congolian domain, e.g. *Musanga cecropioides, Myrianthus arboreus* and *Homalium species*. Large recent clearings are typically overgrown with the stout herb *Chromolaena odorata*. Moreover, depending on the intensity of clearing, many relicts of the previous forests are found reflecting the characteristics of each of the phytogeographic districts.

A more elaborate literature review on vegetation in the TCP research area is given in section 6.1.

2.8 WILDLIFE

The tropical moist forest area of Cameroon possesses high levels of endemic fauna and flora. The Lower Guinea centre of endemism (Gartlan, 1989) stretches from SE Nigeria in the north to Gabon in the south. A subdivision is made into the Cameroon refuge, centring around Mount Cameroon, and the West Equatorial refuge south of the Sanaga river. The two refuges are important with respect to the conservation of biodiversity.

Approximately 132 species of mammals are found in the humid forests of Cameroon (Vivien, 1991), among which endangered species like elephant (*Loxodonta africana cyclotis*), western lowland gorilla (*Gorilla gorilla gorilla*), chimpanzee (*Pan troglodytes troglodytes*), mandrill (*Mandrillus sphinx*), African leopard (*Panthera pardus*), forest buffalo (*Synceras caffer nanus*) and bongo (*Tragelaphus eurycerus*) (IUCN, 1988). No systematic census of the mammals of the TCP area has taken place. Van Dijk (1997), in her study on non-timber forest products, interviewed villagers on the use and presence of `bush meat'. Her survey reveals that, although the elephant has become extinct, the TCP research area still harbours gorillas, chimpanzees and mandrills. Bekhuis (1997) studied, within the framework of the Lu1 project, the habitat requirements of some larger mammal species.

Some 849 species of birds are found in Cameroon (Louette, 1981). A total of 390 bird species are known to occur in the Korup National park and its surroundings in the South-West Province, Cameroon. Although the avifauna of this area is still incompletely known, it is already among the ornithologically most diverse lowland forest sites in Africa (Rodewald *et al.*, 1994). Some 48 of these species are considered globally threatened or near-threatened. The avifauna of the TCP research area has neither been studied intensively nor systematically. The legacy of a few individuals has resulted in the drafting of a preliminary species list of the TCP research area. The total of identified species is at present 96. In Annex VI all recorded species are listed.

2.9 POPULATION

The human population of Southwest Cameroon is concentrated in a few urban centres like Edéa, Kribi and Ebolowa, and in numerous villages along the main access roads. Population density in the rural forest areas averages 5 habitants per km^2 (Foahom & Jonkers, 1992).

The ethnic composition of the population of the TCP research area is diverse. Approximately 90% of the population are Bantus, belonging to the Bulu, Fang, Bassa and Ngumba tribes. They live in villages along the roads. The Bantus practice shifting cultivation, but other activities such as hunting, fishing and gathering of Non Timber Forest Products (NTFPs) are also important. Approximately five percent of the population are Bakola (or Bagyeli) pygmies. They are mainly forest dwelling hunters and gatherers, although they seem to be in the process of sedentarization. Shifting cultivation is practised by Bakola but is not widespread. The life style of the Bakola is seriously threatened by the ongoing logging and shifting cultivation activities in the area.

Traditionally Bantu and Bakola have all sorts of socio-economic relationships. Bakola groups have kinship ties with certain villages which arranges the mutual use of forest areas and protects it from outsiders. Bakola provide agricultural labour and bush meat to the Bantu farmers in return for agricultural products, like cassava and bananas, and increasingly for money. Bakola traditional doctors are regularly consulted by the Bantu villagers. In recent years the relation of the Bakola with their Bantu kin is becoming less exclusive and Bakola are now known to sell NTFPs directly to traders outside the region (pers. comm., F. Tiayon, 1996).

Traditionally men and women of rural communities of Southwest Cameroon have specific tasks with regard to land use. In Bantu villages, the women are responsible for the cultivation of crops, the preparation of food and the general housekeeping. Men are responsible for the clearing of forest and old forest fallow for agricultural fields, hunting and the cultivation of cash crops. Labour provision to logging and other companies is restricted to men. The collection of NTFPs in the vicinity of the village and fields is done by women, whereas those from the virgin forest are gathered by men.

A gradual transformation of the rural communities from subsistence to (partially) market oriented economy, is taking place in the last decade and is strongly influenced by the improved infrastructure. This will trigger changes in the relation between men and women and as a result the dynamics of land utilization by the local population may change (pers. comm., I. Hijman, 1996).

2.10 LAND USE

The main economic activity in the area is timber exploitation. Most of the forest within the TCP research area has at least twice been selectively logged by national and international companies, among them the Dutch GWZ. Logging concessions are granted for a one to three year period. The logging of the forest involves the construction of logging roads with bulldozers and graders. Log extraction from the forest is done by wheeled skidders and crawler tractors. Present logging activities focus on three species; Azobé (*Lophira alata)*, 60% of the extracted volume), Tali (*Erythrophleum ivorense)* and Padouk (*Pterocarpus soyauxii*). Only trees with diameters at breast height (dbh) ≥ 80 cm and straight boles of at least six meters are considered worthwhile. The resulting average logging intensity is low, i.e. 10 m^3 ha^{-1} representing 0.7 trees, compared with regions like Malaysia where on average 15 trees per hectare are removed. The felling and extraction of the logs from the stand are estimated to affect less than 15% of the surface (pers. comm. G.J.R. van Leersum, 1996).

Agriculture is an important land use in the TCP research area. The traditional shifting cultivation system involves the clearing and burning of primary and old secondary forest just before the rainy season and the planting of cucumber, maize, cassava, coco-yam and plantain. With decreasing soil fertility, the tending and harvesting of a field gradually stops and the land is left fallow after a maximum of five years. The former agricultural fields are then colonized by a forest vegetation. The biomass accumulation of the secondary vegetation restores soil fertility. The traditional shifting cultivation cycle is gradually being transformed by the introduction of the chain saw, the limited amount of available labour and the scarcity of new land within reach of the village. More and more farmers are clearing young fallows for agricultural fields. They plant groundnut and cucumber in association with coco-yam, cassava and maize. The total surface of this rotational fallow system is less than ten hectares per farmer (pers. comm., M. Yemefack, 1996).

NTFPs are a major source of food, construction materials, agricultural and household utensils, medicines and cash for the local population of Southwest Cameroon. The gathering of NTFPs is for the Bantu population supplementary to agriculture. For Bakola it is the mainstay. Surveys on NTFP collection have been carried out in the neighbouring Campo-Ma'an area and in the TCP research area. Some 500 plant species were recorded in the TCP area alone that provided a total of nearly 1200 different uses. The trade in NTFPs is an important source of income for the local population. The most traded NTFPs in the TCP area are for the Bantu population: oil palm (*Elaeis guineensis*), bush mango (*Irvingia gabonensis*) and the almond-like `Njansang' (*Ricinodendron heudelotti*). The Bakola collect and trade the fruits of the liana *(Strophanthus gratus*), honey and several oil containing nuts (e.g. *Panda oleosa* and *Poga oleosa*) (Dounias, 1993; pers. comm. H. van Dijk, 1996).

Next to subsistence agriculture, cacao is cultivated for cash revenues by mainly Bantu farmers and small cacao plantations are found throughout the area. In general these plantations are not well maintained due to continuing low world market prices. The devaluation of the Franc CFA in 1994 was an incentive for the production but still more than 50% of the cacao plantations remain abandoned. Recently, industrial size oil palm, pineapple and banana plantations have been created in the TCP area. Villagers who work and live in surrounding towns, appear to be the initiators of this development.

3 METHODOLOGY

3.1 LANDSCAPE ECOLOGICAL APPROACH

The Tropenbos Cameroon Programme aims at the development of sustainable forms of land use in Southwest Cameroon. The specific objective of the first phase of the Lu1 project is to provide base line information on the biotic and abiotic environment of the TCP area. This information will be used for land evaluation and planning procedures and for more detailed ecological research in the area. Based on the size of the area and the need for detail for land evaluation, a landscape ecological survey at scale 1 : 100,000 (reconnaissance scale) was carried out.

Zonneveld defines landscape (1995; after Schroevers, 1982) as `a complex of relationships systems, together forming (. . .) a recognizable part of the earth's surface, which is formed and maintained by the mutual action of abiotic and biotic forces as well as human action'. The landscape can thus be seen, as is done in the present study, as a fully integrated entity that can and should be studied as a whole (e.g. Breimer *et al.*, 1986; Hommel, 1987; Küchler & Zonneveld, 1988; Zonneveld, 1995).

Tropenbos has developed a Common Methodology for Land Inventory and Land Evaluation to contribute to a systematic and interdisciplinary research approach and subsequently sound land use planning (Touber *et al.*, 1989). This methodology focuses on the integrated description of the environment and was used for the land unit surveys conducted in the Tropenbos sites in Côte d'Ivoire (de Rouw *et al.*, 1990; de Rouw, 1991) and Colombia (Duivenvoorden & Lips, 1993; 1995). The holistic nature of the landscape approach requires a multidisciplinary team of surveyors.

An almost indispensable tool in all landscape oriented studies is the use of remote sensing materials. Depending on the scale of the study and the objects to be mapped, satellite images and aerial photographs can be used. For the present reconnaissance survey black & white aerial photographs have been used. These images reveal the identity of the landscape and their systematic interpretation enables the delineation of the different land units. A land unit is `a tract of land that is ecologically relatively homogeneous at the scale level concerned' (Zonneveld, 1995). Aerial photo interpretation provides a basis for stratified sampling in the field.

The aim of the fieldwork is to collect accurate and reliable materials to describe the photo interpretation units. In addition, the relevance of the boundaries of the photo interpretation units is studied. Ecological relevant data on soil, vegetation, geomorphology and land use, as well as geological, hydrological, zoological and other appropriate land attribute information are collected in selected sample sites. The land attributes are classified and a legend is compiled. The resulting landscape ecological map is an important tool for land evaluation. In the following sections, the methodological aspects of the present survey are treated in more detail.

3.2 AERIAL PHOTO INTERPRETATION

Topographical base maps at scale 1 : 50 000 were supplied by the CENADEFOR (1987) and are in fact enlargements of the 1 : 200 000 topographic maps of the Institute Géographie Nationale (CGN, 1976). The sheets Edéa NA-32-XXIII 1b, 2a and 2b and Nyabessan NA-32-XVII 3d, 4c and 4d were joint to make a single topographic map of the TCP area. The topographic map was updated as for the location of logging roads with the aid of a Global Positioning System (GPS).

Black & white aerial photographs of the TCP area were taken in 1963-66 at a scale of 1 : 50 000 and in 1983-85 at a scale of 1 : 20 000. The 1963-66 series has insufficient contrast to allow for stereoscopic vision. The much better quality photographs of the 1983-85 series have therefore been used for photo interpretation in the present survey. A list of the photographs is presented in Annex III.

The interpretation of the aerial photographs resulted in the drafting of preliminary maps on landforms and vegetation at a scale 1 : 50 000 (Touber, 1993a). The maps have hierarchical legends and discern a total of 49 and 25 legends units, respectively. A five week mission to the TCP research area was carried out in 1993 and sites were selected for the efficient sampling of the most important land units in the area (Touber, 1993b).

3.3 FIELDWORK

3.3.1 GENERAL

Observation sites were selected on the basis of the photo interpretation maps. Fieldwork involved the description of the attributes of the units discerned by photo-interpretation. Fieldwork was not merely a check to verify the photo interpretation as it largely entailed the collection of new information.

The land units sampled were considered the most important and widespread in the TCP area. The actual sample sites were selected on the basis of representativeness and accessibility. Transects, or transverses, of one to two kilometres with a general orientation perpendicular to the contour lines, have been laid out. These transects provided access to the land units to be described and enabled the detection of possible catenas or toposequential processes. Within the transect three to seven observation points were selected for detailed description. The locations of the observation points were determined by both the soil surveyor and the vegetation specialist. At each sampled locality, landform, soil and vegetation characteristics were described. In Figure 3.1 the distribution of observation points in the TCP research area is given

During the field work the survey team consisted of a soil surveyor, a vegetation surveyor, a field botanist (part-time), a local tree spotter and a local soil survey assistant. The transects were laid out by a `compass man' and two line cutters recruited from the nearest village. The distance along the transects was measured with a 'Topofyl' and each hundred meter was (temporarily) marked with a pole. The survey team covered approximately one kilometre per day for normal sampling procedures. One or two days extra were needed to dig and describe soil pits.

All transects and observation points have geographical coordinates and can be retraced on the base map and the aerial photographs. Photo interpretation and fieldwork were not strictly separated in time; efforts have been made to study the aerial photographs after each period of fieldwork and to adjust the preliminary legends and maps to the insights gained. The sampling procedures for landform, soil and vegetation aspects are discussed in the sections 3.3.2 and 3.3.3.

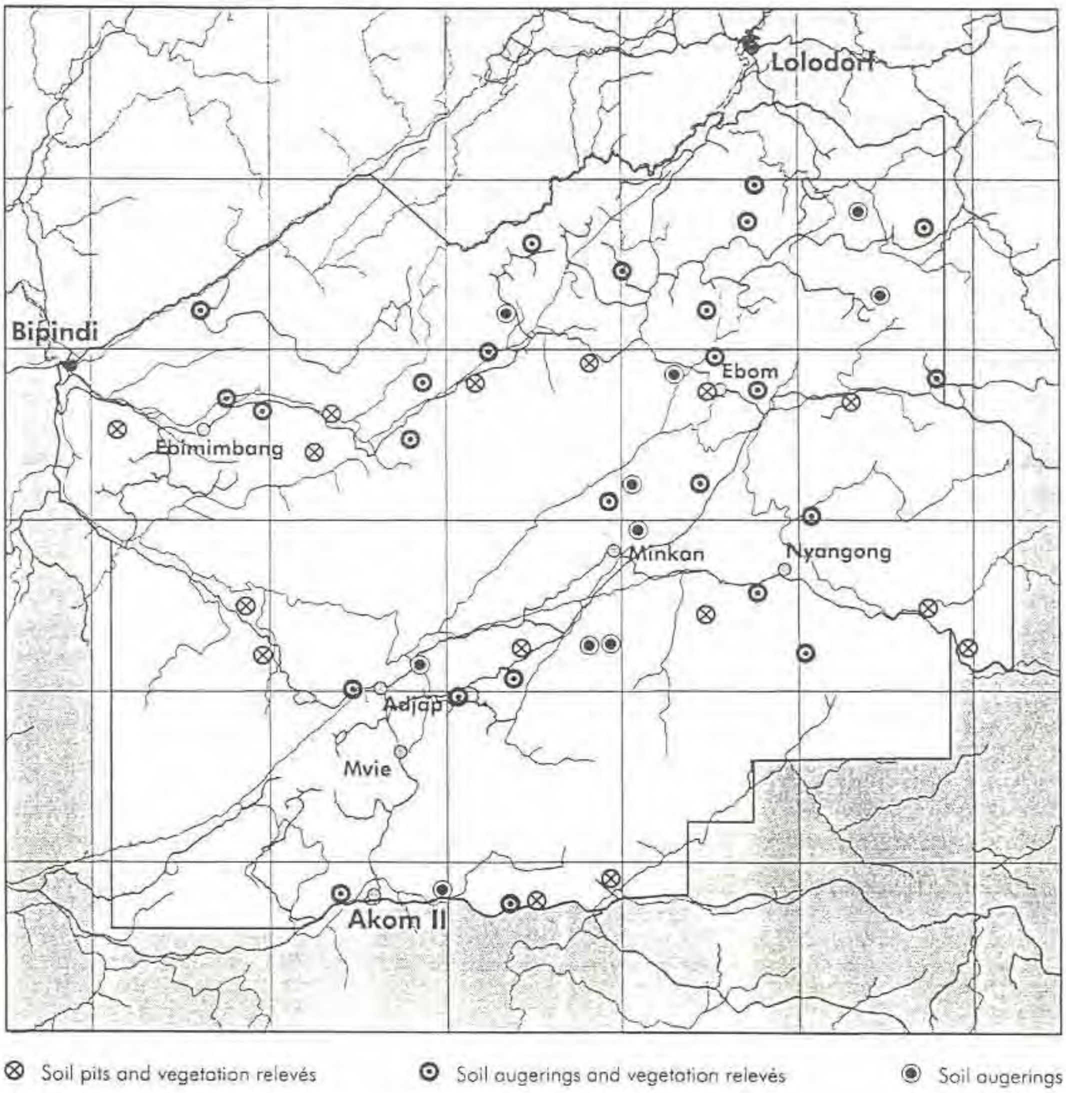

Figure 3.1 Distribution of observation sites of the landscape ecological survey. At each site 4 -7 observation points have been described.

3.3.2 Landform and soil

The landform and soil survey entails the collection of information on the geomorphology and the soils of the various land units. Geomorphological characteristics are often the most striking features of a stereoscopic image of aerial photographs. The relief is an important characteristic of landscape and a main guide for delineation of land unit boundaries (Zonneveld, 1995). The study of soils supplies data for land evaluation and helps to understand patterns in the vegetation.

The selection of observation points in the landform and soil survey was based on the photo interpretation study (Touber, 1993a). As soil forming processes differ in nature and in intensity in relation to the slope position (Embleton and Thornes, 1979; de Rouw *et al.*, 1990), observations are made at different topographical positions, e.g. the summit, upper, middle and lower slope and valley, to detect possible repetitive sequences in soil types, so-called catenas.

The described land and soil related attributes are based on Touber *et al.* (1989), FAO (1990) and Touber *et al.* (1993), and include: altitude, slope length, slope steepness, slope form, exposition, landform, stone and rock coverage, erosion and stability characteristics, drainage characteristics, groundwater level, biological activity and, humus form. Soil characteristics, described per horizon, are: colour, mottling, texture, structure, consistency, cutans, rooting characteristics and pores. Additionally, schematic sketches of the transects were made, showing the variation in slope percentage, slope direction, slope length, and exposition within each land unit.

At least three auger hole observations per transect were made. The auger holes were made with a standard type Edelman auger and range in depth from 1.2 to 2.0 m. A total of 207 soil and landform observations were made. In Figure 3.1 the distribution of observation points in the TCP area is presented.

After a first survey of the transects, about 60 sites representing the different landforms and soil types of the TCP area were selected, soil pits were dug and soil characteristics were described in more detail. All soil pits have a minimum depth of 1.50 m. Samples of horizons were collected for chemical and physical analysis.

Soil samples were chemically and physically analyzed at the IRA soil laboratory in Ekona. Duplicates of some 40 samples were analyzed as control at ISRIC, Wageningen. Chemical soil properties determined are organic carbon, total nitrogen, available and total phosphorous, pH H_2O and KCl, exchangeable bases (Na, K, Mg and Ca), aluminum and hydrogen, and cation exchange capacity (CEC). Physical parameters determined are texture, water retention characteristics (pF) and bulk density. Additionally, the clay mineralogy of some twenty-five samples were analyzed by ISRIC. The methods used for chemical and physical analyses are described in Annex IV.

All field data concerning the site and soil characteristics of the augerings and soil profile descriptions were compiled in the TROFOLIN Database (Touber *et al.*, 1993). Data of chemical and physical analysis are stored in QUATTRO PRO.

3.3.3 Vegetation

The distribution of plant species in tropical forests is not random but reflects environmental conditions (Whitmore, 1984 and Zonneveld, 1995). Species which can successfully compete with one another within the limits of a particular combination of environmental features can be considered as a plant community. The mosaic of plant communities forms the vegetation in an area (Küchler & Zonneveld, 1988). Moreover, the pattern of vegetation types, defined as plant-communities, may be used to assess the distribution patterns of distinct plant species.

In the present survey the vegetation was described on the basis of its structure and floristic composition, in the sense of the French-Swiss school (phytosociological approach; Braun-Blanquet, 1964). The method implies a classification of vegetation types by tabular comparison of plot data, which leads to the identification of communities, characterized by phytosociological groups (Touber *et al.*, 1989).

The localities described in the vegetation survey lie within the most common and widespread photo interpretation units in the TCP research area (see 3.3.1). The stratification of sample points is based on the hypothesis that altitude (Fig. 2.1) and disturbance (both anthropogenic and natural) cause most of the variation in the vegetation in the TCP research area. The observation points are therefore evenly spread along these two environmental gradients (Table 3.1). Additionally, in relatively undisturbed forest vegetation efforts have been made to describe the vegetation along the toposequence, comparable to the study of catena's in the soil survey.

At each selected locality a detailed description of the vegetation, a `relevé', was made. As far as possible all growth forms, excluding mosses, ferns, epiphytes and small seedlings (due to difficulties in field identification), have been recorded in a plot of 100 m^2. In addition, all trees with diameter at breast height (dbh) ≥20 cm were recorded in the surrounding 1000 to 2500 m^2. Though not approaching the minimal area of tropical rain forest communities, this plot size is sufficiently large for classification purposes if all terrestrial growth forms of flowering plants and all size classes are included (Hommel, 1987; 1990; de Rouw, 1991).

The vegetation within each sample plot was homogeneous with respect to its structure, and representative for the surrounding area (Kent & Coker, 1992; Hommel, 1995). The intention was to describe the characteristic vegetation type(s) within each photo interpretation unit and therefore a-typical situations were omitted from sampling. A total of 125 vegetation relevés has been described in the reconnaissance scale survey and is used for the classification of the vegetation in the TCP research area. Table 3.1 gives the distribution of the vegetation relevés over the environmental gradients altitude and disturbance.

Table 3.1 Stratification of vegetation relevés along the environmental gradients altitude and disturbance

Disturbance	Altitude	40-180 m asl	180-340 m as	340-540 m asl	> 540 m asl
vegetation on (former) agricultural fields	thicket	**	*	**	**
	secondary forest	***	***	***	*
	plantations	**	-	-	-
logged-over forest	-	*	**	***	-
dynamic forest on steep slopes	-	**	**	****	
primary forest	valley bottoms	**	***	**	**
	slopes/plateaux	**	**	***	***
	summit areas	*	-	**	***

Number of observations: - = not found; * = 1 relevé; ** = 2-5 relevés; ***= 6-10 relevés; ****= 11-15 relevés.

The recording of plant species was carried out according to guidelines given by Touber *et al.*(1989), i.e. separate records per stratum and with cover/ abundance estimation in 14 classes (`ITC approach'). However, a complete recording of vegetation characteristics according to the TROFOLIN procedure (Touber *et al.*, 1993) was considered too time-consuming for a reconnaissance survey (Hommel, 1995).

Plant identification was done in the field with the help of a field botanist (part time) and a local tree spotter. Plant material of unknown species and for verification purposes has been collected in `Quick Herbarium' style (Küchler & Zonneveld, 1988). The `Herbier National du Cameroun' (HNC), the Limbé Botanic Garden and the Herbarium Vadense were consulted for identification. Under the prevailing conditions the field identification is not to be regarded equal to the botanical identification. Each field `species' often consists a cluster of botanical species with a similar general appearance. Efforts have been made to limit the size of these groups as much as was deemed appropriate in light of reliability. In the analyses of the vegetation data these groups have been used as entity.

Next to the detailed description of the sample points, the vegetation structure and land use along the transects was indicated on drawings. These drawings give insight in the mosaic of the vegetation in the different mapping units. In the second phase of the Lu1 project, will study these mosaics are studied in more detail. Also some 20 incomplete or so-called `quick relevés' were described. These incomplete descriptions do not support the classification of the vegetation, but help to investigate the relations between vegetation and abiotic factors. Moreover, they are of cartographic importance.

All vegetation data have been stored in TURBOVEG, a software package for input, processing and presentation of phytosociological data (Hennekens, 1995). The output of this package is, in contrast to TROFOLIN (Touber *et al.*, 1993), compatible with vegetation classification programmes like TWINSPAN (Hill, 1979a), SHAKE (Tongeren, unpubl.), DECORANA (Hill, 1979b) and CANOCO (ter Braak, 1988).

3.4 CLASSIFICATION

Based on the variation observed within the TCP research area, preliminary classifications were drafted for landforms, soils and vegetation. To describe the landscape as a complex of these attributes, the relations between landforms, soils and vegetation types were studied by means of cross-tables. The aim of this exercise was to trace the parameters of the abiotic environment which may best explain the variation in vegetation types. Based on these analysis, the landforms, soils and vegetation classifications were slightly modified to attain an optimal `ecological' fit.

The classification of landforms is based on differences in relief characteristics, i.e. slope length, slope steepness, relief intensity, and the number of interfluves. These characteristics are important in the light of land utilization.

The classification of soils in the TCP research area is primarily based on soil drainage and soil texture. Soil depth and stoniness are other differentiating criteria but could not be used at this scale. Soil drainage and texture are found to have a correlation with vegetation in the TCP research area. As soil texture and soil drainage are indicators for moisture availability, they are two of the functional soil parameters for land evaluation as well.

The classification of the vegetation of the area was done by means of `tabular comparison' of the relevé data using the computer programme TWINSPAN (Hill, 1979a). The programme performs a multi-variate analysis of vegetation data and produces a hierarchical classification of both sample points and species. Manual refinement of this classification included the reallotment of a limited number of borderline relevés. Also some 11 relevés were excluded from analysis because they proved to represent either intermediate situations on the highest level of classification, or represented ecologically aberrant situations that were not considered relevant to the reconnaissance survey.

The cover values of the three structural layers, i.e. tree, shrub and herb layer, have been combined into one value for each species. Four coverage classes were used, 0-5%, > 5-25%, > 25-50% and > 50-100% cover, regardless of the abundance of the species. For classification of vegetation on a reconnaissance scale, this is considered sufficiently detailed.

The classification by TWINSPAN is primarily based on the floristic composition of the sample plots. Next, a synecological interpretation of the vegetation types discerned has been carried out on the basis of the environmental data collected at the different plot sites.

3.5 LEGEND AND MAP COMPILATION

The final legend of the landscape ecological map is based on the classification systems for the individual attributes (landform, soil and vegetation), the study of correlations between these attributes and the annotated preliminary photo interpretation maps (Hommel, 1987; Küchler & Zonneveld, 1988).

The landscape ecological map (1 : 100 000) is thus based on 256 landform and soil observations and 125 vegetation relevés, and covers a total surface of 167,350 ha. Consequently, the observation density for landform and soil attributes is one per 650 ha and one per 1150 ha for the vegetation attributes. These observation densities are theoretically just sufficient (Landon, 1991).

The representation of the identified vegetation, soil and landform types on a map depends largely on mapping scale. In the present reconnaissance survey (scale 1 : 100 000) most of the units of the present landscape ecological map contain mosaics of soil and vegetation types.

Map compilation has been facilitated by the GIS package ArcInfo (ESRI, 1990; 1994). Digitized topographic base maps have been made compatible with the land attribute classification systems, enabling spatial analysis and the compilation of land attribute and evaluation maps (Bakkum, 1996).

4 LANDFORMS

4.1 LITERATURE REVIEW

The geomorphology of Southwest Cameroon is described by Martin & Segalen (1966) and by Franqueville (1973) at a scale of 1 : 1 000 000. The western part of the TCP area belongs to the coastal lowland of late Tertiary-Quaternary age, whereas the eastern part belongs to the interior plateau of Eocene age. At the boundary of these two zones a transitional complex is found (Segalen, 1967). At this transition different planation levels are present. The planation levels at 200 to 300 m and 600 to 800 m correspond with the erosion surfaces Africa II and I (Martin & Segalen, 1966; Franqueville, 1973). The two erosion surfaces have a well pronounced relief. They are characterized by hills and dissected uplands with numerous small streams. The slopes of the hills and uplands have convex upper parts and concave lower parts. Laterite banks are of minor importance and the tropical clay soils are generally deep.We have subdivided the area into four altitude classes which party coincide with the mentioned erosion surfaces. The altitude classes are < 350 m, 350-500 m, 500-700 m and > 700 m.

Important processes leading to the formation of today's landforms have been tectonic movements of parts of the Precambrian shield, e.g. block faulting along NE - SW lines, climatic changes and erosion processes related to rapid changes of the erosion basis. These processes resulted in different planation levels or erosion surfaces (Martin & Segalen, 1966; Buckle, 1978; Embleton & Thornes, 1979). The physiognomy of the landscape is still being `reformed'. The most important process is water erosion resulting in the dissection of the area. The intensity of this dissection is determined by the relative differences in erodibility of both soil cover and underlying rock, and by the amount of rainfall. Differences in erodibility of the rock are caused by differences in density of fractures and/or its mineral composition.

Table 4.1 Relief characteristics of the different landforms

Landform units	Slope length (m)	Slope (%)	Relief intensity (m)	No. of interfluves per km^2	Altitude range (m)	Surface area (km^2)
Dissected erosional plains (pd)	50-200	5-15	20- 30	3-4	40-280	110
Uplands (u1)	100-200	10-20	10- 40	3-4	120-700	480
Uplands (u2)	150-300	10-30	30- 80	2-3	120-700	690
Isolated hills (h1)	250-500	> 30	120-300		200-900	116
Complex of hills (h2)	200-350	20-40	80-200		350-700	139
Mountains (m)						
- outside slopes	> 400	> 30	> 250		> 500	100
- inside slopes	250-400	30-60	120-250			
Valley bottoms (v)	-	0- 2	< 10		40-700	15

4.2 LANDFORM CLASSIFICATION

At reconnaissance scale seven different landforms are distinguished in the TCP research area. These are characterized by relief intensity, slope steepness, slope length and drainage density. The landforms are: dissected erosional plains, moderately dissected uplands with rolling relief, strongly dissected uplands with hilly relief, isolated hills, complex of hills, mountains, and valley bottoms.

In the following sections the different landforms are discussed. In Table 4.1 and Fig. 4.1 a summary of the landform characteristics is presented.

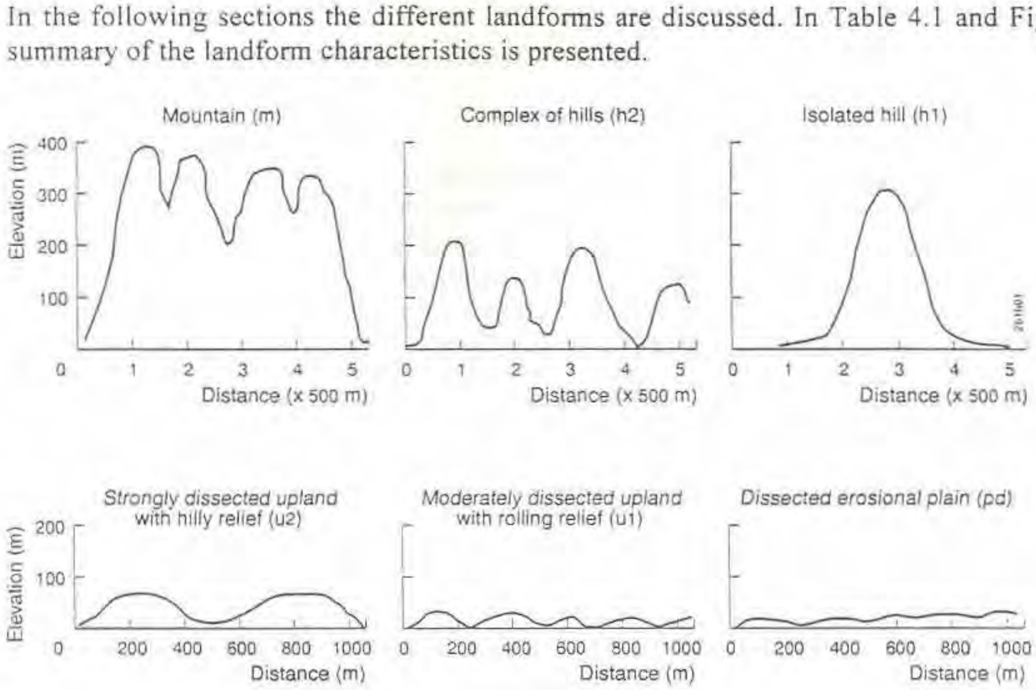

Figure 4.1 Schematic cross sections of six different landforms of the Bipindi - Lolodorf -Akom II region

4.2.1 Dissected erosional plains (pd)

The dissected erosional plains are relatively flat and lack prominent elevations or depressions. Within the TCP research area, they are found at altitudes below 280 m asl. Sedimentation is absent. The overall slopes of the dissected erosional plains are towards the main rivers running through them. River tributaries and creeks have dissected the erosional plains giving them an undulating to rolling relief. Most slopes are short (50-200 m) and have inclinations in the range of 5-15%. The relief intensities are between 20 and 30 meters. The main rivers draining the TCP research area, i.e. the Lokoundjé, Tchangue and Moungué, are located within the erosional plains.

The erosional plains are mainly restricted to the west of the TCP area and the interfluves have altitudes between 40 and 280 m asl. The dissected erosional plains bordering the Moungué are small as a consequence of the surrounding hills and mountains. In the case of the Tchangue river, only the western part of the river basin is classified as dissected erosional plain. Generally, the dissected erosional plains gradually merge into the moderately dissected uplands with rolling relief and the strongly dissected uplands with hilly relief. Sharp transitions occur between the dissected plains and the isolated hills. The dissected erosional plains cover about 8% of the TCP area .

4.2.2 Uplands (u1 and u2)

Two types are distinguished: u1 - moderately dissected uplands with rolling relief, and u2 - strongly dissected uplands with hilly relief. Field observations show that the strongly dissected uplands with hilly relief have narrower valley bottoms, poorer drainage, and more swamp characteristics than those with a rolling relief. A detailed study is needed to confirm these differentiating criteria.

The moderately dissected uplands with rolling relief have slopes of 100 to 200 meters long; these slopes are moderately steep (10-20%). The number of interfluves per kilometre ranges from three to four and the relief intensities are between 10 and 40 meters. This landform covers large surfaces in the central and northern parts of the TCP area, has altitudes between 350 and 500 m asl, and has a general NE-SW direction. It has gradual boundaries with the dissected erosional plains and the strongly dissected uplands with hilly relief. Sharp transitions are found with the hills and the mountains. The `rolling uplands' cover about 27% of the TCP research area.

The strongly dissected uplands with hilly relief have two to three interfluves per kilometre, slopes of 150-300 meter long which are moderately steep (10-30%), and relief intensities of 30-80 meter. The overall relief is hilly. The `hilly uplands' with an extent of 39% of the survey area are the most predominant landform in the TCP research area. They are confined to the 120-700 meter altitude range. They have relatively sharp boundaries with the mountains, hills and complexes of hills, and gradual boundaries with the rolling uplands.

4.2.3 Hills (h1 and h2)

Hills are natural elevations of the earth's surface. Hills occupy smaller areas, are lower and/or have lower relief intensities than the mountains. Two types of hills are discerned in the present reconnaissance survey: isolated hills (h1) and complexes of hills (h2). Both landforms are characterized by erosion, particularly sheet erosion (creep) and rockfalls.

The isolated hills are characterized by steep (> 30%) long slopes (250-500 m) and relief intensities of 120-300 meters. Rock outcrops are common and they are frequently encountered at the convex upper slopes. The isolated hills are steep-sided, isolated, residual and circumdenudated like inselbergs. They are scattered throughout the TCP area and are a characteristic aspect of the landscape, especially in the uplands of the central region. The isolated hills are conspicuously present in the landscape, even though they cover only 9% of the total TCP area.

The landform h2 is a complex of moderately steep to steep (20-40%) hills which are strongly dissected. The slopes are relatively short (200-350 m) and the relief intensities (80-200 m) are relatively low, when compared to the isolated hills and mountains. The complex of hills are characterized by a large variation in summit and valley bottom levels. Complexes of hills are mainly situated in the transition zone between the uplands of the central region and the mountains in the eastern part of the TCP area. They have a general NE-SW direction. Altitudes vary between 500 and 700 m asl. They are absent in the northwest of the TCP research area. The complexes of hills cover a surface of about 130 km^2, which is 9% of the TCP research area.

4.2.4 Mountains (m)

Mountains are complex dissected plateaus or massifs which are isolated and rising above the surrounding landscape. This landform is characterized by an abrupt rise in altitude to a higher level. Sheet erosion (creep) and rockfalls also occur in this landform. The outside slopes of the mountains blocks are very long (> 400 m), very steep (30 to over 60%) with a relief intensity higher than 250 meters. The inside slopes are moderately long (250-400 m), steep (30-60%) and have a relief intensity of 120-250 meters. Rock outcrops are common and mainly occur on the convex upper slopes. The mountains are restricted to the eastern part of the TCP area with altitudes above 500 m asl where they cover about 100 km^2, i.e. some 7% of the TCP research area.

4.2.5 Valley Bottoms (v)

Valley bottoms are poorly to very poorly drained, nearly flat to flat depressions between interfluves. They occupy extensive areas within the uplands and dissected erosional plains. Their widths are mainly 50-150 meters and are thus in general too small to be mapped separately at 1 : 100 000 scale. The slope percentages are between 0 and 2%. Stagnation of water is also an important characteristic. Soils are developed in unconsolidated, unspecified, stratified alluvium, which recently has been deposited.

The valley bottoms are found predominantly in the southeast of the TCP research and in the western lowlands. Large valley bottoms, i.e. wider than 250 m, are separately mapped in the present reconnaissance survey. These large valley bottoms cover approximately one percent of the TCP research area. However, this does not reflect the importance of the landform as the majority of valley bottoms are part of the dissected erosional plains, and uplands.

5 SOILS

5.1 LITERATURE REVIEW

The `Atlas du Cameroun' (1 : 2 000 000) and the `Carte Pédologique du Cameroun Oriental' (1 : 1 000 000) provide information on the soils in the TCP research area. The scales of these soil maps differ greatly from this reconnaissance inventory (1 : 100 000). These maps with their explanatory notes (Segalen, 1957; Martin & Segalen, 1966), together with the `Atlas Régional, Sud-ouest 1' by Franqueville (1973) give a good indication of the main soils of Southwest Cameroon. The three main soil types of Southwest Cameroon, according to the above mentioned studies, are `les sols ferrallitiques jaunes sur roches acides (gneiss)', `les sols ferrallitiques rouges sur roches acides' and `les sols alluviaux' (see also section 2.6).

According to the `Atlas du Sud Cameroon, scale 1 : 500 000 (MINREST & ORSTOM, 1995), the `sols ferralitiques fortement désaturées typiques jaunes ou rajeuni jaunes à ocres' and `les sols peu évolués ou bruts' are found around the city of Ebolowa east of the TCP study area.

South of the line Ebemvok and Akom II, a detailed soil study of 65 hectares has been carried out by Roubain who paid special attention to the genesis of soils. He reports that well drained yellowish brown clay soils dominate on gneisses, whereas the reddish brown soils occur on basaltic rocks. Laterite banks are exceptional in this region (ORSTOM - Roubain, pers. comm., 1995).

Soil studies in the Mbalmayo area, situated northeast of the TCP research area, were carried out on inventory scale by Yemefack & Moukam (1995) and on detailed scale by Ndjib (1987) and Ngeh *et al.* (1995). The soils in this area have been developed on (mica)schists, gneisses and granites of Precambrian age. Yemefack & Moukam (1995) classify the dominating well drained yellowish brown clay soils as Xanthic Ferralsols (low cation exchange capacity, low base saturation) with or without textural differentiation.

Ndjib (1987) differentiates the strongly weathered soils on the basis of texture, coarse fragment content and colour. He relates these differences to parent material (soils on schists have more coarse fragments than the ones on gneiss) and physiographic positions (development of argic properties on top positions and mid-slopes).

Bilong (1992) reports that around Akongo, which is also east of the TCP research area, well drained yellowish brown clay soils are formed on all kinds of parent materials. He relates the yellowish colour to goethite, an iron hydroxide. Goethite, which can be formed under a soil climate with sufficient moisture in the dry seasons, gives a yellowish brown colour to the soil (Bilong, 1992).

According to Touber (1993b) the soils in the TCP research are remarkably uniform throughout the area. They are well to moderately well drained, very deep, yellowish brown clay loams to light clays. Variations in depth, internal drainage, texture and gravel content occur. Some patches of redder soils may occur and an altogether different soil type is found in the valleys.

The present study confirms that deep, moderately well to well drained yellowish brown tropical clay soils predominate in the TCP research area. These soils also described as `les sols ferrallitiques jaunes sur les roches acides (gneiss)' are characterized by Martin & Segalen (1966) as follows:

topsoil (3-10 cm):	15 to 20% clay, ± 3.5% organic matter (C/N = 15), CEC < 8 meq/100 g, base saturation between 12 and 20% and pH < 4.5;
subsoil (> 10 cm):	35-50% clay, low in organic matter (< 3.5%), CEC between 5 and 7 meq/100 g and base saturation < 10%.

Vertical clay movement is described. The mineralogical composition of the clay is: 50-60% kaolinite, 35-45% goethite and < 10% gibbsite and the SiO_2/Al_2O_3 ratio is between 1.1 and 1.6.

5.2 SOIL TYPES AND CLASSIFICATION

The soils in the Bipindi - Lolodorf - Akom II area have been subdivided into four main soil types. This subdivision is based on soil drainage and texture in both topsoil and subsoil (table 5.1).

Well drained, deep to very deep[1], yellowish brown to strong brown clay soils, classified according to FAO-Unesco (1990) as Xanthic Ferralsols, are dominant in the area. These well drained soils are further subdivided according to the clay content in topsoil and subsoil into:
– Nyangong soils which are very clayey soils with no or only a gradual increase in clay content with depth. The clay contents of the subsoils range between 50 and 80%.
– Ebom soils which are clay soils with a gradual to strong differentiation in clay content between topsoils and subsoils. The clay contents of the subsoils range between 35 and 60%.

The moderately well drained soils are:
– Ebimimbang soils which are moderately deep to very deep clay soils with sandy topsoils. The clay contents of the subsoils range between 20 and 45%.

The poorly to very poorly drained soils are:
– Valley Bottom soils which are moderately deep to very deep soils, locally stratified and with variable textures in topsoils and subsoils.

The first three soil types are named after villages in the TCP area in which regions these corresponding soil types dominate. The Valley Bottom soils are, as the name implies, restricted to the valleys and occur all over the area.

Soil depth, soil stoniness and the occurrence of plinthite in the subsoils are other criteria for further subdivision of the soils. During the present reconnaissance survey it has, however, not been possible to find systematic relationships between these factors and positions in the landscape. Therefore, these criteria have not been used to further subdivide the four main soil types mentioned above.

1 Soil depths classes are as follows: shallow 0-50 cm; moderately deep 50-100 cm; deep 100-150 cm and very deep >150 cm.

Table 5.1 Soil types of the TCP research area and their diagnostic criteria

Soil type	Drainage	Texture (% clay topsoil)	Texture (% clay subsoil)
Nyangong	Well drained	35-70%, very clayey	50-80%
Ebom	Well drained	20-50%, clayey	35-60%
Ebimimbang	Moderately well drained	0-25%, sandy	20-45%
Valley Bottom	Poorly to very poorly drained	variable	variable

topsoil = 0-10 cm; subsoil = 20-60 cm

5.2.1 Nyangong soils

The Nyangong soils are deep to very deep, well drained, yellowish brown to strong brown, clays with dark yellowish brown to dark brown clay topsoils. They are developed on fine grained, pyroxene rich gneisses and granites, or other igneous rocks. Soil depth of the deep soils (100 - 150cm) is limited by the occurrence of ferruginated gravel, stones, boulders or weathering bedrock. Nyangong soils are characterised by a high clay content which can reach 80% in the subsoils. The topsoils are none to slightly less clayey than the subsoils whereby the increase in clay content with depth is gradual.

The topsoils are 10 to 20 cm thick with the first 5 to 10 cm having the darkest colours. They have dark yellowish brown to dark brown colours and 40 to 70% clay. The subsoils have yellowish brown to strong brown colours and clay contents of 50 to 80%. In places few reddish mottles and/or laterite gravel is found in the deeper subsoils.

Locally on summits, upper slopes or very steep mountain slopes, moderately deep to very deep, gravelly and stony soils occur as inclusions within the Nyangong soils. These have clay contents in the subsoils of 40 to 50% and are less deeply and less intensively weathered than the typical Nyangong soils. At the present scale of the survey, these soils could not be mapped separately.

The Nyangong soils are characteristic for altitudes above 500 m asl and are therefore found in the mountains and hills in the eastern part of the TCP area. The complexes of hills and isolated hills at altitudes above 500 m are also mainly covered with the Nyangong soils. The soils of the eastern uplands form complexes of Nyangong and Ebom soils. Full profile descriptions with analytical data of the Nyangong soils are given in Annex IV.

5.2.2 Ebom soils

The Ebom soils are deep to very deep, well drained brownish yellow to strong brown, clays with yellowish brown to dark brown sandy loam to sandy clay topsoils. They are developed on gneisses and migmatites. Soil depth of the deep soils (100-150 cm) is limited by plinthite, laterite and/or quartz gravel or bedrock. A relationship between the occurrence of plinthite or limited soil depth within 150 cm and topographical position, could not be detected and therefore not mapped at the scale on the survey. The Ebom soils are characterized by their clayey subsoils with less clayey topsoils whereby an increase in clay content with depth of about 10% generally occurs within 20 to 25 cm of the surface.

The topsoils are 10 to 20 cm thick, have yellowish brown to dark brown colours (with the first 5 cm having the darkest colours), and have 20 to 40% clay (sandy loam to sandy clay). The subsoils generally have 40 to 50% clay with an observed range of 35 to 60% and have brownish yellow to strong brown colours, with yellowish brown dominating. In a majority of the soils reddish mottles occur, starting between 20 and 50 cm depth. Iron concretions occur in the deeper subsoils, starting between 50 to 100 cm depth.

Locally on summits, steep upper slopes or very steep hill slopes, moderately deep to very deep, gravelly and stony soils occur as inclusions within the Ebom soils. These have clay contents in the subsoils of 40 to 50% and are less deeply and less intensively weathered than the typical Ebom soils. At the present scale of the survey, these soils could not be mapped separately.

The Ebom soils are typically found in the uplands and isolated hills in the central and northern regions of the TCP area at altitudes between 350 and 500 m asl. Complexes of the Ebom with Nyangong soils are found in the uplands above 500 m. Full profile descriptions with analytical data of the Ebom soils are given in Annex IV.

5.2.3 Ebimimbang soils

The Ebimimbang soils are moderately deep to very deep, moderately well to well drained, yellowish brown sandy clay loams to sandy clays with sand to sandy loam topsoils and with gravelly subsoils. They are developed on coarse grained gneisses and migmatites. They are characterized by sandy topsoils and a clay increase with depth of 15 to 20% which generally occurs within 20 cm of the surface. The depth of the moderately deep soils (50-100 cm) is limited by weathering bedrock, plinthite or high concentrations of gravel (both iron concretions or quartz gravel).

The topsoils are 5 to 10 cm thick, with colours in the range of dark greyish brown to black and generally with about 20% clay but clay percentages as low as 9% occur as well. The subsurface horizons are 5 to 10 cm thick, have yellowish brown to dark brown colours and have clay percentages of 16 to 25 %, but in places less. As silt contents are low, sand contents of topsoils and subsurface horizons are high.

Subsoils have yellowish brown colours with a range from light yellowish brown to strong brown and commonly have about 40% clay. Clay contents ranges between 30 and 64%. Reddish mottles start to appear between about 15 and 40 cm depth. In places plinthite occurs with in 150 cm, starting between 75 and 140 cm depth. Iron concretions occur in the deeper subsoils, starting at irregular depths, appearing between 15 and 140 cm from the surface downwards. Next to these concretions, quartz gravel and pieces of rotten rock occur in the deeper subsoils giving them a texture of slightly gravelly to gravelly sandy clay loams to sandy clays.

In the survey area, the Ebimimbang soils typically occur at altitudes below 350 m and are thus found on the dissected erosional plains, uplands and isolated hills in this altitude zone. Valley bottom soils occupy up to 15% of these areas but could usually not be mapped separately as most valley bottoms are narrow (< 250 m). Annex IV gives full profiles descriptions with analytical data of the Ebimimbang soils.

5.2.4 Valley Bottom soils

The valley bottoms are dominated by moderately deep to very deep, poorly to very poorly drained soils developed in unconsolidated recent alluvium. The soil profiles are stratified showing alternations of sand, loam and clay layers. Sand, however, is dominant. Flooding, high ground water levels and locally greyish colours are characteristics of this soil type. Depth of groundwater level and soil texture could be used for further subdivision of these soils, although at reconnaissance scale this is not feasible.

The topsoils are thin (< 5cm) very dark brown loamy sand, to sandy clay loams which locally are peaty. Where the groundwater level is relatively deep (> 50 cm), subsoils are light yellowish brown to dark brown, loamy sands to sandy clay loams with oxidation-reduction mottles. Subsoils have light grey to blue colours. In all valley bottoms in the TCP research area, the soils described above are found regardless of altitude. The majority of valley bottom soils, however, could not be mapped individually at scale 1 : 100 000. Valley Bottom soils occupy up to 15% of the area of the dissected erosional plains and rolling uplands. They occupy up to 10% of the hilly uplands. The complexes of hills and mountains are only sparsely covered with the Valley Bottom soils (< 5%). Soil profile descriptions with analytical data of the Valley Bottom soils are given in Annex IV.

5.2.5 Soil classification

All profile descriptions of which complete sets of field and laboratory data are available are presented in Annex IV. These soils are classified according to three international systems of soil classification. These classification systems are: the FAO-Unesco system (FAO, 1988; ISRIC 1994), the Soil Taxonomy of the United States Department of Agriculture (Soil Survey Staff, 1992), and the French system of the `Commission de Pédologie et de Cartographie des sols' (CPCS, 1967).

Table 5.2 presents the classification of the main soil types occurring in the TCP area according to three international soil classification systems. The soils which are most typical for a certain main soil type are heading the list of the soil classification in Table 5.2.

FAO-Unesco

The major part of the Nyangong, Ebom, and Ebimimbang soils classify as Ferralsols in the FAO-Unesco system (FAO, 1988). The Xanthic Ferralsols are most typical for the Nyangong soils. The Acri-xanthic Ferralsols are the most characteristic ones for the Ebom soils. The typical Ebimimbang soils classify as Acri-plinthic Ferralsols and Haplic Acrisols. The poorly drained Valley bottom soils classify as Dystric Fluvisols, the better drained ones classify as Gleyic Cambisols.

Ferralsols are deeply weathered soils, low in weatherable minerals with a CEC in the (ferralic) B-horizon of less than 16 me/100 g clay. The high degree of weathering is expressed by silt/clay ratios of 0.2 or less. In classifying the soils of the area silt/clay ratios of 0.3 were permitted, provided that the CEC-clay was clearly below 16 me/100g. The clay content of the ferralic-B horizon is over 8%. The Xanthic Ferralsols have a yellow to pale yellow B-horizon (hues of 7.5YR or yellower with a moist value of 4 or more and a moist chroma of 5 or more) caused by the presence of goethite. The Acri-xanthic Ferralsols are the yellow coloured Ferralsols with an increase in clay content with depth.

Ferralsols which have plinthite within 125 cm from the surface are the Plinthic Ferralsols. The Plinthic Ferralsols which show an increase in clay content with depth are classified as Acri-plinthic Ferralsols. Acrisols are soils with a CEC clay of less than 24 me/100 g and/or with silt-clay ratios of over 0.2 and with base saturations of less than 50%. Moreover, they show a clay increase with depth which is more than 8% when the clay content of the topsoil is over 40% and more than 20% (relative) if the clay content of the topsoil is between 15 and 40%. Ferric Acrisols have many coarse red mottles or discrete lateritic nodules. Plinthic Acrisols have plinthite within 125 cm from the surface. Ferrali-ferric Acrisols are Acrisols with a CEC clay of less than 16 me/100 g. Haplic Acrisols are the normal ones, without additional characteristics.

Table 5.2 Soils of the TCP research area and their classification according to three international classification systems

Soil type	FAO-UNESCO	Soil Taxonomy	CPCS
Nyangong	Xanthic Ferralsol Acri-xanthic Ferralsol Ferralic Cambisol Ferric Acrisol	Typic Hapludox Typic Kandiudox Oxic Dystropept Typic Hapludult	Sols ferrallitiques fortement désaturés Sols ferrallitiques moyennement désaturés rajeunis/remaniés
Ebom	Acri-xanthic Ferralsol Xanthic Ferralsol Haplic Acrisol Plinthic Acrisol	Typic Kandiudult Typic Hapludox Typic Paleudult Plinthudult	Sols ferrallitiques fortement ou moyennement désaturés
Ebimimbang	Acri-plinthic Ferralsol Haplic Acrisol Acri-xanthic Ferralsol Ferrali-ferric Acrisol	Plinthudult Typic Paleudult Typic Kandiudult Typic Kandiudult	Sols ferrallitiques moyennement désaturés
Valley Bottom	Dystric Fluvisol Gleyic Cambisol	Psammaquent/Fluvaquent Lithic Endoaquent Aquic Dystropept	Sols hydromorphes peu humifères

Cambisols are soils that have yellowish to reddish subsoils and have more than 8% clay. Generally these are relatively young soils with little profile differentiation and not intensively leached. Ferralic Cambisols are soils with CEC-clay of less than 24 me/100 g. Gleyic Cambisols show signs of water stagnation within 100 cm from the surface.

Fluvisols are young soils usually developed on alluvial sediments. They are stratified or have an irregular decrease of organic carbon contents with depth and have no diagnostic B horizon. Dystric Fluvisols have base saturations of less than 50%.

Soil Taxonomy - USDA

The major part of the Nyangong and some of the Ebom soils are classified as Oxisols in the Soil Taxonomy (Soil Survey Staff, 1992). The typical Nyangong soils classify as Typic Hapludox. The characteristic Ebom soils classify as Typic Kandiudults. Both Plintudults and Typic Paleudults represent the typical Ebimimbang soils.

Oxisols are deeply weathered soils with a CEC clay in the (oxic) B-horizon of less than 16 me/100 g and no or only limited clay increase with depth. Clay content of the subsoil is over 8%. The Oxisols in the TCP area are classified at great group level as Hapludox or Kandiudox. These soils have an udic moisture regime. The udic soil moisture regime is common to soils of the humid climates. Here, rainfall plus stored soil moisture exceeds the amount of evapotranspiration in such a way that the soils at about 20 cm depth are not dry for more than 90 cumulative days per year. The Hapludox are the most typical, normal

Oxisols. The Kandiudox have 40% or more clay in the first 18 cm and a clay increase of over 8% between topsoil and subsoil (kandic horizon). The Ebimimbang soils and most of the Ebom soils are classified as Ultisols. Ultisols are soils with a clay increase with depth and a base saturation of <35% in the subsoils. All the Ultisols in the area have an udic moisture regime as explained above for the Oxisols. The Hapludults are the normal Udults. Ultisols with a kandic horizon have less that 40% clay in the top 18 cm and have a CEC clay in the subsoil of less than 16 meq/100 g: Kandiudults. The Paleudults are deeper than 150 cm and do not have a clay decrease with depth of more than 20%. Plintudults have 50% or more plinthite within 150 cm.

The young Valley Bottom soils with high groundwater levels are classified as Aquents. The sandy ones are the Psammaquents and the loamy and clayey ones with irregular decrease in clay contents with depth are the Fluvaquents. Lithic Endoquents are shallower than 50 cm. The valley bottom soils which are somewhat better drained are classified as Inceptisols. The Inceptisols of the tropics are the Tropepts and Dystropepts if they have a base saturation of less than 50% in the subsoil. The Aquic Dystropepts have reduction and oxidation mottles within 100 cm.

CPCS

The three main soil types in the TCP research area can be placed in the `Classe des Sols Ferrallitiques'. These ‘sols ferrallitiques' are developed in the humid tropics and are characterized by high contents of the minerals kaolinite, gibbsite, goethite and hematite. The `Classe des Sols Hydromorphes' is also found in the TCP research area. These soils are characterized by a zone of alternating oxidation-reduction conditions and/or a permanent reduction zone (gley).

The Nyangong soils and the majority of the Ebom soils meet the requirements for the `sous-classe des sols ferrallitiques fortement désaturés en (B)', which are soils with pH lower than 5 and base saturation lower than 20%. The Ebimimbang soils and some of the Ebom soils meet the requirements for the `sous-classe des sols ferrallitiques moyennement désaturés en (B)', which are soils with pH around 5 and base saturation between 20 and 40%. The majority of the Nyangong, Ebom and Ebimimbang profiles can be placed in the group `groupe typique' and `sous-groupe jaune' of the system. In places they are in the 'groupe remanié or rajeuni'. They are all developed on `roches métamorphique' (Segalen, 1957). The Valley Bottom soils belong to the `sous-classe des sols hydromorphes minéraux ou peu humifères' and the `groupes des sols hydromorphes peu humifères à gley'. The depth of the gley horizon determines the subgroup.

5.3 SOIL PHYSICAL CHARACTERISTICS

Several physical characteristics were measured to characterize the soils. In Annex III the different methods used for texture, bulk density and water retention (physical) analysis are presented. Annex IV gives the analytical data of the sampled soil profiles. Table 5.3 presents the ranges of clay, silt sand contents and the average values of bulk densities and water retentions of the three main soil types.

5.3.1 Texture

In Table 5.3 textures of the topsoils and subsoils of the most common soils are presented. Clear clusters are present: (i) Nyangong soils with topsoil clay contents of about 45%, (ii) Ebom soils with intermediate clay and sand contents of about 35% and 45% respectively in the topsoils and (iii) Ebimimbang soils with topsoil clay contents of only 10%. Clay contents increase with depth for all three soil types. The deeper subsoils (BC, CB or C horizons) show slightly lower clay contents compared to the horizons directly above

Table 5.3 Soil physical characteristics of the Nyangong, Ebom and Ebimimbang soils.

Soil type	Depth	Texture (clay%)	Texture (silt%)	Texture (sand %)	Bulk density (g/cm^3)	AWC (%)
Nyangong	1	35-70	10-20	10-40	1.03	10
	2	50-80	5-15	10-40	1.21	12
	3	-	-	-	1.26	7
Ebom	1	20-50	5-20	40-60	1.22	17
	2	35-60	5-15	30-50	1.37	16
	3	-	-	-	1.4	12
Ebimimbang	1	0-25	5-15	60-90	1.3	11
	2	20-45	5-15	40-80	1.55	15
	3	-	-	-	1.63	n.a.

Soil depth classes: 1 = 0-20cm; 2 = 20-60 cm; 3 = 60-90cm. Bulk density values are the average of at least 4 observations. AWC= Available Water Content (one or two observations per soil depth class).

The Valley Bottom soils are dominated by a sandy texture, but in fact all texture classes may occur in all possible sequences. Stratification is characteristic for these soils. In general, the Valley Bottom soils have 5-30% clay and 40-90% sand in the topsoil. The subsurface horizons generally are more sandy.

5.3.2 Bulk density

The ranges in bulk densities of the soils in the TCP research area are 0.8 to 1.4 g/cm^3 in the topsoils (0-10 cm) and 1.0 to 1.7 g/cm^3 in the subsoils (20-90 cm) (Table 5.3). The bulk densities of all three main soil types increase strongly with depth, as effects of cultivation and organic matter content decrease. The increase of the bulk densities with depth take place within 25 cm from the surface. The bulk densities of the Nyangong/Ebom soils and the Ebimimbang soils are within the normal range of 1.0 to 1.6 g/cm^3 and 1.2 to 1.8 g/cm^3 as given by Landon (1991) for clayey and sandy soils, respectively.

Average values of bulk densities for the Nyangong, Ebom and Ebimimbang soils at three depths (0-20 cm, 20-60 cm and 60-90cm) are given in Table 5.3. The Nyangong topsoils have bulk densities of around 1.0 g/cm^3, and below 20 cm the bulk densities increase to values of 1.2 to 1.3 g/cm^3. The topsoils and subsurface horizons of the Ebom soils have bulk densities around 1.2 and 1.4 g/cm^3, respectively. Bulk densities of the Ebimimbang soils are the highest of the TCP research area, i.e. 1.3 g/cm^3 for the topsoils and 1.5 to 1.7 g/cm^3 for the subsoils. There is thus an increasing bulk density with a decreasing clay content.

The Ebimimbang soils have less stable aggregates than the Ebom and Nyangong soils (Waterloo *et al.,* 1997), resulting in vertical clay movement and lower permeability of the Ebimimbang soils. The higher bulk densities of the Ebimimbang soils are explained by the lower aggregate stability and higher sand contents of these soils.

Topsoils under agriculture have decreased organic matter contents and less roots resulting in higher bulk densities compared to identical soils under forest (pers. comm. Yemefack, 1996).

5.3.3 Water retention

The available water content (AWC) of a soil is the difference in water content between field capacity (pF 2) and permanent wilting point (pF 4.2). The range in available water contents in the soils of the area is 7.5 to 17.5%. The AWC's of the Nyangong, Ebom and Ebimimbang soils are within the commonly found range for clayey and sandy soils given by Landon (1991). Bulk density and AWC data are not available for the Valley Bottom soils.

In spite of the limited number of observations, some trends in AWC are apparent. The Nyangong soils have the lowest AWC's despite their high clay contents. Driessen and Dudal (1989) state that Ferralsols have good physical properties: stable microstructure, excellent porosity and high permeability. They have low 'available' water storage capacity as they behave like sandy soils with regard to some physical properties. The AWC of the Ebimimbang soils increases with depth as a consequence of the higher clay content at depth. The AWC's of the subsoils of the Ebimimbang and Ebom soils are related to their clay contents.

5.4 SOIL CHEMICAL CHARACTERISTICS

The chemical status of the soils in the TCP region is generally poor. They are strongly acid, have low levels of nutrient reserves and very low cation exchange capacities. Nevertheless, there are differences within this overall low chemical fertility between the four soil types.

The complete set of chemical data is presented in Annex IV. In Annex III the different methods used for chemical analyses are described. The results of the chemical analyses are summarized in Tables 5.4a and 5.4b and will be discussed in the following sections.

5.4.1 pH and exchangeable acidity

The soils in the TCP research area are very strongly to extremely acidic (pH(H_2O) 3.5-5). The relation between pH (H_2O) and pH (KCl) of all soil samples is linear (Fig. 5.1). The pH (H_2O) generally is about 0.5 to 1 unit higher than pH (KCl), indicating that the clay exchange complex is also occupied by H^+.

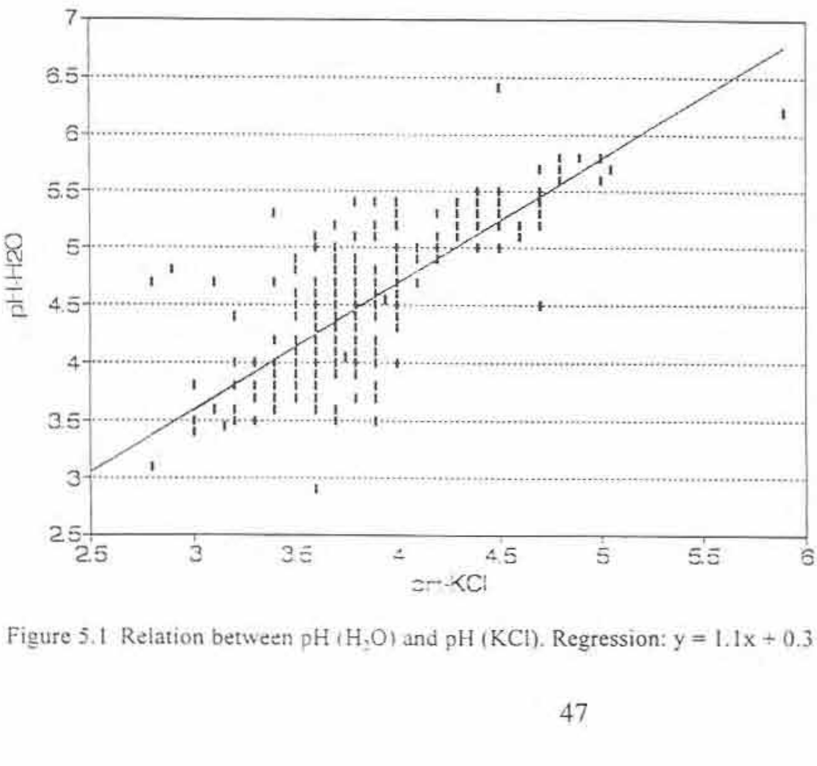

Figure 5.1 Relation between pH (H_2O) and pH (KCl). Regression: $y = 1.1x + 0.3$ ($R^2 = 0.63$; $n = 249$)

The pH[2)] of the Nyangong topsoils and subsoils is in the range of 3.5 to 4.5 (extremely acid). Khanna & Ulrich (1984) define the pH range 3.8-4.2 as the aluminum buffer range, which means that aluminum is exchanged against hydrogen with decreasing pH.

The pH of the Ebom soils is 3.5-5 in the topsoils and 4-5 in the subsurface horizons (very strongly to extremely acid). The pH values of the Ebom soils are only slightly higher than those of the Nyangong soils, and they are intermediate between the Nyangong and Ebimimbang soils.

The pH values of the Ebimimbang topsoils are 1-1.5 units higher than those of the Nyangong and Ebom soils. The topsoil pH is 5-6 (medium to strongly acidic), and the subsurface soil pH is 4.5-5.5 (strongly to very strongly acid). This marked gradient in pH with depth is characteristic for soils in the cation exchange capacity buffer (4.2-5). Cations are exchanged against hydrogen to buffer changes in pH. Soils with pH values within this range are characterized by sharp differences in chemical characteristics (Khanna & Ulrich, 1984), which is confirmed by the base saturation data of Ebimimbang topsoils and subsurface horizons. The Valley Bottom soil has pH values that resemble those of the Ebimimbang soil. The topsoil pH is between 5 and 6 and the subsurface pH is between 4.5 and 5.5.

All subsoils have pH values between 3.5 and 5.5. In these pH ranges manganese (Mn), aluminum (Al), iron (Fe) and trace elements as copper (Cu), zinc (Zn) and borium (B) are available for plant growth (Euroconsult, 1989; Landon, 1991). In general the aluminum concentrations of the soils in the TCP research area are high and exchangeable potassium (K), magnesium (Mg) and calcium (Ca) concentrations are very low in the soil solution (see Table 5.4b.). Crops grown on these soils may experience nutrient deficiencies. High aluminum concentrations in the soil solution are toxic to many crops. Low pH values as found in the Nyangong soils, facilitate the formation of iron and phosphate aluminium compounds. This phosphate is not available to plants. The somewhat higher topsoil pH values might be explained by recent agricultural activities which include the burning of vegetation by which alkaline ashes are formed.

5.4.2 Organic carbon and total nitrogen The organic carbon and related total nitrogen contents of the topsoils differ significantly between the four soil types. The observed organic carbon range within the survey area is 2%-9% and the total nitrogen contents range from 0.15%-0.5%. The topsoils have significantly higher organic carbon and total nitrogen contents than the subsoils. Figure 5.2. shows the relation between organic carbon and total nitrogen concentrations for all samples. The C/N value calculated with regression analysis on all data is 13 ($R^2 = 0.94$).

The Nyangong topsoils have organic carbon contents between 4% and 9% and total nitrogen contents between 0.25% and 0.4%. The C/N values of the topsoils are between 12 and 18. The subsurface horizons have organic carbon contents between 1% and 3% and total nitrogen contents between 0.1% and 0.15% (Table 5.4a.). In the subsoils the organic carbon content drops rapidly to below 0.5%. The C/N values of the subsurface horizons are in the range of 10 to 14.

[2] With pH, we mean pH(H_2O), unless otherwise indicated.

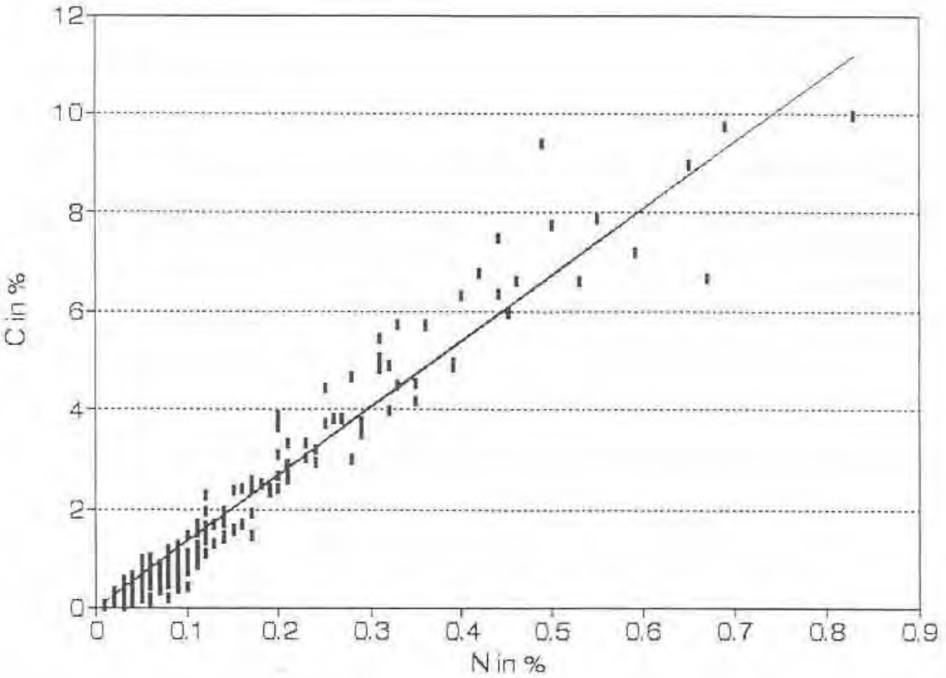

Figure 5.2 Relation between organic carbon and total nitrogen. Regression: y = 13.4x (R^2 = 0.94; n = 249)

The organic carbon and total nitrogen concentrations of the Ebom soils are similar to those of the Nyangong soils. Only the organic carbon concentrations of the Ebom subsurface horizons are lower, resulting in C/N values around 10.

Table 5.4a Ranges in some chemical characteristics of the four soil types in the TCP research area

Soil type	Depth	pH(H_2O)	Total N (%)	O.C. % (%)	Available phosphorous (ppm)
Nyangong	1	3.5-4.5	0.25-0.4	4 -9	4-11
	2	4 -5	0.1 -0.15	1 -3	0- 3
Ebom	1	3.5-5	0.25-0.5	4 -8	12-26
	2	4 -5	0.05-0.15	0.5-1.5	1- 4
Ebimimbang	1	5 -6	0.15-0.35	2 -3.5	10-24
	2	4.5-5.5	0.02-0.06	0.2-0.6	1- 4
Valley Bottom	1	5 -6	0.25-0.4	2.5-6.5	30-60
	2	4.5-5.5	0.05-0.2	0.1-0.7	2-10

Soil depth: 1 = topsoil, generally 0-10 cm; 2 = subsurface horizon of about 20-60 cm depth. O.C. = Organic carbon

The Ebimimbang soils have organic carbon contents in the topsoils of 2% to 3.5% which go down to 0.2 to 0.6% in the subsurface horizons. The Nyangong and Ebom soils have higher organic carbon concentrations than the Ebimimbang soils. This may be explained by the lower soil pH of the Nyangong and Ebom soils which reduces the mineralization rate of organic matter.

The Valley Bottom soils have organic carbon contents of 2.5-6.5% in the topsoils. The total nitrogen contents of the topsoil are comparable with the other soils. The subsurface horizons show organic carbon and total nitrogen contents similar to those of the Ebom and Ebimimbang soils.

5.4.3 Available and total phosphorous

The available phosphorous content in the topsoils of the Nyangong soils ranges between 4 and 11 ppm (low), in the Ebom and Ebimimbang soils between 10 and 26 ppm (moderate) and in the Valley Bottom soils between 30 and 60 ppm (moderate to high). With depth, available phosphorous contents drop rapidly to values below 5 ppm and are invariably approaching 0 in all subsoils.

Total phosphorous contents of the topsoils are high in the Nyangong soils and range between 400 and 600 ppm. With depth, these values go down to 50-250 ppm. The Ebom and Ebimimbang soils have 150-400 ppm total phosphorous in the topsoils and 50-250 ppm in their subsoils. Total phosphorous contents of the Valley Bottom soils are not available. Higher available phosphorous contents coincide with higher pH values as at higher pH values phosphorous is less fixed in aluminium and iron complexes than at lower pH ranges. The higher available phosphorous contents of the Valley Bottoms are explained by colluvial enrichment.

Table 5.4b Ranges in some chemical characteristics of the four soil types in the TCP research area

Soil type	Depth	K^+	Mg^{++}	Ca^{++}	TEB	Al^{+++}	ECEC	CEC	BS (%)
Nyangong	1	0.1-0.5	0.2-0.8	1-2	1.5-3.5	4-9	6-10	10-20	10-20
	2	0-0.1	0-0.5	0.2-0.6	0.5-1.2	2-6	5-7	6-9	5-15
Ebom	1	0.1-0.9	0.4-1.6	0.5-4	2-5	0.5-6	4-9	12-25	10-50
	2	0-0.2	0-0.5	0-0.5	0.3-1	2-5	3-6	5-8	5-20
Ebimimbang	1	0.1-0.7	0-1.5	1-8	3-7	0-3	3-10	4-12	50-100
	2	0-0.2	0-0.5	0-2	0.2-1.5	1-2.5	1.5-1	2-6	10-70
Valley Bottom	1	0-0.5	0.3-1.5	0.5-4	4.5-6	0-3	5-7.5	7-17	15-50
	2	0-0.1	0-0.2	0-0.5	0.5-0.8	0-1.5	0.5-2	1-8	20-40

Soil depth: 1 = topsoil, generally 0-10 cm; 2 = subsurface horizon of about 20-60 cm depth. TEB = Total Exchangeable Bases. ECEC = Effective Cation Exchange Capacity. CEC = Cation Exchange Capacity. BS = Base Saturation. All values, except BS, in meq per 100 g.

5.4.4 Cation exchange capacity and exchangeable bases

The cation exchange capacities (CEC) of the topsoils in the study area are low to moderate with CEC values of 4-20 me/100 gr soil. With depth the CECs drop rapidly to low levels of 1 to 9 me/100 gr in the subsurface horizons to even lower levels in the subsoils. The relatively higher CEC values occur in the topsoils of the Nyangong and Ebom soils and are between 10 and 25 me/100 g soil. These higher values are directly related to the higher organic matter levels of these soils.

The exchange complex is dominated by aluminium (Al) and Al saturation percentages of 30 to 80% are common. The highest saturation values occur in the soils with the lowest pH values, i.e. the Nyangong and Ebom soils. High aluminium saturation levels are toxic to many cultivated plants.

The amounts of exchangeable bases (mainly calcium, magnesium and some potassium) are low to moderate in the topsoils of the Nyangong and Ebom soils with totals of 1.5 to 5 me/100 g soil. With depth, the level of exchangeable bases drops rapidly to very low values of less than 1 me/100 g, whereby hardly any potassium remains. The topsoils of the Ebimimbang and Valley Bottom soils have moderate amounts of total exchangeable bases (3 to 7 me/100 g soil) but with depth also drop to very low values.

The low CEC values of the soils are indicative for kaolinite as the dominating clay mineral (Euroconsult, 1989) which is confirmed by the clay mineralogical analysis (see section 5.4.5). The CEC values calculated for the clay fraction, when corrected for the CEC of the organic matter, are in most profiles, regardless of the soil type, 10 me/100 g or lower. If, in addition, one considers that the CEC of the organic matter is about 200 me/100 g (Landon, 1991), it follows clearly that the total CEC in the soils of the TCP area is mainly determined by the organic matter content of the soils. This strong relationship between the CEC and the organic matter content of the soils in the area is shown in Fig. 5.3.

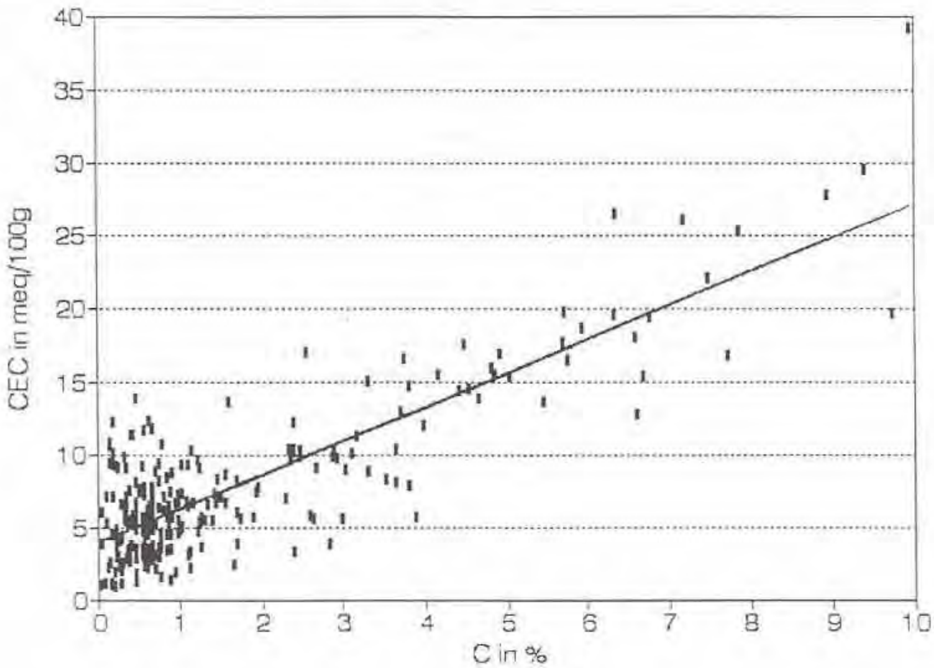

Figure 5.3 Relation between organic carbon content (C) and cation exchange capacity (CEC). Regression: $y = 2.3x + 4.0$ ($R^2 = 0.71$; $n = 249$).

5.4.5 Clay mineralogy

A selected number of soil samples was used for determination of the clay mineralogy at ISRIC in Wageningen, The Netherlands. Annex III gives the details of the methods used, for the results see Annex IV.

The dominant clay mineral in the Nyangong, Ebom and Ebimimbang soils is kaolinite. The dominance of kaolinite in all soils in the TCP area is an indication of strong weathering and therefore low nutrient reserves (Euroconsult, 1989; Landon, 1991).

Next to kaolinite, the aluminum hydroxide gibbsite, is moderately abundant in the Nyangong and Ebom soils. Gibbsite forms in richer parent material (Driessen & Dudal, 1989; Mohr *et al.*, 1972; van Kekem *et al.*, 1997). The drainage conditions of the Ebimimbang soils, are less good when compared to the two other soil types. This might be the explanation for the difference in gibbsite contents of the different soil types.

Vermiculite, chlorite and smectite are clay minerals which are absent or only present in relatively small amounts in the TCP research area. Micas (illite) are moderately abundant in some soil samples, but no relation is found with the different soil types. Feldspars and quartz are absent or only present in small amounts the clay fractions.

The iron hydroxide goethite is moderately abundant in all soils, whereas the iron oxide hematite is absent in the three main soil types of the TCP area. Goethite is formed under a soil climate with sufficient moisture in the dry season even if the soils are well drained. It gives the soil a yellowish brown colour (Bilong, 1992). Driessen & Dudal (1989) state that goethite is formed when the iron concentration is low, the organic matter content is high, the temperature is low and/or soil pH is lower than 4.0.

5.4.6 Nutrient contents

Combining bulk density data and chemical data makes it possible to calculate the total amounts of nutrients potentially available for plant growth. The data give an indication of the fertility of the different soils. The calculated nutrient contents for the three main soil types are averages of four to six profiles. Table 5.5. shows the nutrient contents in kg/ha for a soil column of 1 meter deep. The majority of these nutrients, however, are concentrated in the upper 20 cm of the soil profile.

The Nyangong soil has a relatively high nitrogen content (12.5 ton/ha), whereas available phosphorous and potassium are present in relatively small amounts of 8 and 360 kg respectively (Table 5.5.). Magnesium and calcium amounts are 195 and 1065 kg/ha, respectively. The Ebom soil has less total nitrogen (8900 kg/ha), but a moderate amount of phosphorous (28 kg/ha). The Ebimimbang soil also has a moderate amount of available phosphorous (24 kg/ha) but the total nitrogen amount is low (7000 kg/ha). The potentially available K, Mg and Ca amounts are in the same order of magnitude for all three soils.

Table 5.5 Average nutrient contents of the Nyangong, Ebom and Ebimimbang soils in kg/ha (soil column of 1m)

Soil type	Total N	Available P	K	Mg	Ca
Nyangong soil (n=6)	12500 (7371-24338)	8 (3-16)	360 (168-805)	195 (86-336)	1065 (607-1876)
Ebom soil (n=4)	8900 (5616-13022)	28 (5-59)	755 (361-1601)	175 (60-306)	1785 (867-3558)
Ebimimbang soil (n=6)	7000 (4963-8757)	24 (11-42)	370 (176-395)	165 (27-535)	1810 (1295-2088)

The nutrient contents of the soils in the TCP research area are comparable with data from other studies on humid tropical forest soils (Anderson & Spencer, 1991; Gillman *et al.*, 1985).

The nutrients from the soil are taken up by the crops grown. For instance, maize takes up an average of 16 kg N, 1.5 kg P and 13 kg K per ton harvested grain. With groundnuts an average of 33 kg N, 2 kg P and 17 kg K is removed per 1000 kg of product. With 10 tons of cassava tubers 120 kg N, 7 kg P and 80 kg of K disappears from the field.

The nitrogen is mainly contained in the organic matter fraction of the soil. Assuming a 2% mineralization rate and an availability of 50%, gives for the Ebom soils a potential supply of 89 kg N per ha per year. This means that in the first year after clearing, N will not be a limiting factor. Only if the soil is left bare and organic matter decomposes rapidly, N may become in limited supply. The phosphorous stock, however, will be depleted fast with cultivation and already after one year deficiencies may occur, especially in Nyangong soils. The potassium stock will last a few years but with continuous cultivation would become depleted within 4 to 5 year, depending on the cropping intensity.

5.4.7 Conclusions

The soils in the TCP area have low (chemical) fertility levels. Especially the Nyangong and the Ebom soils are very acid. The cation exchange capacities, which determine the capacities of the soils to retain and subsequently release nutrients, are low to moderate but will drop rapidly with declining organic matter levels. This is because the contribution of the clay fraction to the CEC is very limited as the dominating clay mineral is kaolinite.

A large part of the nutrients is stored in the biomass of the vegetation. Through recycling in a stable environment, these nutrient stocks remain in tact. Removal of the vegetation severely interrupts the nutrient cycle and trough leaching and erosion part of the nutrients may disappear out of the system.

5.5 SOIL-LANDFORM RELATIONS AND SOIL GENESIS

5.5.1 Soil and landform relations

The TCP research area can be divided into three broad areas: (i) the mountainous and hilly eastern region with deep to very deep, well drained, yellowish brown to strong brown clay soils (Nyangong soils); (ii) the rolling and hilly uplands with scattered hills in the transitional or central and northern regions covered with deep to very deep, well drained, brownish yellow to strong brown clay soils (Ebom soils) and (iii) the dissected erosional plains and rolling and hilly uplands in the western lowlands with moderately deep to deep, moderately well to well drained, yellowish brown sandy clay loams to sandy clay soils with sand to sandy loam topsoils (Ebimimbang soils). A fourth category are the valley bottoms with moderately deep to very deep, poorly to very poorly drained soils formed in stratified unconsolidated recent alluvium showing alternating layers of sand, loam and clay (Valley Bottom soils). These Valley Bottom soils are found all over the TCP research area, the majority of which could not be mapped individually.

The major part of rocks in the TCP research area do not differ much from each other. In the eastern part, fine textured gneisses dominate and diorites and/or granites rich in pyroxene are present as well, whereas in the western lowlands, coarse grained gneisses dominate and migmatites occur locally. These relatively uniform mixtures of metamorphic rocks (mainly gneisses) and igneous rocks are not decisive in differentiating landforms and soils in the area. The relatively small variations in mineralogy and density of fracturing of the parent material, result in only small differences in erodibility and soil fertility. Normally, lithological differences largely contribute to the formation of today's landscape (Embleton & Thornes, 1979).

The combination of block faulting and the process of denudation (mechanical and chemical erosion) have resulted in planation or erosion levels of different age, which might be the explanation for the differences encountered in the landforms and soils in the TCP research area. The eastern region of the TCP region has been lifted upwards in relation to the western lowlands along NE-SW orientated faults. The denudation, which can be called (valley floor) pedimentation (Zonneveld, 1981; Embrechts & Dapper, 1987), has resulted in almost flat erosional plains with inselbergs in the western lowlands and in a very dissected landscape in the mountainous eastern region. This dissected landscape has been developed originally from an old erosional plain. The progressive erosion (slope retreat) from West to East has resulted in very small differences in altitude (low relief intensity) between the western part of the TCP research area and the Atlantic Ocean, i.e. the erosion basis. It is concluded that the landscape in the western part of the TCP research area is younger than the eastern one.

The soil forming processes, which are mentioned in section 5.5.2., may have been causing spatial variations. A downward trend from West to East in rainfall and temperature may have caused differences in intensity and nature of the soil forming processes. This trend, however, is locally disturbed by the topography. Lower amounts of rain are observed around Bipindi (Waterloo *et al.*, 1997) and can be an additional explanation for richer and less deep soils in these western lowlands.

Additionally, the age of the landscapes within the TCP research area varies and as a result, the soil forming processes differ in their periods of activity. Hydrolysis in the western lowlands is not in as advanced state as in the eastern region. Moreover, the importance of soil forming processes such as plinthite formation and clay illuviation decreases from West to East. Besides the variation in rainfall and temperature and the different ages of the landscapes in the research area, the spatial distribution of the soil forming processes is also influenced by topographical position. All these factors result in differences in soil drainage, texture and soil depth.

The soils are relatively uniform in colour but differ in texture, depth or drainage. The variation in texture seems to be related to differences in the age of the landscape. Perhaps small, during the survey not noticed, differences in texture and mineralogical composition of parent material could also be important. Younger areas like the western lowlands have less weathered soils, resulting in coarser textured soils (Ebimimbang soils), whereas the deeply weathered soils in the eastern region have a predominant clayey texture. The less weathered soils are richer in nutrients, have higher pHs and clear clay cutans (evidence of active clay movement to the subsoils) and are less deep than the clayey textured Nyangong soils formed in an older landscape.

Drainage differences are especially related to topographical positions. The valleys have poorly to very poorly drained soils, whereas on the other topographical positions, moderately well to well drained soils occur.

The variability in soil depth may be large at small distances for which relative resistance to weathering of the parent rock and the degree of fracturing may be an explanation.

Further research (e.g. clay mineralogy, geomorphological processes, geology) is needed to elaborate these theories. Also, research on the variation of soil depth with topographic position (catena) will be very useful for a better understanding of processes which are active in the TCP research area.

5.5.2 Soil genesis

The following soil forming processes have been contributing to soil formation in the TCP research area: formation A-horizon, hydrolysis, ferralitization, kaolinitization, plinthite and laterite formation, eluvation and illuvation of clay and oxidation/reduction processes.

Accumulation of litter which is decomposed by soil flora and fauna in the mineral topsoils results in the formation of an *A-horizon.* Mineralization of organic matter releases nutrients which can be taken up by the surrounding vegetation. The process of decomposition, mineralization and uptake by the vegetation is relatively quick, therefore A-horizons are thin. Low pH levels, however, will retard the decomposition and organic matter may accumulate (Mohr *et al.*, 1972). The chemical fertility of the tropical soil is strongly related to the presence of organic matter in the topsoil because of its storage and release capacity of nutrients. In the TCP area there are significant differences in organic carbon contents between the different topsoils (section 5.4.2.).

The main soil forming process in the TCP area has been *hydrolysis* (cations in the primary silicate structures of minerals are exchanged against H^+-ions). The hydrogen ion weakens the mineral structure, facilitating the dissolution of Si and Al from the clay lattices. *Ferralitization* or *desilication* is hydrolysis in an advanced stage. A combination of slow release and subsequent leaching of cations and silica keeps the concentration in the soil solution low. If the soil temperature is high and percolation is intense, ultimately all weatherable primary minerals will be removed from the soil mass. Less soluble compounds such as iron and aluminum oxides and hydroxides, as well as coarse quartz grains, remain behind (Driessen & Dudal, 1989; Mohr *et al.*, 1972). A low pH, low concentrations of dissolved weathering products in the soil solution (low EC - values) and geomorphic stability over prolonged periods of time are conditions which accelerate the process of ferralitization (Driessen & Dudal, 1989). All these conditions are present in the TCP area. Due to the presence of gneiss (acid rock) with few easily weatherable minerals and much quartz, ferralitization proceeds much slower. Although much silica disappears through leaching (desilication), silica contents remain higher than in soils formed on basic material. This silica combines with aluminum to the 1:1 clay mineral kaolinite, which is called the *kaolinitization* process. Gibbsite is normally absent. It is however, formed under freely drained conditions and from richer rocks. The dominant minerals in the soils in the TCP research area are kaolinite, goethite (FEO(OH)) and gibbsite ($Al(OH)_3$). The colour of the soils, orange to yellowish brown, is determined mainly by the presence of goethite (section 5.4.5.). Hematite (Fe_2O_3), which gives the soil a bright-red colour, is not observed in the TCP research area.

Plinthite is an iron-rich, humus-poor mixture of clay and quartz. It is formed by the (relative and/or absolute) accumulation of sesquioxides (i.e. removal of silica and bases by ferralitization and/or enrichment from outside) and the segregation of iron mottles (alternating reduction and oxidation). In the TCP research area plinthite is regularly found on the lower slopes between 40 and 500 meters altitude (uplands and dissected erosional plains). Within the Ebimimbang soils, a subtype can be distinguished with plinthite in the upper 125 cm. *Laterite formation* is the hardening of plinthite to laterite. The main processes are the crystallization of amorphous iron compounds to aggregates of iron oxide minerals and the dehydration of goethite to hematite and of gibbsite to boehmite (Aleva, 1994; Driessen & Dudal, 1989). Laterite gravels are present in limited amounts in the TCP research area. The laterite gravels are remnants of old eroded surfaces. Ferruginated rock fragments are more common.

Clay eluviation/illuviation is the redistribution of clay in the profile, resulting in an increase in clay content with depth. Mobilized clay is transported downward and deeper in the profile where it is immobilized (Driessen & Dudal, 1989). Cutans of clay on the structural elements in the subsoil are evidence for recent illuviation. Biological activity may destruct these clay cutans. These cutans are mainly found in the Ebimimbang soils in the western lowlands in the TCP research area (40-350 m asl). All soils in the TCP research area have a clay increase with depth, but cutans are rarely found in the eastern part. Clay movement is probably related to the past when the soil was still less weathered and soil pH was somewhat higher than at present (van Kekem *et al.,* 1997).

In the *oxidation* phase, the presence of oxygen leads to the transformation of soluble ferrous compounds to ferric compounds. These precipitate on soil particles, giving the soil its reddish colour. The reverse occurs during the *reduction* phase. The lack of oxygen causes dissolution of ferric compounds, giving the soil the colour of non-ferrous minerals, forming its matrix (grey, olive or blue matrix colours). This soil forming process of oxidation-reduction is associated with the fluctuation of the groundwater table. In the zone with alternating oxidizing and reducing conditions, mottles are often formed (Driessen & Dudal, 1989). This soil forming process is important in the Valley Bottom soils.

6 VEGETATION

6.1 LITERATURE REVIEW

Flora and vegetation of Cameroon are relatively well known. The most relevant studies for the present vegetation inventory are Letouzey's `Étude Phytogéographique du Cameroun' (1968) and his `Carte Phytogéographique du Cameroun au 1 : 500 000' (1985).

The TCP research area is part of the Guineo-Congolian domain of dense humid evergreen forests (see 2.7) and for the greater part belongs to the Biafran Atlantic district (low and medium altitude). Only along the fringes elements of the low and medium altitude Littoral Atlantic district may be found. Individual small summit areas belong to the submontane zone of the Guineo-Congolian domain (Letouzey, 1968, 1985).

In Table 6.1, the original french denominations of the districts are presented, together with the in the TCP area represented formations. In Figure 6.1 the area relevant to the present survey of Letouzey's (1985) phytogeographical map is reproduced. In the following a brief description of the different vegetational zones is given.

Table 6.1 Forest types of the TCP research area and its surrounding; 1 : 500,000 phytogeographical map (Letouzey, 1985)

Région Guinéo-Congolaise
Étage submontagnard (800-2 200 m)
- Forêts submontagnardes 800-2 200 m (n° 117)
Étage de basse et moyenne altitude (0 - 800 m)
District atlantique biafréen
- Forêts atlantiques biafréennes à *Caesalpiniaceae* (n° 228)
- Forêts atlantiques biafréennes à *Caesalpiniaceae* encore abondantes, avec *Saccoglottis gabonensis* et autres indices littoraux (n° 231)
- Forêts mixtes, toujours vertes atlantiques et semi-caducifoliées, avec prédominance d'éléments de forêts toujours vertes atlantiques (n° 233)
- Faciès de dégradation prononcée des forêts toujours vertes (n° 234 = n° 251)
District atlantique littoral
- Forêts atlantiques littorales à *Caesalpiniaceae* relativement rares, avec *Saccoglottis gabonensis* (n° 247)
- Faciès de dégradation prononcée des forêts toujours vertes (n° 251 = n° 234)

The majority of the TCP research area lies within the Atlantic Biafran forests zone rich in *Caesalpiniaceae* (n° 228 in Letouzey, 1985). The vegetation can be characterized as evergreen tropical moist forest with many species of the *Caesalpiniaceae* family. Of the total of 130-140 species of shrubs and trees of this family recorded in Cameroon, more than half appear to be concentrated in the Biafran Atlantic forests. Many *Caesalpiniaceae* species are gregariously distributed. The range in altitude of this forest type is (100) 200-500 m asl.

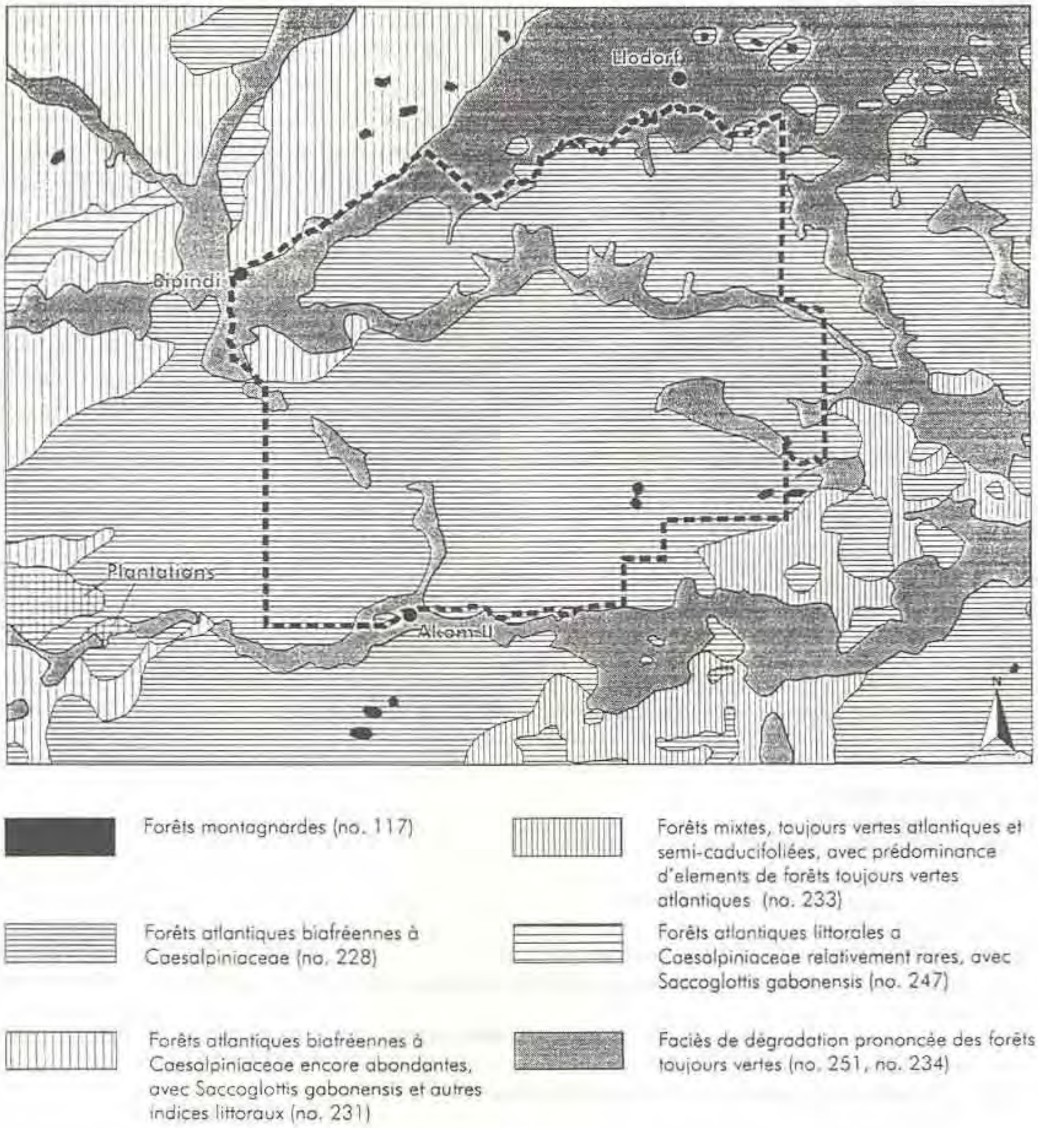

Figure 6.1 Phytogeographical map of the TCP research area and its direct surroundings (after Letouzey, 1985)

To the west, and including the most western tip of the TCP research area near the village of Ebimimbang, Atlantic Biafran forest with *Caesalpiniaceae* and *Saccoglottis gabonensis* (n° 231) is found. Other characteristic 'littoral' species found in this forest type are *Cynometra hankei*, *Coula edulis*, *Glossocalyx brevipes* and *Scyphocephalium mannii.* This forest predominantly occupies valleys with altitudes between 20 and 200 m asl.

In the west the Atlantic littoral forest zone (n° 247) intermingles with the Biafran Atlantic forest zone (n° 231). A fringe of the littoral forests can be found just north of the TCP area, near the village of Bipindi. The importance of the *Caesalpiniaceae* family is greatly reduced as compared to the forests directly to the East and many of the littoral species mentioned above occur. In general, forests of this type cover on altitudes between 50 and 80 m asl.

The summit areas of the mountain range in the southeastern part of the TCP research area belong to the Guineo-Congolian domain of submontane forest (n° 117). The altitude surpasses 800 m asl and the vegetation resembles `cloud forests' with many epiphytes and a canopy that reaches only 20-30 m. Another striking characteristic is the near complete absence of members of the *Caesalpiniaceae* family, apart from typical mountain species like *Monopetalanthus* spp., *Plagiosiphon* sp., *Hymenostegia* sp. and *Anthonotha* cf. *cladantha*.

Along the main access routes and in the vicinity of the larger villages strongly degraded remnants of evergreen forests (n^{os} 234 and 251) are found. In general the degraded vegetation is characterized by the absence of a tree layer, except for a few residual forest trees, and the abundance of pioneer species such as *Haumania danckelmanniana*, *Harungana madagascariensis*, *Megaphrynium macrostachyum*, *Xylopia aethiopica*, and *Musanga cecropioides*. According to Letouzey's map, the degraded areas are not differentiated by phytogeographical zone, i.e. littoral Atlantic district and Biafran Atlantic district.

6.2 BOTANICAL DIVERSITY

A total surface of approximately 20 ha was inventoried during the present vegetation survey. A total of 490 taxa have been identified to the species level, be longing to 76 families. The most species rich families are: Euphorbiaceae (47 species), Caesalpiniaceae (43 species), Rubiaceae (29 species) and Annonaceae (18 species). All identified species are listed in Annex Va.

Identification in the field proved to distinguish some 530 `species', including several (small) groups of botanical species. The basis for the vegetation classification is the field identification.

The number of plant species encountered will surely increase with time when collecting is continued and the skill of the collectors grows. It is therefore difficult to indicate the plant diversity of the TCP area on the basis of these results. A large and species rich area like ours, needs intensive collection to properly reveal species number, rarity and endemics. The second phase of the Lu1 project will give some indications in this respect, while the forthcoming Ecol1 project is will be properly equipped to address the question of plant diversity.

6.3 Vegetation classification

The vegetation of the TCP research area can be divided into seven distinct plant communities. Information gathered during the reconnaissance vegetation survey clearly indicates that within each of the plant communities two or three variants can be distinguished.

A dendrogram representing the hierarchical vegetation classification is presented in Figure 6.2. The hierarchy is based on similarities in species composition as given by the TWINSPAN analysis. A division at a high level coincides with major differences in floristic composition. A division at a lower level coincides with more subtle differences in species composition.

Not surprisingly, a distinction is made on the highest level between the floristic composition of forest and shrub land. Of more interest is the distinction at the second level between the forest at low altitudes and those on high altitudes. The flora of mountain forests (> 700 m above sea level) proves to deviate strongly from that of lowland forests, apparently regardless of soil type and former disturbances. In Table 6.2 an overview of the vegetation types is presented. Each community is named after a characteristic combination of occurring genera.

Table 6.2 Vegetation types of the TCP research area

	Denominations	Interpretation
I.	*Maranthes-Anisophyllea* community group	Submontane primary and old secondary forest; altitude > 700 m asl; well drained soils
II.	*Polyalthia* community group	Primary and old secondary lowland forest; altitude < 700 m asl;
IIa.	*Podococcus - Polyalthia* community	- : altitude 500 - 700 m asl; well drained soils
IIb.	*Strombosia - Polyalthia* community	- : altitude 350 - 500 m asl; well drained soils
IIc.	*Diospyros - Polyalthia* community	- : altitude < 350 m asl; moderately well drained soils
III.	*Carapa-Mitragyna* community group	Swamp forest; most common on low altitudes; valley bottoms
IV.	*Xylopia-Musanga* community	Young secondary forest; throughout area but most common on low altitudes
V.	*Macaranga-Chromolaena* community	Thicket on recently abandoned fields and Cacao plantations; throughout the area but most common on low altitudes

Additional sampling is required in order to describe the various variants of each plant community in more detail. In the second phase of the Lu1 project four representative sample areas are inventoried at a 1:20,000 scale. The present document describes the vegetation on the level of plant communities only.

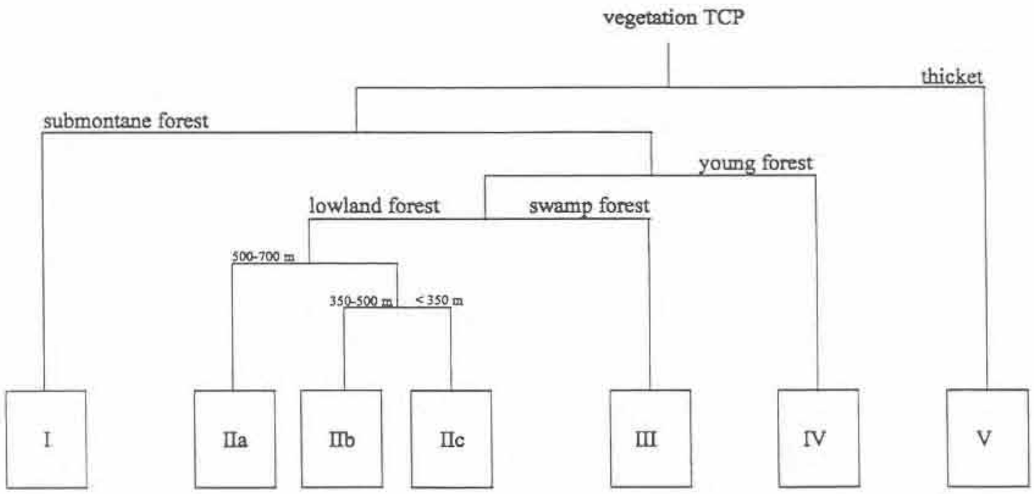

Figure 6.2 Hierarchy of the TCP vegetation classification. I = *Maranthes-Anisophyllea* community (n=11 relevés); IIa = *Podococcus-Polyalthia* (n=13); IIb = *Strombosia-Polyalthia* (n=23); IIc = *Diospyros-Polyalthia* (n=21); III = *Carapa-Mitragyna* (n=12); IV = *Xylopia-Musanga* (n=16) and V = *Macaranga-Chromolaena* (n = 18).

Each community is defined by its species composition. For practical reasons the occurring species are clustered in 'sociological groups'. The species within a sociological group have a similar distribution over the plant communities. Therefore, they are supposed to have, within the boundaries of the TCP area, similar ecological requirements and thus indicative value. A total of 20 sociological species groups have been identified for the TCP research area. The composition boundaries of the TCP area, similar ecological requirements and thus indicative value. A total of 20 sociological species groups have been identified for the TCP research area. The composition of these groups is presented in Annex Vb. Table 6.3 is a concise `summary table' presenting the most important differentiating species for the vegetation of the TCP research area.

Table 6.3 Concise summary table of plant communities in the TCP research area listing the most important differentiating species, clustered in `sociological species groups'

Plant communities **Differentiating species:**	I Maranthes - Anisophyllea community	IIa Podococcus - Polyalthia community	IIb Strombosia - Polyalthia community	IIc Diospyros - Polyalthia community	III Carapa - Mitragyna community	IV Xylopia-Musanga community	V Macaranga-Chromolaena community
Drypetes `group 1'	V	II	I	+	+	.	.
Anisophyllea polyneura	V	II	II	r	.	+	+
Maranthes glabra	IV	.	.	.	.	.	.
Scorodophloeus zenkeri	IV	II	+	+	.	+	+
Monop. `group 1'	IV	III	II	I	II	+	.
Raphia `species 1'	IV	IV	+	+	.	.	.
Geophila `species 1'	II	II	.	r	.	+	.
Hymenostegia afzelii	.	IV	I	r	.	.	.
Podococcus barteri	+	III	I	+	I	I	.
Crotonogyne preussii	+	II	.	r	.	.	.
Treculia obovoidea	V	III	V	.	+	I	+
Calpocalyx `group 1'	II	I	I	r	.	.	.
Ptychop. petiolatum	III	IV	III	III	+	II	I
Sorindeia `species 1'	II	II	II	II	.	+	.
Polyalthia suaveolens	I	IV	IV	IV	II	I	.
Grossera `group 1'	II	IV	IV	IV	I	III	+
Scaphopetalum blackii	II	IV	IV	III	II	+	I
Plagiostyles africana	II	IV	IV	IV	III	I	+
Dialium `group 1'	II	III	IV	IV	.	II	+
Diospyros bipindensis	.	II	II	II	.	+	.
Carpolobia `group 1'	+	II	II	+	.	+	I
Erythrop. ivorense	.	II	III	+	.	+	.
Grewia coriacea	+	.	II	r	+	I	.
Saccoglottis gabonensis	.	.	I	r	+	+	.
Calpocalyx dinklagei	.	I	III	III	I	I	+
Rinorea kamerunensis	II	I	III	IV	+	I	.
Diospyros suaveolens	+	II	I	IV	III	I	+
Dracaena `group 1'	+	+	.	II	I	.	.
Picralina nitida	.	+	I	II	.	.	.
Strombosia pustulata	I	II	IV	III	II	.	.
Halopegia `group 1'	III	IV	IV	III	IV	.	.
Santiria trimera	III	III	III	II	II	+	.
Calamus deërratus	III	IV	IV	III	III	III	.
Palisota mannii	III	IV	IV	II	IV	II	.
Strombosia `group 1'	III	IV	II	III	III	II	.
Scaphopetalum thonneri	II	IV	III	II	II	I	.
Uapaca guineensis	III	IV	III	II	III	II	II

Plant communities Differentiating species:	I Maranthes - Anisophyllea community	IIa Podococcus - Polyalthia community	IIb Strombosia - Polyalthia community	IIc Diospyros - Polyalthia community	III Carapa - Mitragyna community	IV Xylopia-Musanga community	V Macaranga-Chromolaena community
Coelocaryon preussii	III	III	IV	V	V	IV	II
Haumania danckelm.	I	IV	IV	V	III	V	III
Pycnanthus angolensis	I	IV	II	IV	III	IV	III
Cercestis ivorensis	+	II	II	III	III	III	I
Lophira alata	.	I	II	II	II	II	III
Leea guineensis	+	.	.	.	II	I	II
Elaeis guineensis	.	.	.	+	III	II	III
Mitragyna stipulosa							
Carapa `species 1'	.	.	.	.	III	.	.
Trichillia heudelotii	.	+	I	+	III	I	I
Xylopia `group 1'	I	+	II	I	II	IV	II
Fagara macrophylla	+	II	II	I	II	IV	III
Thaumantoc. `group 1'	.	.	I	I	I	IV	II
Eribroma `group 1'	.	+	.	III	+	II	III
Terminalia superba	.	.	.	II	+	II	I
Myrianthus arboreus	.	.	r	II	.	II	I
Musanga cecropioides	+	+	.	r	II	IV	IV
Funtumia elastica	.	I	r	r	.	III	III
Rauvolfia macrophylla	.	.	.	r	+	II	II
Macaranga `group 1'	.	.	.	.	.	II	IV
Chromolaena odorata	.	.	.	.	.	+	IV
Milicia excelsa	.	.	.	r	.	.	III
Rauvolfia vomitoria	.	.	.	.	.	I	III
Ceiba pentandra	.	+	.	r	.	+	III
Trifolium `species 1'	.	.	.	.	.	.	(III)
Anchom. `species 1'	.	.	.	.	.	+	III
Manihot esculenta	.	.	.	.	.	+	(III)

Frequency classes: . = absent; r = occurring once; + = present in 1-9% of the relevés; I = 10-19%; II = 20-39%; III = 40-59%; IV = 60-79% and V = 80-100% () = cultivated.

6.4 PLANT COMMUNITIES

In this section the floristic composition, the physiognomy and the distribution of the seven plant communities are described. A tentative comparison with the vegetation types described by Letouzey (1968, 1985) and UNESCO (1981), and an ecological interpretation is included.

6.4.1 Maranthes - Anisophyllea community (I)

The *Maranthes-Anisophyllea* community includes submontane primary and old secondary forests; its distribution within the TCP research area is restricted to hill and mountain tops surpassing 700 m asl. Differentiating species of this community are *Drypetes* `group 1', *Anisophyllea polyneura, Maranthes glabra*, *Scorodophloeus zenkeri, Gambeya* `group 1' *Cola attiensis*, *Garcinia lucida* and *Diospyros hoyleana*.

In general, the physiognomy of this forest is characterized by the absence of emergents. Three structural layers can be distinguished. The tree layer forms an irregular canopy at a height of 15-20 m, occasionally reaching 35 m, with an external foliage cover of 70-80 %. The canopy is often climber infested and the presence of epiphytic mosses is characteristic. The broad-leaved trees, probable both evergreen and deciduous, are branched at low heights and may have a crooked form. Stilt roots are common. *Scorodophloeus zenkeri, Carapa `group 1', Monopethalanthus spp., Uapaca guineensis, Santira trimera, Allanblackia kisonghi, Anisophyllea polyneura, Baphia lepitobotryx, Coelycaryon preussi, Maranthes glabra* and *Tetraberlinia bifoliata* are relatively common in the canopy. In some localities palms (*Raphia* `species 1') are present. The shrub layer (3-7 m), sometimes replacing the tree layer as canopy, varies from closed to very open. The shrub layer is mainly composed of saplings of forest trees. Only a few shrub species are present. Climbers such as *Haumania danckelmanniana* and *Ancistrophyllium secundiflorum* are frequently found. *Treculia obovoides, Scorodophloeus zenkeri, Baphia lepitobotryx, Garcinia lucida, Garcinia mannii, Mammea africana* and *Drypetes `group 1'.* are the most common species of the shrub layer. The herb layer is closed and may reach a height of one meter. This layer is dominated either by seedlings of forest trees or by herbs. *Diospyros hoyleana, Scaphopetalum thonneri, Halopegia spp, Mapania amplivaginata* and *Palisotha mannii* are frequently found.

The forests of this type appear to be highly dynamic. Many traces of uprooted and broken trees are found. The gaps thus created are often infested by climbers that may reach down to the herb layer. Pioneer species like *Musanga cecropioides* are found in the larger gaps. Possible explanations for the dynamic nature of this vegetation are exposure to wind and instable steep slopes, often with rock outcrops.

The submontane forest of the *Maranthes - Anisophyllea* community covers major parts of the Bingalanda mountain range in the southeastern part of the TCP area. The predominating landforms are mountains and isolated hills. The soils of these areas belong to the Nyangong type, i.e. very clayey soils with 40 to 80% clay in the B horizon.

The structure of this forest type resembles `cloud forests'. As the elevation surpasses the average height of the cloud layer, the vegetation is regularly engulfed in mist and drizzle (Hommel, 1985). A characteristic growth form of such forests is beard moss. In the UNESCO classification of vegetation (1981), this vegetation can be typified as Tropical ombrophilous submontane forest.

The distribution of this community coincides with the forest types n° 117, n° 233 and partly with n° 228 of the phytogeographic map of Letouzey (1985, see Figure 6.1). Structurally, it resembles Letouzey's *Forêts submontagnardes* (n° 117) although species composition is distinctly different. Quite a number of species characteristic for the *Maranthes - Anisophyllea* community are typical for Letouzey's Semi-deciduous forest with *Sterculiaceae* and *Ulmaceae* (n^{os} 160 and 161). Also many representatives of the Atlantic Biafran forest with *Caesalpiniaceae* (n° 228) are found. The *Maranthes - Anisophyllea* community apparently is a transitional vegetation between the moist Atlantic forest zone and the drier Guineo-Congolian semi-deciduous forest zone.

Mbatchou (1995) studied the vegetation of the proposed Etinde Rainforest reserve on the slopes of Mt Cameroon (4095 m asl) in the South-West Province of Cameroon. The submontane forest described by Mbatchou is divided in closed canopy submontane forest, discontinuous canopy submontane forest and submontane scrub. It is found between 800 and 1,700 m asl.. The submontane forests appears to be the transition between the lowland forest and the lower montane forest, and the species composition is a mixture of Guineo-Congolian and afromontane species. In structure and floristic composition, the *Maranthes-Anisophyllea* community resembles the closed canopy submontane forest of Mount Cameroon, although it is found in the TCP research area at much lower altitudes. The `telescope-effect', i.e. the vegetation of the highest summits in a given area more or less imitates the physiognomy and species composition of forest types generally bound to far higher altitudes elsewhere (Hommel, 1987), could possibly be an explanation for the difference in altitude range.

6.4.2 Podococcus - Polyalthia community (IIa)

The *Podococcus - Polyalthia* community is a primary and old secondary lowland forest type; it is found at altitudes between 500 and 700 m asl. Differentiating species are *Hymenostegia afzeilii*, *Podococcus barteri*, *Crotonogyne preussii*, *Tabernaemontana* `species 1', *Culcasia dinklagei*, *Duboscia macrocarpa* and *Petersianthus africana*.

At least four principal strata characterize the physiognomy of the *Podococcus - Polyalthia* community, although their boundaries are often difficult to establish. Large trees, often surpassing 55 meters in height, form the open (20 -30% cover) emergent layer. *Klainedoxa microphylla* and *Monopethalanthus spp.* frequently dominate this stratum. The tree layer forms a canopy at 25 to 40 meters. The external foliage coverage is 60-80 %. Large trees are the most common growth form and lianas appear to be restricted to the canopy and larger gaps. In general the trees have a smooth bark and only few have buttresses surpassing one meter in height. The most common species are *Pycnanthus angolensis, Uapaca guineensis, Strombosia* `group 1', *Dichostemma glaucescens, Plagiostyles africana, Santira trimera, Alstonia congensis, Hymenostegia afzeilii, Desbordensia glaucescens and Scyphocephalium mannii*. The shrub layer is relatively open, covering 40-60% and between two and ten meters high. Shrubs and saplings of forest trees are most common. Palms (*Raphia `species 1'* and *Podococcus barteri*) are frequently present but never dominate. Frequently found species of the shrub layer are *Ptycopetalum petiolanum, Polyalthia suaveolens, Scaphopetalum thonneri, Scaphopetalum blackii, Plagiostyles africana, Voacanga* `group 1'*, Dialium* `group 1'*, Coffea* `group 1' and *Grossera* `group 1'. The herb layer is relatively open, covering 40-50%, and often low. Broad leaved herbs, seedlings of trees, palms and lianas are the major components. Frequently occurring species include *Haumania danckelmannia, Palisota mannii, Halopegia* `group 1'*, Calamus deëratus, Scaphopetalum thonneri, Rektophyllium* `group 1'*, Cercestis ivorensis, Trachyprhrynium braunianum* and *Podococcus barteri*.

The *Podococcus - Polyalthia* community is found at altitudes between 500 and 700 m asl. It is found mainly in the southeastern zone of the TCP research area covering the slopes of the Bingalanda mountain range. The soils are mostly of the Nyangong type, i.e. very clayey soils with 40 to 80% clay in the B horizon. Land forms encountered are, in descending order of importance: hilly uplands, complexes of hills, rolling uplands and isolated hills.

According to the UNESCO classification (1981) this community is a Tropical ombrophilous lowland forest. The distribution of *Podococcus - Polyalthia* community in the TCP area coincides with the eastern part of Letouzey's Atlantic Biafran forest with *Caesalpiniaceae* (N° 228) of which the physiognomy and species composition indeed resemble the *Podococcus - Polyalthia* community.

6.4.3 Strombosia - Polyalthia community (IIb)

The primary and old secondary lowland forest of the *Strombosia - Polyalthia* community is found between 350 and 500 m asl. On the basis of the present vegetation survey only two (weakly) differentiating species have been identified, i.e. *Grewia coriacea* and *Saccoglottis gabonensis*. The community is intermediate in both altitude and floristic composition between the two other primary to old secondary lowland forest communities: the *Podococcus - Polyalthia* community (IIa) and the *Diospyros - Polyalthia* community (IIc).

The physiognomy of the *Strombosia - Polyalthia* community is similar to that of the *Podococcus - Polyalthia* community. The complex structure of the forest has four principal strata, including an emergent layer, a tree layer, a shrub layer and a herb layer. The height of the different strata varies and the boundaries are often difficult to establish. The emergent layer is open (external foliage cover < 20%) and reaches a height of 45-55 meters. The floristic composition is heterogeneous although *Erythrophleum ivorensis* appears to be the most common species. The external foliage cover of the tree layer is generally 60 - 70 %. The tree layer is found at the height of 25 to 35 meters. Broad-leaved evergreen trees are the dominant growth form Lianas are relatively rare and no palms have been observed. The most common species are *Plagiostyles africana, Coula edulis, Staudtia kamerunensis, Treculia obovoides, Coelecaryon preussii, Polyalthia suaveolens, Strombosia pistulata* and *Erythrophleum ivorensis*. The shrub layer is dense (70-80%) and variable in height. In general it reaches from three to eight meters. It consists mainly of saplings of trees and shrubs. Lianas are scarce. The floristic composition of the shrub layer is heterogenous. The most frequently observed species are *Treculia obovoides, Scaphopetaleum blackii, Ptycopetalum petiolanum, Carapa* `group 1', *Dialium* `group 1', *Grossera* `group 1', *Polyalthia suaveolens, Strombosia pistulata, Coelocaryon preussii, Staudtia kamerunensis* and *Calpocalyx dinklagei*. The herb layer is relatively open (40%) and is in general 0.4 to 0.7 meters high. Broad leaved herbs (e.g. *Rektophyllium* `group 1', *Palisota mannii, Halopegia* `group 1', *Cercestis ivorensis, Stylochiton zenkeri*), seedlings of shrubs and trees (e.g. *Pentaclethra macrophylla, Treculia obovoides, Dialium* `group 1', *Scaphopetaleum blackii, Scaphopetalum thonneri*) and thorny lianas (e.g. *Calamus deëratus, Haumannia danckelmanniana*) are the most important components.

The *Strombosia - Polyalthia* community is found in the central part of the TCP area forming a band of 10 to 15 km wide with a general southwest to northeast direction. The altitude range is 350 to 500 m asl. Rolling and hilly uplands are the most important land forms in this zone. The soils are classified as `Ebom', i.e. clayey soils with 30 to 60% clay in the B horizon.

According to the UNESCO classification (1981) this community is a tropical ombrophilous lowland forest. The distribution of the *Strombosia - Polyalthia* community is strictly confined to Letouzey's Atlantic Biafran forest with *Caesalpiniaceae* (n^{o} 228, 1985, see Figure 6.1). Letouzey's description of the physiognomy and floristic composition of the Atlantic Biafran forest with *Caesalpiniaceae* corresponds with the *Strombosia - Polyalthia* community.

6.4.4 Diospyros - Polyalthia community (IIc)

The *Diospyros - Polyalthia* community is a primary to old secondary forest of altitudes below 350 m asl. Differentiating species of this community are *Diospyros suaveolens*, *Draceana* `group 1' and *Picralima nitida*.

The physiognomy of the vegetation again is very similar to the structure of the other two communities of the *Polyalthia* community group. The forest structure is characterized by four principal strata. The emergent stratum is very irregular and its coverage varies between 0 and 30%. The average height of this layer is 45 meters. Among the most common species are *Desbordensia glaucescens, Klainendoxa gabonensis* and *Distamonanthus benthamianus*. The tree layer is dense (70-80%) and is, in general, 20 to 35 meters in height. Trees are the sole important growth form in the canopy, except for the numerous gaps which are infested with thorny lianas. The most frequently occurring species of the tree layer are *Plagiostyles africana, Coelocaryon preussii, Staudtia kamerunensis, Pycnanthus angolensis, Desbordensia glaucescens, Eribroma* `group 1', *Hylodendron* `group 1' and *Distamonanthus benthamianus*. The shrub layer is relatively open where the canopy is closed, but can be very dense in the vicinity of gaps. Its height is variable but generally ranges from three to eight meters. Shrubs, small trees and saplings are the most important components. The most common species are *Rinorea kamerunensis, Diospyros suaveolens, Calpocalyx dinklagei, Scaphopetaleum blackii, Anthonotha macrophylla, Grossera* `group 1', *Ptycopetaleum petiolanum, Polyalthia suaveolens* and *Tabernaemontana crassa*. The herb layer is relatively open (40%), again with the exception of gaps where it is very dense. The average height is 0.5 meters and it consists of broad leaved herbs, lianas, ferns, grasses and tree seedlings. Most common species in the herb layer are *Haumannia danckelmanniana, Rektophyllium* `group 1', *Gauduella spp., Cercestis ivorensis, Stylochiton zenkeri* and *Palisota ambigua*.

The *Diospyros - Polyalthia* community is found at low altitudes (< 350 m asl) in the northwest of the TCP area. The most important land forms are dissected plains, rolling uplands and hilly uplands. The soils in these regions are classified as `Ebimimbang' type, i.e. moderately well drained soils with sandy top soils and less than 40% clay in the sub soil.
The dissected plains in the northwest are relatively intensively used for shifting cultivation practices. Moreover, the area has been repeatedly logged. As a result the vegetation in this area is a mosaic of agricultural fields and more or less secondary forest and only small patches of relatively undisturbed forest of the *Diospyros - Polyalthia* community.

According to the UNESCO classification (1981) this community is a tropical ombrophilous lowland forest. The distribution of the *Diospyros - Polyalthia* community within the TCP area includes the area designated by Letouzey (1985, see Figure 6.1) for the Biafran Atlantic forest rich in *Caesalpiniaceae* (n° 228) and Biafran Atlantic forest with *Caesalpiniaceae* still abundant (n° 231). Although the physiognomy is similar, the species composition of the tree and shrub layer of the *Diospyros - Polyalthia* community is quite different from the two Letouzey types. In fact, none of the Letouzey forest types is similar to this community neither in physiognomy nor in species composition. A possible explanation could be that the floristic composition of the forest has changed quite recently due to repetitive logging operations, while Letouzey bases his classification on more or less primary vegetation.

6.4.5 Carapa - Mitragyna community (III)

The *Carapa - Mitragyna* community is a swamp forest. Differentiating species for this community are *Mitragyna stipulosa*, *Carapa* `species 1', *Trichillia heudelotii*, *Diospyros preussii Cyathea* `species 1' and *Curcuma longa*.

The *Carapa - Mitragyna* community has three principal structural layers. The tree layer forms an open (60% cover) canopy at 35-40 m. Lianas like *Ancistrophrynium secundiflorum*, *Haumania danckelmaniana* and *Calamus deëratus* are abundant. The trees are often stilt rooted, crooked and branching at low heights. Mosses and epiphytes are found all along the stems. Common species of the tree layer are *Coelycaryon preussi*, *Mitragyna stipulosa*, *Strombosia* `group 1', *Uapaca guineensis,* *Uapaca venhussii, Carapa* `species 1' (`engang osoé') and *Raphia* `species 2'. The shrub layer (2-7 m) is often open and is composed of saplings, lianas, palms, shrubs and tree ferns. *Anthonotha macrophylla, Elaeis guineensis, Carapa* `species 1', *Diospyros preussii, Trichillia heudelotii* and *Raphia* `species 2' are the most common species. In some localities the abundance of *Draceana* spp. is remarkable. The distribution of herbaceous plants is very irregular. Very dense patches alternate with stretches with virtually no terrestrial plants. *Palisotha mannii*, *Halopegia azurea* and *Sarcophrynium prionogonium* grow gregariously and often dominate the herb layer. Other frequently occurring species are *Curcuma longa, Stylochiton zenkeri, Draceana phrynioides* and *Rektophylium mirabiles*.

The community is found in valley bottoms and along creeks and rivers throughout the TCP research area. It covers fair surfaces of the dissected plains of the western part of the study area. Forests of the *Carapa - Mitragyna* community are found between 40-700 m asl. The vegetation is restricted to the soil type `valley bottoms', which are poorly to imperfectly drained soils which tend to be shallow and having a thin organic layer.

The vegetation of this community group are broad-leaved tropical ombrophilous swamp forests and broad-leaved tropical ombrophilous alluvial forests (UNESCO, 1981). Due to the small scale of Letouzey's phytogeographic map, i.e. 1 : 500 000, the small areas covered by swamp vegetation have not been accounted for individually. They appear as complexes with the surrounding forest types.

6.4.6 Xylopia - Musanga community (IV)

The *Xylopia - Musanga* community is a young secondary forest. Differentiating species of this community are *Xylopia* `group 1', *Fagara macrophylla*, *Palisota ambigua*, *Thaumantococcus* `group 1', *Megaphrynium secundiflorum* and *Ancistrophyllum* `group 1'.

In general, the vegetation consists of three distinct strata: tree, shrub and herb layer. Often relics of the undisturbed forest are presents. In general the external foliage cover of these emergents is less than ten percent. The tree layer is open (40-50%) and is only 15-25 m high. Dominant growth forms are evergreen broad-leaved trees and palms. The most common species are *Musanga cecropioides*, *Pycnanthus angolensis, Coelocaryum preussii, Funtumia elastica, Xylopia* `group 1'*, Tabernaemontana crassa*, *Rauvolfia macrophylla* and *Ricinodendron heudelotti*. Other frequently occurring species are *Fagara macrophylla, Vitex grandifolia* and *Macaranga* `group 1'. The shrub layer is 2-7 m high and often merges into the tree layer. It is closed and infested with thorny lianas such as *Ancistrophrynium secundiflorum* and *Haumania danckelmanniana*. The trees in this layer often have thorns, e.g. *Fagara macrophylla*. Stilt roots are abundant. *Xylopia* `group 1'*, Alchornea floribunda, Anthonotha macrophylla, Megaphrynium secundiflorum* and *Ouratea flava* are the most common species. The herb layer is rather open and has an average height of 50 cm. Broad-leaved herbs tend to dominate. Characteristic species are *Stylochiton zenkeri*, *Thaumantococcus* `group 1'*, Haumannia danckelmanniana, Palisotha ambigua*, *Rektophylium* `group 1' and *Stipularia africana*.

This community is the typical fallow vegetation in shifting cultivation areas and is found near villages and along the main access roads, throughout the TCP area. To a lesser extent it is found in logged-over forests. It is induced by human activity and appears to be rather insensitive to soil and landform variation. The *Xylopia - Musanga* community forms a transitional stage between the *Macaranga - Chromolaena* community (V) and old secondary forest types (IIa, IIb, IIc and III; all p.p.). It develops some five years after fallow. The vegetation can be typified as evergreen broad-leaved woodland in the UNESCO classification of vegetation (UNESCO, 1981). The distribution of the *Xylopia - Musanga* community within the TCP research area coincides with Letouzey's type n^o 251, i.e. remnants of strongly degraded evergreen forests. Physiognomy and species composition is also comparable although some elements of Letouzey's `strongly degraded remnants of semi-deciduous forest' (type n^o 169) are also present.

6.4.7 Macaranga - Chromolaena community (V)

The *Macaranga - Chromolaena* community forms thickets on recently abandoned fields and in cacao plantations. The differentiating species of this community are *Macaranga* `group 1', *Chromolaena odorata*, *Albyzia zygia*, *Costus violaceus*, *Milicia excelsa*, *Rauvolfia vomitoria* and *Ceiba pentandra*. In addition, some cultivated species are still present, e.g. *Trifolium* `species 1' (groundnut), *Manihot esculenta* (cassava), *Colocasia* `species 1' (coco-yam) and *Musa* `species 1' (plantain).

In the shrub like vegetation of the *Macaranga - Chromolaena* community three (sometimes only two) structural layers can be discerned. The tree layer is very open (20-40%) and is very low (8-15 m). The canopy is formed by trees and palms. The most frequent species are, in descending order, *Musanga cecropioides*, *Albyzia zygia, Pycnanthus angolensis, Antocleista vogelii* and *Elaeis guineensis*. The most characteristic feature of the vegetation of this community is the very dense and high shrub layer (up to five meters) in which broad-leaved robust herbs are by far the dominant growth form. Additionally, broad-leaved trees, palms, lianas are also present. The vegetation is literally overgrown by *Chromolaena odorata*. Other non-woody species are *Costus violaceus, Aframomum alboviolaceum, Megaphrynium secundiflorum, Thaumantococcus daniellii* and *Palisota ambigua*. Characteristic woody species of the shrub layer are *Funtumia elastica*, *Macaranga* `group 1', *Rauvolfia macrophylla*, *Eleais guienensis* and *Fagara macrophylla*. Also many residual agricultural crops are present, e.g. *Musa parodisiaca*, *Manihot esculenta*, *Colocasia* sp. and *Carica papaya*. Underneath the dense shrub layer, a very open (20%) and low herb layer (20-40 cm) can be distinguished. Here, herbs, ferns and seedlings form the majority of the plant life encountered. Often *Trifolium* sp. is abundant.

The *Macaranga - Chromolaena* community is found in the vicinity of villages and roads and is strongly related to recent agricultural activities. It is most common on the dissected plains in the western part of the TCP area, and in the surroundings of Akom II. It does not occur (yet) at altitudes above 600 m asl.. The vegetation is typical for recently abandoned fields, approximately between one and five years after cultivation. Also Cacao (*Theobroma cacao*) plantations with a lush understorey of broad-leaved herbs are part of this community group. Many transitions between this community and young secondary forests (community IV) are found.

The Macaranga-Chromolaena community can be classified as an evergreen broad-leaved thicket according to the UNESCO vegetation classification (1981). Because of the small scale of his phytogeographic map, Letouzey (1985, see Figure 6.1) incorporates these recently abandoned agricultural fields in type n^o 251, i.e. remnants of strongly degraded evergreen forest. Physiognomy and species composition correspond closely to what he describes as `ultimate degraded remnants of evergreen and semi-deciduous forest' (type n^o 170).

7 LANDSCAPE ECOLOGICAL MAP

7.1 LEGEND

Four altitude zones, seven different landforms, four main soil types and seven broadly defined plant communities form the basis of the reconnaissance landscape ecological map of the TCP research area (Annex I.) The legend of the landscape ecological map is based on altitude, landform, soil and vegetation, and has a hierarchical structure. A total of 14 main land mapping units is discerned. These units are further subdivided based on vegetation characteristics, resulting in 34 mapping units. Each mapping unit is represented by a code, which is a combination of the ecological zone (A to E) and the predominant landform (v, pd, u1, u2, h1, h2 and m). The legend is presented on the landscape ecological map (Annex 1).

Five ecological zones are identified and form the highest level of division of the legend. Soil drainage and altitude are the differentiating criteria on this level. Four of the ecological zones have well to moderately well drained soils. The altitude ranges of these four ecological zones are: > 700 m asl (zone A), 500-700 m asl (zone B), 350-500 m asl (zone C) and < 350 m asl (zone D). The fifth ecological zone (zone E) comprises swamp forests on poorly to very poorly drained soils. Altitude is not differentiating for this zone. Although swamp environments are found locally throughout the study area, only those of sufficient size to be mapped individually on reconnaissance scale are considered part of this ecological zone. Small swamp areas occur as part of the vegetation and soil complexes within the zones B, C and D.

Landform has been introduced at the second level of the legend. Seven landforms are discerned: valley bottom (v), dissected erosional plain (pd), rolling upland (u1), hilly upland (u2), isolated hill (h1), complex of hills (h2) and mountain (m). Their characteristics are discussed in chapter 4.

At the third level of the legend the characteristics of soils and vegetation of each landform unit within a particular ecological zone are given. These aspects are described in the chapters 5 and 6.

7.2 LAND USE

The aerial photographs, on which the present landscape ecological map is based, were taken in 1983-1985. Recent changes in vegetation cover can therefore not be accounted for. Field observations suggest that especially dynamic forms of land use such as shifting cultivation and commercial logging have affected the vegetation to a considerable extent during the last ten years.

The natural vegetation of the above described landscape ecological units has been affected by agricultural practices. Based on the 1983-85 aerial photographs a subdivision of the land mapping units into `relatively undisturbed areas', `low intensity shifting cultivation areas' and `high intensity shifting cultivation areas' is made. The degree of disturbance in each unit determines the composition of the vegetation. Relatively undisturbed areas are characterized by the (near complete) absence of agricultural fields. These areas cover about 70% of the TCP area or 116 170 ha. Within the low intensity shifting cultivation areas actual and recently abandoned agricultural fields cover less than 20% of the unit. Young secondary vegetation accounts for another 20%.

The low intensity shifting cultivation covers about 18% or 29 800 ha. In the high intensity shifting cultivation areas actual fields and recently abandoned agricultural fields cover more than 40% Additionally, more than 20% of the unit is young secondary forest. The high intensity shifting cultivation takes up about 13% of the TCP area or 21 360 ha. Within the shifting cultivation areas patches of forest are found, both undisturbed and disturbed.

Unlike shifting cultivation activities, which are strongly concentrated in specific areas, the impact of logging on the forest vegetation could not be mapped accurately. This is primarily due to scale problems. Moreover, with time the differences between extensively logged-over forest and `virgin' forest stands become quite subtle, whereas the seven plant communities given in the legend are broadly defined. Each of the five types of relatively undisturbed forest (I, IIa, IIb, IIc and III) in fact comprise both virgin stands and various regeneration stages of old secondary forest. During the second phase of the LU1-project the distribution and floristic composition of these `variants' are studied in more detail.

7.3 LAND MAPPING UNITS

The characteristics of the fourteen main land mapping units of the landscape ecological map are presented in the following section. For more elaborate descriptions of the landforms, soil types and plant communities reference is made to the chapters 4, 5 and 6. The two table below summarize the spatial coverages of each main mapping unit.

Table 7.1a Surface areas in ha of the main land mapping units.

Main mapping	Surface area in	% of total
Ah1		
Am	10	
Bh1	3	
Bh2	13	
Bu1	5	
Bu2	19	
Ch1	4	
Cu1	31	
Cu2	25	
Dh1	3	
Dpd	11	
Du1	12	
Du2	23	
Ev	1	
Total TC	167	1

Table 7b Extent of the areas influenced by shifting cultivation

Intensity of shifting cultivation	Extent (ha)	% of total
No to hardly any (u)	116 170	69.4
Low intensity (l)	29 820	17.8
High intensity (h)	21 360	12.8

7.3.1 Am: mountains above 700 m asl, well drained soils

The Am land mapping units coincide with the Bingalanda mountain range in the eastern part of the TCP area, with altitudes between 700 and 1000 m asl. They cover a surface area of 10,000 ha. The mountainous area is strongly dissected and has steep outer slopes. Valley bottoms are narrow and cover only very limited surfaces. The soils are very clayey and belong to the Nyangong type. The predominant forest type is the submontane *Maranthes-Anisophyllea* community (I). In general, the vegetation is not affected by human activity.

7.3.2 Ah1: isolated hills above 700 m asl, well drained soils

These mapping units are found along the fringes of the Bingalanda massive in the eastern part of the TCP area where they cover some 880 ha. The altitude of the isolated hills vary from 700 to 900 m asl. Valley bottoms are not included in this unit. The soils are very clayey (Nyangong). The predominant forest type is the submontane *Maranthes - Anisophyllea* community (I). Human activities have not altered the vegetation in these units.

7.3.3 Bh2: complex of hills between 500 and 700 m asl, well drained soils

Mapping units Bh2 are complexes of hills between 500 and 700 m asl, and are found in the strongly dissected eastern part of the TCP research area. They cover large surfaces just west of the Bingalanda mountain range and have a general SW-NE orientation. In addition, Bh2 units are found in the southwestern part of the TCP research area, where they form the foothills of the mountain range that is situated west of the TCP research area. The total surface area of these mapping units is some 13,890 ha. The dominant soils are very clayey (Nyangong). Valley bottoms are narrow and cover only limited surfaces. The vegetation is predominantly primary and old secondary lowland forest of the *Podococcus-Polyalthia* community (IIa). Human activities have not altered the vegetation of these units.

7.3.4 Bh1: isolated hills between 500 and 700 m asl, well drained soils

These mapping units are found scattered as small patches in the eastern part of the TCP area. Although their total area does not cover more than 3 820 ha, the isolated hills form a characteristic aspect of the landscape. The elevation of the hills is between 500 to 700 m asl. The soils are very clayey and belong to the Nyangong type. Valley bottoms are almost completely absent. The vegetation is predominantly primary and old secondary lowland forest of the *Podococcus-Polyalthia* community (IIa). Human activities have not altered the vegetation of these units.

7.3.5 Bu2: hilly uplands between 500 and 700 m asl; well drained soils

The hilly uplands of the Bu2 units cover some 19,700 ha. They are located at the foot of the Bingalanda mountain range in the eastern part of the TCP area and in the northeastern part of the area. The uplands are strongly dissected and valley bottoms are estimated to cover between 5 and 10% of their surface. The soils are an association of very clayey Nyangong soils and the clayey Ebom ones. The predominant vegetation type of these units is the primary and old secondary lowland forest of the *Podococcus - Polyalthia* community (IIa). The valley bottoms are characterized by poorly drained soils and by the swamp forest of the *Carapa - Mitragyna* community (III).

The units are to a limited extent affected by agricultural practices. Only along the roads some low intensity encroachment is visible on the 1984-85 air photo's. In these areas, especially near the villages Nyangong and Ebemvok, the composition of the vegetation has gradually been changing into a mosaic of thicket of the *Macaranga - Chromolaena* community (V), young secondary forest of the *Xylopia - Musanga* community (IV), and lowland forest of the *Podococcus - Polyalthia* community (IIa).

7.3.6 Bu1: rolling uplands between 500 and 700 m asl; well drained soils

Rolling uplands between 500 and 700 m asl are only found in the most eastern part of the TCP area, where they cover a total surface area of 5,400 ha. The rolling uplands are moderately dissected and valley bottoms are estimated to cover 10 to 15% of these mapping units. In places, these valley bottoms are sufficiently large to be mapped individually. The soils form an association of Nyangong and Ebom types. The valley bottoms are typically poorly to very poorly drained and are occupied by swam forest of the *Carapa - Mitragyna* community (III).

The Bu1 units are affected by human activities especially near the village of Nyangong a large area with low intensity shifting cultivation area has been discerned. Primary and old secondary lowland forest of the *Podococcus-Polyalthia* (IIa) community is the predominant vegetation of the relatively undisturbed areas. The shifting cultivation areas are characterized by a vegetation mosaic that contains obviously disturbed lowland forest of the *Podococcus -Polyalthia* community, young secondary forest of the *Xylopia - Musanga* community (IV) and thicket of the *Macaranga - Chromolaena* community (V).

7.3.7 Ch1: isolated hills between 350 and 500 m asl, well drained soils

The isolated hills form a characteristic aspect of the central and northern region of the TCP area, which is mainly composed of uplands. The characteristically scattered hills cover a total surface area of 4,520 ha. Within the Ch1 units no valley bottoms are found. The soils are predominantly clayey and are classified as Ebom soils. The vegetation is primary and old secondary forest of the *Strombosia - Polyalthia* community (IIb). Human activities have not affected the vegetation of these units, most likely because of the steep slopes,

7.3.8 Cu2: hilly uplands between 350 and 500 m asl; well drained soils

These mapping units occupy considerable surface areas, i.e., 25,070 ha, in the central and northern regions of the TCP area. The general orientation of these mapping units is SW-NE. The uplands are strongly dissected and an estimated 5 to 10% of their surface are covered by valley bottoms. The soils of the higher parts are clayey (Ebom type) and those of the valley bottoms are typically poorly to very poorly drained. The vegetation of the well drained part of the Cu2 units is primary and old secondary lowland of the *Strombosia - Polyalthia* community (IIb). Swamp forest of the *Carapa - Mitragyna* community (III) covers the valley bottoms.

Shifting cultivation is restricted to the southern edge of the unit near the villages of Adjab and Akom II and to the northern parts and is generally of low intensity. The vegetation in these areas is a mosaic of obviously disturbed lowland forest of the *Strombosia - Polyalthia* community (IIb), and young secondary vegetation of the *Xylopia - Musanga community* (IV), and the *Macaranga - Chromolaena* community (V). Furthermore it is observed that most of the forest has been logged in the recent past.

7.3.9 Cu1: rolling uplands between 350 and 500 m asl; well drained soils

The rolling uplands between 350 and 500 m asl also occupy considerable surface areas, i.e. 31,270 ha, in the central and northern regions of the TCP area. With the mapping units Cu2 (hilly uplands) they form the major land mapping units of this regions. Both units have a similar SW to NE direction and are found to alternate. Some 10 to 15% of the rolling uplands are occupied by valley bottoms. The dominating soils of the slope and summit areas are clayey Ebom soils, whereas the soils of the valley bottoms are typically poorly to very poorly drained. The well drained areas are covered by primary and old secondary lowland forest of the *Strombosia - Polyalthia* community (IIb) , whereas the vegetation of the valley bottoms belongs to the *Carapa - Mitragyna* community (III).

Near villages and roads considerable parts of the Cu rolling uplands are occupied by high intensity shifting cultivation. The vegetation in these areas is characterized by patches of obviously disturbed lowland forest of the *Strombosia - Polyalthia* community (IIb) and by a mosaic of young secondary vegetation: the *Xylopia - Musanga* community (IV), and the *Macaranga - Chromolaena* community (V). According to the aerial photographs, the vegetation outside the shifting cultivation areas units is relatively undisturbed. Field observations, however, suggest that considerable parts of the forest have been exploited for timber. Due to the lack of recent remote sensing material the extent of logging could not be mapped.

7.3.10 Dh1: isolated hills below 350 m asl, moderately well drained soils

Isolated hills below 350 m asl are restricted to the western part of the TCP area, where they are sparsely scattered. They form although their a total surface area (3,310 ha), small but characteristic aspects of the landscape. Within the units no valley bottoms are found. The predominant soils are moderately well drained, have sandy topsoils and up to 40% clay in the subsoils and are classified as Ebimimbang soils in the TCP soil classification. The predominant vegetation of these units is primary and old secondary lowland forest of the *Diospyros - Polyalthia* community (IIc). The vegetation of the isolated hills with their steep slopes has not been affected by shifting cultivation practices.

7.3.11 Du2: hilly uplands below 350 m asl; moderately well drained soils

The western lowlands of the TCP area are predominately covered by hilly uplands, which cover a total area of 23 950 ha. The uplands are strongly dissected and an estimated 5 to 10% of them is covered by valley bottoms. The predominating soils of the slope and summit areas are of the Ebimimbang type, i.e. moderately well drained with sandy topsoils and less than 40% clay in the subsoils. The valley bottoms are typically poorly to very poorly drained. The vegetation of the moderately well drained parts of the units is *Diospyros - Polyalthia* forest (IIc). The swamp forest of the *Carapa -Mitragyna* community (III) covers the valley bottoms.

Shifting cultivation has affected the hilly uplands only to a limited extent and appears to be restricted to those areas bordering the high intensity shifting cultivation areas of the rolling uplands and dissected erosional plains units. The vegetation in the shifting cultivation areas is a mosaic of forest of the *Diospyros - Polyalthia* community (IIc), with young secondary vegetation of the *Xylopia - Musanga* community (IV), and the *Macaranga - Chromolaena* community (V). Field observations suggest that most of the forest in these units have suffered commercial logging activities in the recent past.

7.3.12 Du1: rolling uplands below 350 m asl; moderately well drained soils

Rolling uplands below 350 m asl are restricted to the western part of the TCP area, where they cover a surface area of 11,620 ha. Some 10 to 15% of the rolling uplands are occupied by valley bottoms. The slope and summit areas of the rolling uplands have predominately Ebimimbang soils, whereas those of the valley bottoms are typically poorly to very poorly drained. The vegetation in the moderately well drained areas is primary and old secondary lowland forest of the *Diospyros - Polyalthia* community (IIc), whereas the vegetation of the valley bottoms belongs to the *Carapa - Mitragyna* community (III).

The units Du1 and Dpd contain the main shifting cultivation areas of the TCP area. Favorable soils and landforms have resulted in a long tradition of agricultural practice, especially near the village of Bipindi. Moreover, repeated logging for commercial timber has taken place in the last decennia. As a result the primary forest vegetation in these units is mostly disturbed, leaving only small patches of relatively undisturbed forest. Based on the air photographs of 1984-85 and field observations both high and low intensity shifting cultivation areas have been designated. Field observations, however, show that neither the surface of these areas nor their boundaries are static.

Within the shifting cultivation areas the vegetation is a mosaic of actual fields, thickets of the *Macaranga - Chromolaena* community (V) on recently abandoned fields, young secondary forest of the *Xylopia - Musanga* community (IV), and patches of lowland forest of the *Diospyros - Polyalthia* community (IIc).

7.3.13 Dpd: dissected erosional plains below 350 m asl; moderately well drained soils

The dissected erosional plains are found in the northwest of the TCP area. The low relief intensity and low altitude (40 to 200 m asl) are a characteristic features of the landscape. These units cover a surface area of 11,260 ha and an estimated 10-15% of them are valley bottoms. The soils are an association of Ebimimbang and Valley Bottom soils.

No significant stretch of natural forest is found within these units which are the core of the shifting cultivation area of the TCP area. These units have at least three times been logged for commercial timber. The units have been identified as high intensity shifting cultivation areas and the vegetation is a mosaic of actual fields, recently abandoned fields with the *Macaranga - Chromolaena* community (V), young secondary forest (*Xylopia - Musanga* community (IV)) and obviously disturbed lowland forest (*Diospyros - Polyalthia* community (IIc)).

7.3.14 Ev: valley bottom; poorly to very poorly drained soils

Valley bottoms occur throughout the TCP area. The majority however is too small to be mapped individually at reconnaissance scale and appears as inclusions in other mapping units. Some large valley bottom areas, however, do exist throughout of the TCP research area. The total surface of these units is only 1 600 ha. Because of the high ground water table and water stagnation, the vegetation structure and composition are very distinct. The soils are typically poorly to very poorly drained, are shallow to moderately deep and stratified, i.e. alternation of sand and clay. The swamp forest is characterized by the *Carapa - Mitragyna* (III) community. The Ev units appear not to be affected by human activity.

REFERENCES

Aleva, G.J.J. (ed.), 1994. *Laterites.* Concepts, geology, morphology and chemistry. ISRIC, Wageningen, The Netherlands. 169 pp.

Anderson, J.M. & Spencer, T., 1991. *Carbon, nutrient and water balances of tropical rain forest ecosystems subject to disturbance.* Management implications and research proposals. MAB Digest 7. UNESCO, Paris, France. 95 pp.

Bakkum, A.W.G., 1996. *GIS and computer maintenance mission to the Tropenbos-Cameroon Programme.* SC-DLO mission report. SC-DLO, Wageningen, The Netherlands.

Bekhuis, P., 1997. *Habitat requirements and potential distribution of some large mammals in Southwest Cameroon.* MSc thesis. Dept. Terrestrial Ecology and Nature Conservation, Wageningen Agricultural University, Wageningen, The Netherlands. 126 pp.

Bilong, 1992. *Caractères des sols ferrallitiques à plinthite et à pétroplinthite développés sur roches acides dans la zone forestière du sud du Cameroun.* Cah. Orstom, sér. Pédol., vol. XXVII, No.2: 203-224.

Braak, C.J.F. ter, 1988. *CANOCO - a FORTRAN program for canonical community ordination by [partial] [detrended] [canonical] correspondence analysis (version 2.0).* TNO Institute of Applied Computer Science, Wageningen, The Netherlands.

Braun-Blanquet, J., 1964. *Planzensoziologie.* 3rd ed. Springer Verlag, Vienna, Austria.

Bregt, A.K. & Kekem, A.J. van, 1995. *Land inventory and GIS mission to Tropenbos Cameroon.* International Activities Report 43, SC-DLO, Wageningen, The Netherlands. 43 pp.

Breimer, R.F., Kekem, A.J. van & Reuler, H. van, 1986. *Guidelines for soil survey and land evaluation in ecological research.* MAB Technical Notes 17. UNESCO, Paris, France.

Buckle, C., 1978. *Landforms in Africa.* An introduction to geomorphology. Longman, Harlow, United Kingdom. 249 pp.

CENADEFOR, 1987. *Carte forestière, 1 : 50,000, feuilles Edéa 1B, 2A, 2B, Nyabessan 3D, 4A, 4B.* CENADEFOR, Yaoundé, Cameroon.

CGN, 1976. *Carte du Cameroun.* Feuilles Edéa NA 32-XVIII sur l'échelle 1 ; 200,000. Centre Géographique Nationale, Yaoundé, Cameroon.

Champetier de Ribes, G., 1956. *Carte géologique de reconnaissance 1 : 500 000 - Notice explicative sur la feuille Yaoundé-Est.* Direction de Mines et de la Géologie, Yaoundé, Cameroon.

CPCS, 1967. *Classification des sols.* Travaux Commission de Pédologie et de Cartographie des Sols (CPCS) 1963-1969.

Dijk, H. van, 1997. *Ecological and economical assessment of non-timber forest products in the Bipindi - Akom II area, Cameroon.* Final report of the first phase. (Draft). Tropenbos-Cameroon Programme, Kribi, Cameroon.

Dolman, A.J. & Waterloo, M.J., 1995. *Hydrology mission Tropenbos Cameroon Programme.* International Activities Report 49, SC-DLO, Wageningen, The Netherlands. 29 pp.

Dounias, E. , 1993. *Dynamique et gestion différentielles du système de production à dominante agricole des Mvae du Sud-Cameroun forestier.* Thèse de Doctorat Académie de Montpelier, Université de Montpelier II, France.

Driessen, P.M. & Dudal, R. (eds.), 1989. *Lecture notes on the major soils of the world.* Geography, formation properties and use. Wageningen Agricultural University / Katholieke Universiteit Leuven, Wageningen, The Netherlands/Leuven, Belgium. 296 pp.

Duivenvoorden, J.F. & Lips, J.M., 1993. *Ecologia del paisaje del Medio Caquetá - Landscape ecology of the Middle Caquetá Bassin.* Estudios en la Amazonia Colombiana IIIa+b. Tropenbos-Colombia, Santa Fé de Bogotá, Colombia. 301 pp. + maps.

Duivenvoorden, J.F. & Lips, J.M., 1995. *A land - ecological study of soils, vegetation, and plant diversity in Colombian Amazonia.* Tropenbos Series 12. The Tropenbos Foundation, Wageningen, The Netherlands. 438 pp.

Embleton, C. & Thornes, J. (eds.), 1979. *Process in Geomorpholgy.* Edward Arnold (Publishers) Ltd., London, United Kingdom.

Embrechts, J. & Dapper, M. de, 1987. *Morphology and genesis of hillslope pediments in the Febe area (South-Cameroon).* Catena Vol. 14, pp. 31-43.

ESRI, 1990. *PC ARC/INFO.* Environmental Systems Research Institute, California, USA.

ESRI, 1994. *ArcView.* Environmental Systems Research Institute, California, USA.

Euroconsult (ed.), 1989. *Agricultural Compendium.* For rural development in the tropics and subtropics. Elsevier Science Publishers, Amsterdam, The Netherlands. 740 pp.

FAO, 1988. *FAO-Unesco Soil map of the world.* World Soil Resources Report 60. FAO, Rome, Italy.

FAO, 1990. *Guidelines for soil description.* 3rd Edition (Revised). FAO, Rome, Italy. 70 pp.

Foahom, B. & Jonkers, W.B.J., 1992. *A programme for Tropenbos Research in Cameroon.* The Tropenbos Foundation, Wageningen, The Netherlands. 181 pp.

Franqueville, A., 1973. *Atlas Régional Sud-Ouest 1.* République du Cameroun. ORSTOM, Yaoundé, Cameroon. 93 pp.

Gartlan, J.S., 1989. *La conservation des ecosystèmes forestiers du Cameroun.* IUCN, Gland, Switzerland & Cambridge, United Kingdom. 186 pp.

Gillman, G.P., Sinclair, D.F., Knowlton, R. & Keys, M.G., 1985. *The effect on some soil chemical properties of selective logging of a North Queensland rainforest.* Forest Ecology and Management 12, 195-214.

Hennekens, S.M., 1995. *TURBO(VEG) - Software package for input, processing, and presentation of phytosociological data.* IBN-DLO, Wageningen, The Netherlands, & University of Lancaster, Lancaster, United Kingdom.

Hesse, P.R., 1971. *A textbook of soil chemical analysis.* John Murry, London, United Kingdom.

Hill, M.D., 1979a. *TWINSPAN, a Fortran program for arranging multivariate data in an ordered two-way table by classification of the individuals and attributes.* Ecology and Systematics. Cornell University, Ithaca, New York, USA.

Hill, M.D., 1979b. *DECORANA, a Fortran program for detrended correspondance analysis and reciprocal averaging.* Ecology and Systematics. Cornell University, Ithaca, New York, USA.

Hommel, P.W.F.M., 1987. *Landscape-ecology of Ujung Kulon (West Java, Indonesia).* Doctoral thesis, Wageningen Agricultural University, Wageningen, The Netherlands. 206 pp.

Hommel, P.W.F.M., 1990. *A phyto-sociological study of a forest area in the humid tropics (Ujung Kulon, West Java, Indonesia).* Vegetatio 89, pp. 39-54.

Hommel, P.W.F.M., 1995. *Vegetation survey on a reconnaissance scale, Tropenbos Cameroon.* International Activities Report 48. SC-DLO, Wageningen, The Netherlands. 38 pp.

Hommel, P.W.F.M. & Kekem, A.J. van, 1996. *Forest land evaluation and land inventory project of Tropenbos Cameroon Programme.* International Activities Report 60. SC-DLO, Wageningen, The Netherlands. 50 pp.

Houba, V.J.G., Lee, J.J., Novozamsky, I. & Wallinga, I., 1989. *Soil and Plant analysis, a series of syllabi.* Part 5, Soil Analysis Procedures (5th edition). Wageningen Agricultural University, Wageningen, The Netherlands.

ISRIC, 1994. *FAO-Unesco Soil map of the world.* Revised legend with corrections. ISRIC, Wageningen, The Netherlands. 140 pp.

IUCN, 1988. *IUCN Red list of threatened animals.* IUCN, Gland, Switzerland. 186 pp.

Kekem, A.J. van, Pulles, J.H.M. & Khan, Z., 1997. *Soils of the rainforest in Central Guyana.* Guyana Tropenbos Series 2, the Tropenbos-Guyana Programme, Georgetown, Guyana.

Kekem, A.J. van and P.W.F.M. Hommel. Land evaluation approach for the Tropenbos Cameroon Programme. Mission April 1997. SC-DLO International Activities Report 68. SC-DLO, Wageningen, The Netherlands, 40 pp.

Kent, M. & Coker, P., 1992. *Vegetation description and analysis: a practical approach.* CRC Press, Boca Raton, Florida & Belhaven Press, London, United Kingdom. 363 pp.

Khanna, P.H. & Ulrich, B., 1984. *Soil characteristics influencing nutrient supply in forest soils.* In: Bowen, G.D. & Nambiar, E.K.S. (eds.), Nutrient of forest trees in plantations, 79-117, Academic Press Inc., London, United Kingdom.

Köppen, W., 1936. *Das geographische System der Klimate.* In: Köppen, W. & Geiger, R. (eds.). Handbuch der Klimatologie. Verlag von Gebrüder Bornträger, Berlin, Germany. 44 pp.

Küchler, A.W. & Zonneveld, I.S., 1988. *Vegetation mapping.* Handbook of Vegetation Science Vol. 10. Kluwer Academic Publishers, Dordrecht, The Netherlands. 635 pp.

Landon, J.R. (ed.), 1991. *Booker Tropical Soil Manual.* A handbook for soil survey and agricultural land evaluation in the tropics and sub tropics. Longman Scientific & Technical, Harlow, United Kingdom. 474 pp.

Letouzey, R., 1968. *Etude phytogéographique de Cameroun.* Ed. P. Lechevalier, Paris, France. 508 pp.

Letouzey, R., 1985. *Notice de la carte phytogéographique du Cameroun au 1 : 500 000.* Institut de la Carte Internationale de la Végétation, Toulouse, France. 142 pp.

Louette, M., 1981. *The birds of Cameroon: an annotated checklist.* Verhandeling wetenschappen. Jaargang 43, no 163. Brussels, Belgium.

Martin, D. & Segalen, P., 1966. *Notice explicative.* Carte Pédologique du Cameroun Oriental au 1/1,000,000. ORSTOM, Yaoundé, Cameroon.

Mbatchou, G.P.T., 1995. *The vegetation of the proposed Etinde Rainforest Reserve, Mount Cameroon and its conservation.* MSc thesis, University of Edinburgh, Royal Botanic Garden, Edinburgh, United Kingdom. 94 pp.

Mohr, E.C.J., Baren, F.A. van & Schuylenborgh, J. van, 1972. *Tropical Soils.* A comprehensive study of their genesis. 3rd ed. Geuze, Dordrecht, The Netherlands. 481 pp.

MINREST & ORSTOM, 1995. *Atlas du Sud Cameroun.* MINREST/ORSTOM, Yaoundé, Cameroon.

Ndjib, G., 1987. *Catenary relationships in tropical forest soils (Mbalmayo area, south Cameroon).* ITC, Enschede, The Netherlands.

Ngeh, P., Furley, P.A. & Grace, J., 1995. *Effect of land clearing methods on soil physical and chemical properties in a lowland tropical rainforest at Mbalmayo, Cameroon.* 10 pp.

Olivry, J.C., 1986. *Fleuves et Rivières du Cameroun.* Collection Monographies Hydrologiques d'ORSTOM No. 9. MESRES-ORSTOM, Paris, France.

Reeuwijk, L.P., 1995. *Procedures for soil analysis, Technical Paper no. 9 (5th edition).* International Soil Reference and Information Centre (ISRIC), Wageningen, The Netherlands. 112 pp.

Reuler, H. van, 1996. *Nutrient management over extended cropping periods in the shifting cultivation system of south-west Côte d'Ivoire.* PhD thesis. Wageningen Agricultural University, Wageningen, The Netherlands. 189 pp.

Rodewald, P.G., Dejaifve, P.-A. & Green, A.A., 1994. *The birds of Korup national park and Korup project area, Southwest Province, Cameroon.* Bird conservation International 4: 1-68.

Rouw, A. de, Vellema, H.C. & Blokhuis, W.A., 1990. *Land Unit Survey of the Taï region, southwest Côte d'Ivoire. Tropenbos Technical Series 7.* The Tropenbos Foundation, Wageningen, The Netherlands. 222 pp. + maps.

Rouw, A. de, 1991. *Rice, weeds and shifting cultivation in a tropical rain forest. A study of vegetation dynamics.* PhD thesis. Wageningen Agricultural University, Wageningen, The Netherlands.

Schroevers, P.J. (ed.), 1982. *Landschapstaal.* Een stelsel van basisbegrippen voor landschapsecologie. Reeks Landschaps Studies. Centrum voor Landbouw publikaties en Landbouw Documentatie, Wageningen, The Netherlands. 109 pp.

Segalen, P., 1957. *Atlas du Cameroun.* Notice explicative sur les sols du Cameroun. Carte au 1 : 2, 000,000. ORSTOM, Yaoundé, Cameroon.

Segalen, P., 1967. *Les sols et géomorphologie du Cameroun.* Cahiers ORSTOM, Série Pédologie: 137-187. ORSTOM, Paris, France.

Serle, W. & Morel, G.J., 1977. *A field guide to the birds of West Africa.* Willam Collins Sons & Co. Ltd. London, United Kingdom. 352 pp.

Soil Survey Staff, 1992. *Keys to Soil Taxonomy.* SMSS Technical Monograph No. 19, 5th ed., Blacksburg, Virginia, USA. 541 pp.

Toteu, S.F., Schmus, W.R. van, Penaye, J. & Nyobé, J.B., 1994. *U-Pb and Sm-Nd evidence for Eburnian and Pan-African high-grade metamorphism in cratonic rocks of southern Cameroon.* Precambrian Research 67, 321-347.

Touber, L., 1993a. *Air photo interpretation for overall land inventory of the research area (TCP, LU1). Explanatory note.* Internal document, SC-DLO, Wageningen, The Netherlands. 19 pp. + maps.

Touber, L., 1993b. *Report on a mission in support of the Land Inventory Project in the Tropenbos Cameroon Programme.* International Activities Report 32. SC-DLO, Wageningen, The Netherlands. 35 pp.

Touber, L., Smaling, E.M.A., Andriesse, W. & Hakkeling, R.T.A., 1989. *Inventory and evaluation of tropical forest land.* Guidelines for a common methodology. Tropenbos Technical Series 4. The Tropenbos Foundation, Ede, The Netherlands. 170 pp.

Touber, L., Randen, Y. van & Gijsen, N., 1993. *Trofolin database.* User manual. Tropenbos

Documents 4. The Tropenbos Foundation, Wageningen, The Netherlands. 31 pp. + annexes.

UNESCO, 1981. *Carte de la végétation d'Amerique du Sud.* Recherches sur les resources naturelles N. 17. 183 pp. Unesco, Paris, France.

Vivien, J., 1991. *Faune du Cameroun: guide des mammifères et poissons.* GICAM & Ministère de la Coopération et du Développement, Yaoundé, Cameroon. 271 pp.

Waterloo, M.J., Ntonga, J.C., Dolman, A.J. & Ayangma, A.B., 1997. *Studies on the impact of land use on the hydrology and erosion of rain forest land in South Cameroon.* DLO Winand Staring Centre Report 134. SC-DLO, Wageningen, The Netherlands.

Whitmore, T.C., 1984. *Tropical rain forests of the far east.* Clarendon Press, Oxford, United Kingdom. 352 pp.

Yemefack, M. & Moukam, A., 1995. *Biophysical Land Resources Inventory and Characterization of ASB Forest Margin Benchmark sites of Cameroon.* Report of the field tour carried out from 13 to 18 November 1995. IRA/ASB Project, Yaoundé, Cameroon.

Zonneveld, J.I.S., 1981. *Vormen in het landschap.* Hoofdlijnen van de geomorfologie. Het Spectrum, Utrecht/Antwerpen, The Netherlands/Belgium. 515 pp.

Zonneveld, I.S., 1995. *Land Ecology.* An introduction to landscape ecology as a base for land evaluation, land management and conservation. SPB Academic Publishing, Amsterdam, The Netherlands. 199 pp.

Annex II List of aerial photographs 1983 - 1985, 1 : 20 000 series covering the TCP research area (Photosur Inc.)

Line	Line Number		Photo Numbers
40	CAM - 84040	L-40	58- 60
38	CAM - 84044	L-38	46- 53
37	CAM - 84040	L-37	33- 42
36	CAM - 84039	L-36	74- 87
35	CAM - 84040	L-35	05- 11
35	CAM - 84039	L-35	49- 68
34	CAM - 84039	L-34	171-198
33	CAM - 85007	L-33	112-137
32	CAM - 84029	L-32	34- 44
32	CAM - 85019	L-32	58- 65
32	CAM - 84046	L-32	65- 75
31	CAM - 84046	L-31	88- 96
31	CAM - 85023	L-31	57- 62
31	CAM - 84046	L-31	99-101
30	CAM - 85023	L-30	141-150
30	CAM - 58025	L-30	142-154
29	CAM - 85023	L-29	126-139
29	CAM - 85023	L-29	63- 75
29	CAM - 85025	L-29	163-167
28	CAM - 85008	L-28	203-217
27	CAM - 84041	L-27	99-118
26	CAM - 84041	L-26	163-180
24	CAM - 85010	L-24	23- 26

Annex III Methods for chemical and physical soil analysis

IIIA Laboratory of `Institute de la Recherche Agricole pour le Développement', station Ekona
IIIB Comparison of soil data analysed in duplo (IRAD, Ekona, Cameroon and ISRIC, Wageningen, The Netherlands)

IIIA. Laboratory of `Institut de la Recherche Agricole pour le Développement', station Ekona

The analytical methods used are essentially those described in `Soil and Plant Analysis, a series of syllabi. Part 5, Soil Analysis Procedures', published by the Department of Soil Science and Plant Nutrition (Houba *et al.*, 1989) and in' Procedures for soil analysis. Techn. Pap. No. 9 (5th ed.), published by Int. Soil Ref. and Info. Centre (ISRIC) (Reeuwijk, 1995).

Texture
Air-dry samples are sieved through a 2 mm sieve, and the material retained is crushed and sieved again. The material > 2 mm is indicated as coarse fraction.

The soil material finer than 2 mm is used for particle size analysis by the sieve and pipette method after treatment with H_2O_2 to destroy organic matter, and HCl to dissolve carbonates, if present, and other cementing agents. The fractions obtained were < 2 μm (clay), 2-20 μm and 20-50 μm (silt), and 50-100 μm, 100-250 μm, 250-500 μm and 500-2000 μm. These fractions represent the USDA classes of very fine, fine, medium + coarse and very coarse sand respectively.

Moisture content (105 C)
Air-dry samples are dried 24 hrs at 105 ^oC to give the moisture content.

pH H_2O and KCl
The pH is measured potentiometrically in the soil suspension after equilibrium on 24 hours. The soil to liquid ratio was 1:2.5. The liquid was either distilled water (pH-H_2O) or 1 M potassium chloride (pH-KCl).

Organic carbon (Walkley-Black) %
After the carbonization of soil organic matter with conc. H_2SO_4, carbon was oxidized by dichromate. The green chromium solution is read colorimetrically on Technicon Auto-Analyzer II. The method had a recovery of 75% of the total organic C, which is about 58% of the total organic matter.

Total N (Kjeldahl) %
Catalytic oxidation of organic and chemically combined N and subsequent alteration to NH_4 (except $NO_3 + NO_2$) by the Kjeldahl process (Hesse, 1971). Nitrogen is measured on Technicon

AA II.

Available P (Bray-II) ppm
The soil is extracted by a solution of 0.03 M NH_4F and 0.1 M HCl. In this way, acid-soluble P, a major part of the calcium phosphates, and part of the aluminium and iron phosphates are extracted. NH_4F dissolves aluminium and iron phosphates by formation of complexes with these metal ions in acid solutions, then measured on Technicon AA II (Ascorbic-Molybdate blue coloration).

Total P (with H_2SO_4 and HNO_3)
The soil sample is treated with a 1:1 mixture of H_2SO_4 and HNO_3. The catalyzer is $CuSO_4$ -Se mixture (10 : 1). In this step the larger part of the organic matter is oxidized. After decomposition of the excess and evaporation of water (boiling at 360 ^oC for 3 - 5 hours), the digestion is finished by conc. H_2SO_4. The molybdenum blue method is used to measure spectrophotometrically the concentration of phosphates.

CEC and exchangeable bases (with 1 M NH_4OAc pH 7)
The soil is leached with a 1 M ammonium acetate solution (pH 7). The total amount of ammonium retained by the soil after washing it free of excess ammonium acetate is an estimate of the cation exchange capacity. The absorbed ammonium is released by leaching with acidified potassium chloride solution (pH 2.5) and subsequently determined colorimetrically on Technicon AA II. In the first leachate Na, K, Ca and Mg are determined by spectrophotometry (Na, K and Ca with the flame photometer and Mg colorimetrically by titan yellow method).

Al^{3+} and H^+ (with KCl)
Leaching with 1 M KCl and titration of exchangeable Al + H by 0.1 M NaOH.

Moisture retention (pF)
The pF is measured with the help of moisture plates. pF is measured at 0 / 0.1, 0.3, 1 and 15 bar (respectively pF 0 / 2, 2.5, 3.5 and 4.2).

Bulk density
Soil samples taken with the 100 cc pF rings are dried for 24 hours at 105 ^oC. The dry weight divided by 100 gives the bulk density (g/cm^3).

X-ray diffraction of clay
The clay fraction was separated from the fine-earth and deposited in an orientated fashion on porous ceramic plates to be analyzed on an X-ray diffractometer (Philips PW 1820/1710 assembly). Various treatments (e.g. glycerol, K-saturation, heating) were applied for identification of the various clay mineral species.

IIIB. Comparison of soil data analyses in duplo (IRA, Ekona, Cameroon and ISRIC, Wageningen, The Netherlands)

The comparison of soil data analyses at IRA, Ekona and ISRIC, Wageningen, The Netherlands is based on Hommel & van Kekem's mission report (1996).

Conditions
All soil samples were analyses at IRA Ekona. Some samples were analyses in duplo. Also a selected set of soil samples were analyses at ISRIC, Wageningen, The Netherlands.

Interpretation
First of all the course with depth of all elements analyses were interpreted. The original data were compared with the duplo analysis of Ekona and ISRIC.

Results
Texture analysis do not show large variation comparing the data sets of Ekona and ISRIC. The texture with depth is becoming more clayey. The Ekona gravel data are higher as consequence of their method of sieving.

The pH H_2O and pH KCl are in general a little higher in the Ekona case. However the differences between the two data sets are always smaller than 0.5 unit.

Organic matter concentration is sometimes a little higher in the surface horizons of the Ekona data set. The different nitrogen concentrations (Ekona and ISRIC) are comparable. C/N values are therefore higher in the surface horizons of the Ekona data. The nitrogen and organic carbon concentrations decrease with depth.

Available and total phosphorous can not be compared as consequence of different methods used. Both data sets decrease also with depth.

The exchangeable bases sodium (Na) and potassium (K) are exchangeable within the data sets. The data do not differ more than 0.2 unit.
Magnesium and calcium have sometimes large differences (> 0.2 unit). The methods used in Ekona are susceptible to errors if the concentrations of magnesium and calcium in the soil samples are low. Two third of the Ekona data is more than 0.2 unit (mainly) too high. Nevertheless the differences in total exchangeable bases between the data sets are mostly smaller than 1 unit (in meq/100 g).

Aluminium (Al^{3+}) and hydrogen (H^+) data differ not more than 1.5 and 0.4 unit, respectively. The hydrogen data have proportional large differences (> 20%). Nevertheless the differences in effective cation exchangeable capacity between the data sets are in majority smaller than 2 units. In general the Ekona data are higher than the ISRIC data.

The Cation Exchange Capacity (CEC) is largely of the same order for the data sets (< 2 units). Differences occur mainly in the surface horizons. The surface horizon CEC values of Ekona are mainly lower than those of ISRIC.

Conclusions
The majority of original Ekona data[1] can be trusted as real values. The difference between the

original data[1] and the duplos and/or ISRIC data were small. Sometimes differences were larger, but they are ambiguous. Nevertheless this differences were not that big that chemical characteristics of the profiles differ really between the data sets of Ekona and ISRIC.

The data used in the description of chemical and physical properties of the different soil profiles were original Ekona data[1]. Exceptions were noted down in the descriptions of the analysis data.

[1] Original Ekona data concerning a certain sample are data of that sample which was first analyses.

Annex IV Soil profile descriptions and data of analysis

A. Nyangong soil type
B. Ebom soil type
C. Ebimimbang soil type
D. Valley bottom soil type

A. Nyangong soil type

PROFILE 21

Legend unit:	Bu2
Soil classification:	Xanthic Ferralsol (FAO) Typic Hapludox (Soil Taxonomy)
Description:	On 22-03-95 by Gerard Hazeu and Arie van Kekem
Location:	About 2 km E of Nko'Adjap village;
Elevation:	600 m
Landform and slope:	rolling to hilly uplands; upper slope 25%
Parent material:	Gneisses of the Precambrian shield
Vegetation:	Forest
Drainage:	Well drained
Soil:	Very deep, yellowish brown to strong brown clay.

Depth (cm)	Hor.	Description
0- 10	Ah	dark brown (7.5YR3/4); clay; strong fine to medium, granular to subangular blocky; friable, slightly sticky and slightly plastic; few to abundant, fine to coarse roots; clear and smooth transition to
10- 25	BA	brown (7.5YR4/5); clay; moderate fine to medium subangular blocky; friable, slightly sticky and slightly plastic; patchy thin clay cutans; very few to common, fine to coarse roots; gradual and smooth transition to
25- 57	Bws1	strong brown (7.5YR4/6); clay; weak very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; patchy thin clay cutans; very few to few, fine to medium roots; diffuse and smooth transition to
57- 160	Bws2	strong brown (7.5YR4/7); clay; weak very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; patchy thin clay cutans; very few fine to medium roots; diffuse and smooth transition to
160- 230	Bws3	strong brown (7.5YR4/7); clay; very few (<5%) small hard spherical iron concretions; weak fine to medium subangular blocky; friable, slightly sticky and slightly plastic; patchy thin clay cutans; very few fine roots.

Profile 21										
Horizon	Depth (cm)	Particle size distribution % of fine earth; in µm								
						pH				
		<2	2-50	50-2000		1 : 2.5	KCl			
Ah	0-10	72	13	14		4.1	3.7			
BA	10-25	74	12	14		4.3	3.8			
Bws1	25-57	78	9	12		4.8	4.0			
Bws2	57-160	77	11	12		4.9	4.0			
Bws3	160-230	76	12	12		5.0	4.2			
Horizon	Exchangeable bases(NH_4OAc, pH7), meq/100 g					%		C/N	ppm	
	Na	K	Mg	Ca	TEB	Org. C	N total		Available P	Total P
Ah	0.1	0.2	0.6	0.5	1.4	5.5	0.31	18	4	
BA	0.1	0.1	0.3	0.5	1.0	3.1	0.2	16	1	
Bws1	0.0	0.0	0.0	0.4	0.4	1.5	0.12	12	0	
Bws2	0.1	0.0	0.0	0.4	0.6	0.7	0.07	10	0	
Bws3	0.1	0.1	0.3	0.4	0.9	0.6	0.07	9	0	
Horizon	meq/100 g soil		ECEC in meq/100 g		CEC in meq/100 g			%		
	Al	H	fine earth	clay	fine earth	clay	C	BS	Al Sat.	RAS
Ah	6.8	0.6	8.8	12	13.6	19	250	10	50	78
BA	6.3	0.6	7.9	11	10.1	14	326	10	62	80
Bws1	3.5	0.5	4.4	6	7.1	9	n.a.	6	49	79
Bws2	3.1	0.4	4.1	5	5.3	7	n.a.	11	60	77
Bws3	2.7	0.9	4.5	6	4.9	6	n.a.	19	56	61

PROFILE 22

Legend unit:	Bu2
Soil classification:	Xanthic Ferralsol (FAO) Typic Hapludox (Soil Taxonomy)
Description:	On 22-03-95 by Gerard Hazeu and Arie van Kekem
Location:	About 2 km E of Nko'Adjap village;
Elevation:	590 m
Landform and slope:	rolling to hilly uplands; middle slope 15%
Parent material:	Gneisses of the Precambrian shield
Vegetation:	Secondary forest
Drainage:	Well drained
Soil:	Very deep, yellowish brown to strong brown clay.

Depth (cm)	Hor.	Description
0- 6	Ah	brown to dark brown (7.5YR4/4); clay; strong, fine granular to subangular blocky; friable, slightly sticky and slightly plastic; abundant very fine to medium roots; clear and smooth transition to
6- 29	BA	strong brown (7.5YR4/6); clay; moderate fine subangular blocky; friable, slightly sticky and slightly plastic; few to common, fine to medium roots; diffuse and smooth transition to
29- 60	Bws1	strong brown (7.5YR5/6); clay; weak to moderate, fine subangular blocky; friable, slightly sticky and slightly plastic; patchy thin clay cutans; very few to few, fine to medium roots; diffuse and smooth transition to
60- 170	Bws2	strong brown (7.5YR5/7); clay; weak fine subangular blocky; friable, slightly sticky and slightly plastic; patchy thin clay cutans; few very fine to fine roots.

Profile 22									
Horizon	Depth (cm)	Particle size distribution % of fine earth; in µm				pH			
						pH			
		<2	2-50	50-2000		1 : 2.5	KCl		
Ah	0-6	68	9	24		4.5	3.7		
BA	6-29	75	10	15		4.5	3.9		
Bws1	29-60	80	7	13		4.4	4.0		
Bws2	60-170 (100)	77	10	13		4.7	4.1		
Bws2	60-170 (170)	77	10	13		4.7	4.1		
Horizon	Exchangeable bases (NH_4OAc, pH7), meq/100 g					%		C/N	ppm	
	Na	K	Mg	Ca	TEB	Org. C	N total		Available P	Total P
Ah	0.1	0.3	0.3	1.6	2.3	4.2	0.35	12	5	
BA	0.1	0.1	0.2	0.5	1.0	1.7	0.16	11	0	
Bws1	0.1	0.1	0.0	0.4	0.6	1.0	0.11	9	0	
Bws2	0.1	0.1	0.4	0.4	0.9	0.9	0.11	8	0	
Bws2	0.1	0.1	0.0	0.4	0.6	0.8	0.08	9	0	
Horizon	meq/100 g soil		ECEC in meq/100 g		CEC in meq/100 g			%		
	Al	H	fine earth	clay	fine earth	clay	C	BS	Al Sat.	RAS
Ah	4.4	0.9	7.5	n.a.	15.5	n.a.	371	15	28	58
BA	5.0	0.9	6.9	9	8.2	11	486	12	61	73
Bws1	5.8	0.4	6.7	8	7.4	9	n.a.	8	78	86
Bws2	4.1	0.8	5.8	8	6.7	9	n.a.	14	61	71
Bws2	4.1	0.6	5.3	7	6.4	8	n.a.	9	63	77

PROFILE 70

Legend unit: Am
Soil classification: Xanthic Ferralsol (FAO)
Typic Hapludox (Soil Taxonomy)
Description: On 26-04-95 by Gerard Hazeu
Location: About 4 km SE of Bityili village; 2°56'06 N and 10°49'55 E
Elevation: 800 m
Landform and slope: mountains; upper slope 30%
Parent material: Gneisses and/or diorite of the Precambrian shield
Vegetation: Forest
Drainage: Well drained
Soil: Very deep, yellowish brown to strong brown clay.

Depth (cm)	Hor.	Description
0- 4	Ah	dark brown (10YR3/3); clay; moderate to strong, fine to medium crumb to subangular blocky; friable, slightly sticky and slightly plastic; few to abundant, very fine to fine roots; clear and smooth transition to
4- 11	BA	dark yellowish brown (10YR3/6); clay; moderate, fine to medium subangular blocky; friable, slightly sticky and slightly plastic; few to common, very fine to fine roots; clear and smooth transition to
11- 26	Bws1	strong brown (7.5YR5/6); clay; weak to moderate, fine to medium subangular blocky; friable, slightly sticky and slightly plastic; few to common, fine to coarse roots; gradual and smooth transition to
26- 72	Bws2	strong brown (7.5YR5/8); clay; weak fine to medium subangular blocky; firm, slightly sticky and slightly plastic; patchy thin clay cutans; few fine to coarse roots; gradual and wavy transition to
72-102	Bc	strong brown (7.5YR5/8); gravelly, slightly stony clay; very few to frequent, small to large, hard irregular to angular iron concretions; weak fine to medium subangular blocky; firm, slightly sticky and slightly plastic; patchy thin clay cutans; few fine to medium roots; diffuse and irregular transition to
102-135	BC	strong brown (7.5YR5/8); slightly stony clay with many boulders; weak fine to medium subangular blocky; few fine roots.

Profile 70										
Horizon	Depth (cm)	Particle size distribution % of fine earth; in µm				pH				
		<2	2-50	50-2000		1 : 2.5	KCl			
Ah	0-4	61	21	18		4.4	3.7			
BA	4-11	61	16	23		4.0	3.7			
Bws1	11-26	59	18	23		4.1	3.7			
Bws2	26-72	66	16	18		4.2	3.7			
BC	72-102	47	28	25		4.7	4.0			
Horizon	Exchangeable bases (NH_4OAc, pH7), meq/100 g					%		C/N	ppm	
	Na	K	Mg	Ca	TEB	Org. C	N total		Available P	Total P
Ah	0.1	0.4	0.1	1.0	1.7	8.9	0.65	14	7	
BA	0.1	0.2	0.1	0.5	0.8	5.7	0.36	16	3	
Bws1	0.1	0.1	0.0	0.4	0.6	2.4	0.17	14	1	
Bws2	0.1	0.1	0.0	0.3	0.5	1.3	0.12	11	0	
BC	0.1	0.1	0.6	0.6	1.4	1.0	0.08	12	0	
Horizon	meq/100 g soil		ECEC in meq/100 g		CEC in meq/100 g			%		
	Al	H	fine earth	clay	fine earth	clay	C	BS	Al Sat.	RAS
Ah	7.8	0.9	10.3	n.a.	27.8	n.a.	311	6	28	75
BA	8.5	0.7	10.1	n.a.	17.7	n.a.	311	5	48	84
Bws1	6.0	0.8	7.4	13	10.2	17	424	6	59	81
Bws2	5.9	0.9	7.3	11	6.6	10	n.a.	7	91	81
BC	3.3	0.8	5.5	12	6.8	14	n.a.	20	48	60

PROFILE 71

Legend unit:	Am
Soil classification:	Xanthic Ferralsol (FAO)
	Typic Hapludox (Soil Taxonomy)
Description:	On 26-04-95 by Gerard Hazeu
Location:	About 4 km SE of Bityili village; 2°56'06 N and 10°49'55 E
Elevation:	720 m
Landform and slope:	mountains; middle slope 30%
Parent material:	Gneisses and/or diorite of the Precambrian shield
Vegetation:	Forest
Drainage:	Well drained
Soil:	Very deep, yellowish brown to strong brown clay.

Depth (cm)	Hor.	Description
0- 3	Ah	dark yellowish brown (10YR3/6); clay; weak to moderate, very fine to fine crumb to subangular blocky; friable, slightly sticky and slightly plastic; common to many, very fine to fine roots; clear and smooth transition to
3- 8	BA	dark yellowish brown (10YR4/6); clay; weak to moderate, fine subangular blocky; friable, slightly sticky and slightly plastic; few to common, very fine to fine roots; clear and smooth transition to
8- 42	Bws1	yellowish brown (10YR5/6); clay; weak fine to medium subangular blocky; firm, slightly sticky and slightly plastic; few to common, very fine to fine roots; clear and wavy transition to
42-135	Bc1	yellowish brown (10YR5/6); very gravelly, slightly stony clay; few to frequent, small to large, hard irregular to spherical iron concretions; weak fine to medium subangular blocky; firm, slightly sticky and slightly plastic; few to many, fine to medium roots; gradual and smooth transition to
135-195	Bc2	strong brown (7.5YR5/8); very gravelly, slightly stony clay; few (5%) medium faint diffuse 5YR5/8 mottles; few to very frequent, small to large, hard irregular to angular iron concretions; weak fine subangular blocky; firm, slightly sticky and slightly plastic; no roots.

Profile 71										
Horizon	Depth (cm)	Particle size distribution % of fine earth; in µm								
						pH				
		<2	2-50	50-2000		1 : 2.5	KCl			
Ah	0 - 3	50	12	38		4.0	3.2			
BA	3 - 8	55	11	34		3.9	3.7			
Bws	8 - 42	62	12	26		4.3	3.7			
Bc1	42 - 90	60	14	26		4.9	4.0			
Bc1	90 - 135	65	12	23		4.9	4.0			
Bc2	135 - 195	62	20	18		5.2	4.3			
Horizon	Exchangeable bases NH_4OAc, pH7), meq/100 g							C/N	ppm	
	Na	K	Mg	Ca	TEB	Org. C	N total		Available P	Total P
Ah	0.2	0.3	0.4	1.1	1.9	4.8	0.31	16	5	
BA	0.1	0.1	0.4	0.4	1.1	2.9	0.21	14	2	
Bws	0.1	0.1	0.2	0.3	0.6	1.5	0.14	10	1	
Bc1	0.2	0.2	0.5	1.0	1.9	0.9	0.1	9	1	
Bc1	0.2	0.1	0.1	0.5	0.9	0.6	0.08	8	1	
Bc2	0.1	0.1	0.2	0.5	0.9	0.7	0.07	10	1	
Horizon	meq/100 g soil		ECEC in meq/100 g		CEC in meq/100 g			%		
	Al	H	fine earth	clay	fine earth	clay	C	BS	Al Sat.	RAS
Ah	6.0	0.4	8.4	n.a.	16.0	n.a.	332	12	38	72
BA	6.1	0.7	7.8	14	10.3	19	357	10	59	78
Bws	5.1	0.7	6.4	10	8.4	14	n.a.	7	61	80
Bc1	3.9	0.8	6.6	11	7.5	12	n.a.	25	52	59
Bc1	3.6	0.7	5.2	8	6.2	10	n.a.	14	58	70
Bc2	2.4	0.8	4.1	7	6.0	10	n.a.	14	40	60

PROFILE 74

Legend unit:	Am
Soil classification:	Acri-xanthic Ferralsol (FAO) Typic Kandiudox (Soil Taxonomy)
Description:	On 26-04-95 by Gerard Hazeu
Location:	About 4 km SE of Bityili village; 2°56'06 N and 10°49'55 E
Elevation:	660 m
Landform and slope:	mountains; lower slope 25%
Parent material:	Gneisses and/or diorite of the Precambrian shield
Vegetation:	Forest
Drainage:	Well drained
Soil:	Deep, yellowish brown to strong brown clay.

Depth (cm)	Hor.	Description
0- 5	Ah	dark yellowish brown (10YR3/4); clay; moderate to strong, fine granular to subangular blocky; friable, slightly sticky and slightly plastic; few to common, very fine to fine roots; clear and smooth transition to
5- 12	BA	dark yellowish brown (10YR3/6); clay; moderate, fine to medium subangular blocky; friable, slightly sticky and slightly plastic; few to common, fine to medium roots; clear and smooth transition to
12- 32	Bws1	yellowish brown (10YR5/6); slightly gravelly clay; very few (<5%) small hard spherical iron concretions; weak to moderate, fine to medium subangular blocky; friable to firm, slightly sticky and slightly plastic; few to common, fine to medium roots; clear and smooth transition to
32- 76	Bc1	yellowish brown (10YR5/8); gravelly, slightly stony clay; very few (<5%) fine faint diffuse 5YR5/8 mottles; few to frequent, small to large, hard irregular to spherical iron concretions; weak to moderate, fine angular to subangular blocky; firm, slightly sticky and slightly plastic; few to common, very fine to fine roots; diffuse and wavy transition to
76-113	Bc2	strong brown (7.5YR5/8); gravelly stony clay; very few (<5%) fine faint diffuse 5YR5/8 mottles; few to frequent, small to large, hard irregular to spherical iron concretions; weak to moderate, fine subangular blocky; firm, slightly sticky and slightly plastic; few very fine to fine roots; diffuse and wavy transition to
113-170	BC	strong brown (7.5YR5/8); slightly gravelly, very stony clay; very few (<5%) fine faint diffuse 5YR5/8 mottles; very few to few, small to large, hard irregular to spherical iron concretions; weak to moderate, fine subangular blocky; firm, slightly sticky and slightly plastic; very few fine roots.

Profile 74										
Horizon	Depth (cm)	Particle size distribution % of fine earth; in µm				pH				
		<2	2-50	50-2000		1 : 2.5	KCl			
Ah	0-5	45	16	39		4.4	3.6			
BA	5-12	48	12	40		4.2	3.7			
Bws	12-32	56	12	33		4.3	3.8			
Bc1	32-76	53	15	32		4.4	4.0			
Bc2	76-113	60	12	28		4.6	4.0			
BC	113-170	46	29	26		5.2	4.4			
Horizon	Exchangeable bases (NH_4OAc, pH7), meq/100 g					%		C/N	ppm	
	Na	K	Mg	Ca	TEB	Org. C	N total		Available P	Total P
Ah	0.1	0.6	0.8	2.0	3.5	6.3	0.4	16	7	
BA	0.0	0.1	0.6	0.3	1.1	2.5	0.18	14	3	
Bws	0.1	0.1	0.6	0.5	1.3	1.2	0.11	11	1	
Bc1	0.1	0.1	0.0	0.5	0.7	0.8	0.1	8	1	
Bc2	0.1	0.1	0.2	0.4	0.8	0.9	0.1	9	1	
BC	0.1	0.1	0.5	0.3	1.0	0.6	0.09	6	1	
Horizon	meq/100 g soil		ECEC in meq/100 g		CEC in meq/100 g			%		
	Al	H	fine earth	clay	fine earth	clay	C	BS	Al Sat.	RAS
Ah	4.9	0.6	9.0	n.a.	19.5	n.a.	308	18	25	55
BA	6.0	0.6	7.7	n.a.	10.3	n.a.	415	11	58	77
Bws	5.5	0.5	7.3	13	9.2	16	n.a.	14	60	75
Bc1	4.6	0.9	6.2	12	8.5	16	n.a.	8	54	74
Bc2	4.8	0.5	6.1	10	8.7	15	n.a.	9	55	78
BC	2.7	0.6	4.3	9	7.2	16	n.a.	13	38	63

PROFILE 76

Legend unit: Am
Soil classification: Xanthic Ferralsol (FAO)
Typic Hapludox (Soil Taxonomy)
Description: On 27-04-95 by Gerard Hazeu
Location: About 4 km SE of Bityili village; 2°56'06 N and 10°49'55 E
Elevation: 800 m
Landform and slope: mountains; upper slope 30%
Parent material: Gneisses and/or diorite of the Precambrian shield
Vegetation: Forest
Drainage: Well drained
Soil: Very deep, yellowish brown to strong brown clay.

Depth (cm)	Hor.	Description
0- 7	Ah	dark brown (7.5YR3/3); clay; strong fine granular to subangular blocky; friable, slightly sticky and slightly plastic; common very fine to fine roots; clear and smooth transition to
7- 16	BA	dark brown to brown (7.5YR4/3); clay; strong fine granular to subangular blocky; friable, slightly sticky and slightly plastic; common fine to medium roots; clear and smooth transition to
16- 42	Bws1	strong brown (7.5YR5/6); clay; moderate fine to medium subangular blocky; friable, slightly sticky and slightly plastic; few to common, fine to medium roots; diffuse and smooth transition to
42-250	Bws2	strong brown (7.5YR5/7); clay; very few (<5%) fine faint diffuse 5YR5/8 mottles; moderate, fine to medium subangular blocky; friable, slightly sticky and slightly plastic; few very fine to fine roots.

Profile 76										
Horizon	Depth (cm)	Particle size distribution % of fine earth; in µm				pH				
		<2	2-50	50-2000		1:2.5	KCl			
Ah	0-7	48	16	36		4.6	3.7			
BA	7-16	50	15	35		4.2	3.8			
Bws1	16-42	57	17	26		4.4	3.6			
Bws2	42-250 (80)	58	16	26		4.8	4.0			
Bws2	42-250 (160)	57	15	28		4.5	3.9			
Horizon	Exchangeable bases (NH_4OAc, pH7), meq/100 g					%		C/N	ppm	
	Na	K	Mg	Ca	TEB	Org. C	N total		Available P	Total P
Ah	0.1	0.4	0.2	1.3	2.0	5.7	0.36	16	10	
BA	0.1	0.2	0.4	0.6	1.2	4.4	0.25	18	6	
Bws1	0.1	0.1	0.1	0.4	0.7	1.4	0.12	12	1	
Bws2	0.0	0.1	0.5	0.3	0.9	0.6	0.05	12	1	
Bws2	0.1	0.1	0.3	0.2	0.6	0.3	0.05	7	0	
Horizon	meq/100 g soil		ECEC in meq/100 g		CEC in meq/100 g			%		
	Al	H	fine earth	clay	fine earth	clay	C	BS	Al Sat.	RAS
Ah	4.0	0.6	6.6	n.a.	19.8	n.a.	345	10	20	61
BA	5.9	0.8	7.9	n.a.	14.4	n.a.	326	8	41	74
Bws1	5.2	0.6	6.5	11	7.4	13	n.a.	9	70	80
Bws2	4.0	0.6	5.5	10	4.5	8	n.a.	21	87	72
Bws2	4.0	0.7	5.3	9	5.4	10	n.a.	12	74	75

PROFILE 122

Legend unit:	Bh2
Soil classification:	Xanthic Ferralsol (FAO) Typic Hapludox (Soil Taxonomy)
Description:	On 16-06-95 by Gerard Hazeu
Location:	About 600 m N of Mebanga village; 2°48'64 N and 10°37'87 E
Elevation:	620 m
Landform and slope:	complex of hills; summit, upper slope 10%
Parent material:	Gneisses of the Precambrian shield
Vegetation:	Forest
Drainage:	Well drained
Soil:	Very deep, yellowish brown to strong brown clay.

Depth (cm)	Hor.	Description
0- 5	Ah	dark yellowish brown (10YR3/6); sandy clay; moderate to strong, very fine subangular blocky; friable, slightly sticky and slightly plastic; common to many, very fine to medium roots; clear and smooth transition to
5- 13	BA	yellowish brown (10YR5/6); clay; weak to moderate, very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; few to common, fine to medium roots; gradual and smooth transition to
13- 31	Bws1	strong brown (7.5YR5/6); clay; weak to moderate, very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; patchy thin clay cutans; few fine to medium roots; gradual and smooth transition to
31- 84	Bws2	strong brown (7.5YR5/7); clay; weak to moderate, very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; few very fine to fine roots; diffuse and smooth transition to
84-190	Bws3	strong brown (7.5YR5/8); clay; very few (<5%) small hard spherical iron concretions; weak to moderate, very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; few very fine to fine roots.

Profile 122											
Horizon	Depth (cm)	Particle size distribution % of fine earth; in µm				pH					
		<2	2-50	50-2000		1 : 2.5	KCl				
Ah	0-5	62	17	20		3.5	3.2				
BA	5-13	64	15	21		3.4	3				
Bws1	13-31	67	15	18		3.5	3.2				
Bws2	31-84	70	14	16		4.4	3.2				
Bws3	84-190 (105)	68	14	18		4.4	3.6				
Bws3	84-190 (160)	69	12	19		4.3	3.6				
Horizon	Exchangeable bases (NH_4OAc, pH7), meq/100 g					%		C/N	ppm		
	Na	K	Mg	Ca	TEB	Org. C	N total		Available P	Total P	
Ah	0.1	0.2	0.8	0.7	1.8	5.9	0.45	13	10	628	
BA	0.2	0.0	0.1	0.0	0.3	3.2	0.24	13	3	255	
Bws1	0.1	0.0	0.1	0.1	0.3	1.7	0.14	12	1	412	
Bws2	0.1	0.0	0.0	0.0	0.1	1.2	0.11	11	0	398	
Bws3	0.1	0.0	0.0	0.0	0.2	0.8	0.09	8	0	198	
Bws3	0.0	0.0	0.0	0.0	0.1	0.6	0.08	7	0	261	
Horizon	meq/100 g soil		ECEC in meq/100 g		CEC in meq/100 g			%			
	Al	H	fine earth	clay	fine earth	clay	C	BS	Al Sat.	RAS	
Ah	6.7	0.6	9.1	n.a.	18.6	n.a.	314	10	36	73	
BA	7.6	0.5	8.5	n.a.	11.2	n.a.	354	3	68	90	
Bws1	6.2	0.4	6.9	10	5.7	8	330	5	108	90	
Bws2	3.1	0.5	3.7	5	5.4	8	436	2	57	83	
Bws3	3.0	0.3	3.4	5	3.0	4	407	6	97	86	
Bws3	3.0	0.5	3.6	5	4.1	6	n.a.	1	74	83	

PROFILE 123

Legend unit:	Bh2
Soil classification:	Xanthic Ferralsol (FAO)
	Typic Hapludox (Soil Taxonomy)
Description:	On 16-06-95 by Gerard Hazeu
Location:	About 400 m N of Mebanga village; 2°48'64 N and 10°37'87 E
Elevation:	590 m
Landform and slope:	complex of hills; upper slope 40%
Parent material:	Gneisses of the Precambrian shield
Vegetation:	Secondary forest
Drainage:	Well drained
Soil:	Very deep, yellowish brown to strong brown clay.

Depth (cm)	Hor.	Description
0- 5	Ah	dark yellowish brown (10YR3/4); clay; strong, very fine to fine crumb to subangular blocky; friable, slightly sticky and slightly plastic; common very fine to fine roots; clear and smooth transition to
5- 16	BA	dark yellowish brown (10YR4/6); clay; strong very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; patchy thick clay cutans; few to common, very fine to medium roots; gradual and smooth transition to
16- 54	Bws1	strong brown (7.5YR5/6); clay; moderate very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; patchy thick clay cutans; few to common, fine to medium roots; gradual and smooth transition to
54-119	Bws2	strong brown (7.5YR5/8); clay; weak to moderate, very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; very few to few, fine to medium roots; diffuse and smooth transition to
119-210	Bws3	strong brown (7.5YR5/8); clay; very few (<2%) very fine fresh gravels; weak to moderate, very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; very few fine to medium roots.

Profile 123									
Horizon	Depth (cm)	Particle size distribution % of fine earth; in µm				pH			
		<2	2-50	50-2000		1 : 2.5	KCl		
Ah	0 - 5	56	15	29		3.8	3		
BA	5 - 16	62	12	26		3.6	3.1		
Bws1	16 - 54	72	9	19		3.7	3.3		
Bws2	54 - 119	68	11	21		3.8	3.6		
Bws3	119 - 170	67	12	21		3.7	3.5		
Bws3	170 - 210	66	12	21		3.9	3.6		
Horizon	Exchangeable bases (NH_4OAc, pH7), meq/100 g					%		C/N	ppm	
	Na	K	Mg	Ca	TEB	Org. C	N total		Available P	Total P

Horizon	Na	K	Mg	Ca	TEB	Org. C	N total	C/N	Available P	Total P
Ah	0.2	0.3	0.3	1.8	2.4	7.5	0.44	17	11	403
BA	0.1	0.0	0.3	0.5	0.9	1.5	0.17	9	2	226
Bws1	0.1	0.0	0.4	0.2	0.7	2.3	0.12	19	0	176
Bws2	0.1	0.1	0.4	0.5	1.0	0.7	0.07	9	0	209
Bws3	0.1	0.0	0.0	0.2	0.3	0.6	0.06	9	0	208
Bws3	0.1	0.0	0.3	0.6	0.9	0.6	0.06	9	1	192

Horizon	meq/100 g soil		ECEC in meq/100 g		CEC in meq/100 g			%		
	Al	H	fine earth	clay	fine earth	clay	C	BS	Al Sat.	RAS
Ah	3.1	0.5	6.0	n.a.	22.0	n.a.	293	11	14	51
BA	5.7	0.6	7.3	12	7.1	11	487	12	81	79
Bws1	5.1	0.4	6.2	9	7.0	10	308	10	72	82
Bws2	4.0	0.5	5.6	8	6.8	10	n.a.	15	60	72
Bws3	3.8	0.3	4.4	6	3.3	5	n.a.	8	100	88
Bws3	3.9	0.4	5.3	8	5.5	8	n.a.	17	70	74

PROFILE 132

Legend unit:	Bh2
Soil classification:	Acri-xanthic Ferralsol (FAO) Typic Kandiudox (Soil Taxonomy)
Description:	On 16-06-95 by Gerard Hazeu
Location:	About 300 m N of Mebanga village; 2°48'64 N and 10°37'87 E
Elevation:	540 m
Landform and slope:	complex of hills; middle slope 25%
Parent material:	Gneisses of the Precambrian shield
Vegetation:	Secondary forest
Drainage:	Well drained
Soil:	Very deep, yellowish brown to strong brown clay.

Depth (cm)	Hor.	Description
0- 5	Ah	dark yellowish brown (10YR3/4); sandy clay; weak to moderate, very fine to fine crumb to subangular blocky; friable, slightly sticky and slightly plastic; many very fine to fine roots; clear and smooth transition to
5- 12	BA	dark yellowish brown (10YR3/6); clay; weak to moderate, very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; few to many, very fine to fine roots; clear and smooth transition to
12- 27	Bws1	strong brown (7.5YR5/7); clay; weak to moderate, very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; patchy thick clay cutans; few fine to medium roots; gradual and smooth transition to
27- 84	Bws2	strong brown (7.5YR5/8); clay; weak to moderate, very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; patchy thick clay cutans; very few to few, very fine to fine roots; diffuse and smooth transition to
84-122	Bws3	strong brown (7.5YR5/8); clay; very few (<5%) fine faint diffuse 5YR5/6 mottles; weak very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; patchy thick clay cutans; very few very fine to fine roots; diffuse and smooth transition to
122-190	Bws4	strong brown (7.5YR5/8); clay; many fine faint diffuse 2.5YR5/6 mottles; very few (<2%) very fine fresh gravels; weak very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; very few very fine to fine roots.

Profile 132							
Horizon	Depth (cm)	Particle size distribution % of fine earth; in µm				pH	
		<2	2-50	50-2000		1 : 2.5	KCl
Ah	0-5	44	14	42		3.9	3.6
BA	5-12	48	13	39		3.8	3.5
Bws1	12-27	58	13	30		3.8	3.4
Bws2	27-84	70	8	22		3.5	3.3
Bws3	84-122	69	10	21		3.6	3.4
Bws4	122-190	67	11	21		3.8	3.4

Horizon	Exchangeable bases (NH_4OAc, pH7), meq/100 g					%		C/N	ppm	
	Na	K	Mg	Ca	TEB	Org. C	N total		Available P	Total P
Ah	0.1	0.1	0.5	1.2	1.8	3.0	0.23	13	9	400
BA	0.1	0.0	0.7	0.6	1.3	1.6	0.15	10	2	251
Bws1	0.0	0.0	0.0	0.6	0.6	1.3	0.13	10	1	245
Bws2	0.0	0.0	0.4	0.2	0.6	0.9	0.11	8	1	239
Bws3	0.0	0.0	0.3	0.2	0.5	0.6	0.09	7	1	260
Bws4	0.1	0.0	0.3	0.6	1.0	0.5	0.07	7	1	198

Horizon	meq/100 g soil		ECEC in meq/100 g		CEC in meq/100 g			%		
	Al	H	fine earth	clay	fine earth	clay	C	BS	Al Sat.	RAS
Ah	2.8	0.5	5.2	n.a.	9.0	n.a.	299	20	31	55
BA	3.7	0.4	5.3	n.a.	6.7	n.a.	431	19	54	69
Bws1	4.4	0.5	5.4	9	5.5	10	422	11	79	80
Bws2	4.5	0.4	5.6	8	4.5	7	516	14	100	81
Bws3	4.5	0.1	5.2	8	4.8	7	n.a.	11	95	88
Bws4	3.9	0.2	5.0	8	6.5	10	n.a.	15	60	78

PROFILE 134

Legend unit: Bh1
Soil classification: Ferralic Cambisol (FAO)
Oxic Dystropept (Soil Taxonomy)
Description: On 24-06-95 by Gerard Hazeu
Location: About 3 km N of Esseng village; 2°49'75 N and 10°39'53 E
Elevation: 690 m
Landform and slope: isolated hill; summit 0-5%
Parent material: Gneisses of the Precambrian shield
Vegetation: Forest
Drainage: Well drained
Soil: Very yellowish brown to strong brown clay.

Depth (cm)	Hor.	Description
0- 6	Ah	dark brown (7.5YR3/4); clay; moderate to strong, fine crumb to subangular blocky; very friable, slightly sticky and slightly plastic; abundant very fine to fine roots; clear and smooth transition to
6- 14	BA	strong brown (7.5YR5/6); clay; moderate to strong, fine crumb to subangular blocky; friable, slightly sticky and slightly plastic; common to many, fine to medium roots; gradual and smooth transition to
14- 50	Bws1	strong brown (10-7.5YR5/8); clay; weak to moderate, fine subangular blocky; friable, slightly sticky and slightly plastic; very few to common, fine to medium roots; gradual and smooth transition to
50- 65/120	Bws2	strong brown (10-7.5YR5/8); very gravelly, stony clay; frequent small hard angular to spherical iron concretions; weak to moderate, fine to medium subangular blocky; friable, slightly sticky and slightly plastic; very few to common, very fine to fine roots; gradual and broken transition to
65/120-175	BC	strong brown (10-7.5YR5/8); stony, very bouldery clay; weak fine subangular blocky; friable, slightly sticky and slightly plastic; no roots.

Profile 134

Horizon	Depth (cm)	Particle size distribution % of fine earth; in µm				pH	
		<2	2-50	50-2000		1 : 2.5	KCl
Ah	0 - 6	60	18	22		4	3.2
BA	6 - 14	65	14	22		3.9	3.4
Bws1	14 - 50	62	20	18		4.1	3.8
Bws2	50 - 65/120	44	19	37		4.5	3.9
BC	65/120 - 175	40	21	38		4.5	4.7

Horizon	Exchangeable bases (NH_4OAc, pH7), meq/100 g					%		C/N	ppm	
	Na	K	Mg	Ca	TEB	Org. C	N total		Available P	Total P
Ah	0.2	0.5	1.7	1.9	4.4	9.7	0.69	14	21	674
BA	0.1	0.2	0.4	0.3	0.9	3.8	0.26	15	3	363
Bws1	0.1	0.1	0.4	0.6	1.1	1.7	0.13	13	1	271
Bws2	0.0	0.2	0.3	0.0	0.4	0.8	0.06	14	1	178
BC	0.1	0.0	0.3	0.0	0.4	0.6	0.04	14	1	229

Horizon	meq/100 g soil		ECEC in meq/100 g		CEC in meq/100 g			%		
	Al	H	fine earth	clay	fine earth	clay	C	BS	Al Sat.	RAS
Ah	2.7	0.3	7.4	n.a.	19.6	n.a.	202	22	14	36
BA	6.8	0.6	8.3	13	7.9	12	207	12	86	81
Bws1	5.8	0.4	7.3	12	6.0	10	360	18	97	80
Bws2	3.0	0.7	4.1	9	4.5	10	n.a.	10	66	72
BC	2.1	0.8	3.3	8	2.5	6	n.a.	15	86	65

PROFILE 214

Legend unit:	Bh2
Soil classification:	Ferralic Cambisol (FAO) Oxic Dystropept (Soil Taxonomy)
Description:	On 12-08-95 by Gerard Hazeu
Location:	About 1 km S of Ma'amenyin village; 3°03'58 N and 10°46'42 E
Elevation:	580 m
Landform and slope:	complex of hills; summit, upper slope 25 - 30%
Parent material:	Gneisses of the Precambrian shield
Vegetation:	Forest
Drainage:	Well drained
Soil:	Moderately deep, yellowish brown clay with sandy clay loam to sandy clay topsoil.

Depth (cm)	Hor.	Description
0- 6	Ah	dark brown (10YR3/3); sandy clay; moderate to strong, very fine to fine crumb to subangular blocky; very friable, slightly sticky and slightly plastic; common to many, fine to medium roots; clear and smooth transition to
6- 17	BA	dark yellowish brown (10YR3/6); clay; moderate to strong, very fine subangular blocky; friable, slightly sticky and slightly plastic; few to common, very fine to fine roots; clear and smooth transition to
17- 55/63	Bws	yellowish brown (10YR5/6); clay; moderate very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; common very fine to fine roots.
55/63	C	

Profile 214										
Horizon	Depth (cm)	Particle size distribution % of fine earth; in µm								
						pH				
		<2	2-50	50-2000		1 : 2.5	KCl			
Ah	0 - 6	43	15	42		3.6	3.1			
BA	6 - 17	47	12	41		3.45	3.15			
Bws	17 - 55/63	51	13	36		3.7	3.6			
C	55/63									
Horizon	Exchangeable bases (NH_4OAc, pH7), meq/100 g					%		C/N	ppm	
	Na	K	Mg	Ca	TEB	Org. C	N total		Available P	Total P
Ah	0.2	0.4	1.1	1.7	3.3	6.8	0.42	16	20	267
BA	0.1	0.1	0.4	0.7	1.2	2.3	0.19	12	4.00	207
Bws	0.1	0.1	0.0	0.6	0.7	1.1	0.12	9	1	220
C										
Horizon	meq/100 g soil		ECEC in meq/100 g		CEC in meq/100 g			%		
	Al	H	fine earth	clay	fine earth	clay	C	BS	Al Sat.	RAS
Ah	5.2	0.6	9.1	n.a.	19.4	n.a.	287	17	27	58
BA	6.2	0.4	7.8	17	10.4	22	447	12	59	79
Bws	5.1	0.4	6.2	12	6.5	13	n.a.	11	79	83
C										

PROFILE 215

Legend unit: Bh2
Soil classification: Acri-xanthic Ferralsol (FAO)
Typic Kandiudox (Soil Taxonomy)
Description: On 12-08-95 by Gerard Hazeu
Location: About 1 km S of Ma'amenyin village; 3°03'58 N and 10°46'42 E
Elevation: 545 m
Landform and slope: complex of hills; upper slope 35 - 40%
Parent material: Gneisses of the Precambrian shield
Vegetation: Forest
Drainage: Well drained
Soil: Very deep, yellowish brown clay with sandy clay loam to sandy clay topsoil.

Depth (cm)	Hor.	Description
0- 7	Ah	dark yellowish brown (10YR3/4); sandy clay; moderate very fine crumb to subangular blocky; very friable, slightly sticky and slightly plastic; very few to many, fine to coarse roots; clear and smooth transition to
7- 22	BA	dark yellowish brown (10YR4/6); sandy clay; moderate very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; few to common, very fine to medium roots; clear and smooth transition to
22- 98	Bws1	yellowish brown (10YR5/7); clay; many (20%) fine to medium, distinct diffuse 5YR5/8 mottles; weak to moderate, very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; few to common, very fine to fine roots; gradual and smooth transition to
98-200	Bws2	yellowish brown (10YR5/8); clay; many (50%) fine to medium, distinct diffuse 5YR5/8 mottles; weak to moderate, very fine subangular blocky; friable, slightly sticky and slightly plastic; few very fine roots.

Profile 215							
		Particle size distribution % of fine earth; in µm				pH	
Horizon	Depth (cm)	<2	2-50	50-2000		1 : 2.5	KCl
Ah	0 - 7	32	12	56		3.8	3.2
BA	7 - 22	45	11	43		3.8	3.6
Bws1	22 - 98	55	9	36		3.9	3.6
Bws2	98 - 200	53	12	35		4	3.8

	Exchangeable bases (NH_4OAc, pH7), meq/100 g					%			ppm	
Horizon	Na	K	Mg	Ca	TEB	Org. C	N total	C/N	Available P	Total P
Ah	0.2	0.2	0.6	0.6	1.5	4.9	0.32	15	12	245
BA	0.1	0.1	0.2	0.5	0.8	1.4	0.14	10	2	192
Bws1	0.0	0.0	0.2	0.6	0.9	0.4	0.1	4	1	144
Bws2	0.1	0.0	0.7	1.2	2.1	0.4	0.09	4	1	220

	meq/100 g soil		ECEC in meq/100 g		CEC in meq/100 g			%		
Horizon	Al	H	fine earth	clay	fine earth	clay	C	BS	Al Sat.	RAS
Ah	4.3	0.4	6.2	n.a.	15.5	n.a.	320	10	27	69
BA	4.9	0.4	6.1	13	5.5	12	395	15	88	80
Bws1	4.2	0.5	5.6	10	5.8	11	n.a.	16	72	75
Bws2	3.8	0.5	6.4	12	5.5	10	n.a.	37	68	59

PROFILE 253

Legend unit:	Am
Soil classification:	Ferralic Cambisol (FAO) Oxic Dystropept (Soil Taxonomy)
Description:	On 11-01-96 by Gerard Hazeu
Location:	About 8 km S of Meka'aII village; 2°56'91 N and 10°41'59 E
Elevation:	????
Landform and slope:	mountains; summit, upper slope 10%
Parent material:	Gneisses and/or diorite of the Precambrian shield
Vegetation:	Forest
Drainage:	Well drained
Soil:	Very deep, yellowish brown to strong brown clay.

Depth (cm)	Hor.	Description
0- 5	Ah	dark brown dark yellowish brown (10YR3/6); clay loam; moderate to strong, very fine to fine crumb to subangular blocky; loose, friable, slightly sticky and slightly plastic; many to abundant, very fine to fine roots; clear and smooth transition to
5- 13	BA	dark yellowish brown (10YR4/6); sandy clay; moderate to strong, very fine to fine crumb to subangular blocky; soft, friable, slightly sticky and slightly plastic; common to many, fine to medium roots; clear and smooth transition to
13- 55	Bws1	yellowish brown (10YR5/8); clay; very few (<5%) small hard spherical iron concretions; moderate to strong, very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; few, medium to coarse roots; gradual and smooth transition to
55-185	Bws2	strong brown (7.5YR5/8); clay; moderate to strong, very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; few very fine to fine roots.

Profile 253										
Horizon	Depth (cm)	Particle size distribution % of fine earth; in µm				pH				
		<2	2-50	50-2000		1 : 2.5	KCl			
Ah	0 - 5	50	23	27		3.5	3			
BA	5 - 15	45	22	33		3.8	3.6			
Bws1	15 - 55	54	19	27		4.2	3.8			
Bws2	55 - 120	48	24	28		4	3.9			
Bws2	120 - 185	51	18	31		3.9	3.8			
Horizon	Exchangeable bases (NH_4OAc, pH7), meq/100 g					%		C/N	ppm	
	Na	K	Mg	Ca	TEB	Org. C	N total		Available P	Total P
Ah	0.1	0.6	1.0	2.2	3.9	9.4	0.49	19	7	
BA	0.1	0.1	0.2	0.5	0.9	2.6	0.17	15	1	
Bws1	0.0	0.0	0.2	0.5	0.7	0.8	0.07	11	0	
Bws2	0.0	0.0	0.1	0.2	0.4	0.2	0.04	6	0	
Bws2	0.0	0.1	0.1	0.5	0.7	0.4	0.05	8	0	
Horizon	meq/100 g soil		ECEC in meq/100 g		CEC in meq/100 g			%		
	Al	H	fine earth	clay	fine earth	clay	C	BS	Al Sat.	RAS
Ah	2.3	2.1	8.2	n.a.	29.5	n.a.	314	13	27	8
BA	3.6	2.6	7.1	n.a.	17.0	n.a.	n.a.	5	51	21
Bws1	2.8	1.8	5.2	10	10.8	20	n.a.	6	53	26
Bws2	2.6	1.1	4.1	9	9.1	19	n.a.	4	64	29
Bws2	2.8	1.8	5.3	10	11.3	22	n.a.	6	53	25

PROFILE 254

Legend unit: Am
Soil classification: Ferralic Cambisol (FAO)
Oxic Dystropept (Soil Taxonomy)
Description: On 11-01-96 by Gerard Hazeu
Location: About 8 km S of Meka'aII village; 2°56'91 N and 10°41'59 E
Elevation: ????
Landform and slope: mountains; upper slope 70 - 80%
Parent material: Gneisses and/or diorite of the Precambrian shield
Vegetation: Forest
Drainage: Well drained
Soil: Very deep, yellowish brown to strong brown sandy clay.

Depth (cm)	Hor.	Description
0- 7	Ah	strong brown (7.5YR4/6); sandy clay loam; moderate to strong, medium crumb to granular; loose, friable, slightly sticky and slightly plastic; common to abundant, fine to medium roots; clear and smooth transition to
7- 44	BA	strong brown (7.5YR5/6); sandy clay; moderate to strong, medium crumb to subangular blocky; loose, friable, slightly sticky and slightly plastic; few to common, fine to coarse roots; gradual and irregular transition to
44-132	Bws1	strong brown (7.5YR5/8); sandy clay; moderate fine to medium crumb to subangular blocky; friable, slightly sticky and slightly plastic; few, very fine to fine roots; gradual and smooth transition to
132-210	Bws2	strong brown (7.5YR5/8); slightly gravelly clay; few small hard spherical iron concretions; moderate fine to medium subangular blocky; friable, slightly sticky and slightly plastic; few very fine to fine roots.

Profile 254									
Horizon	Depth (cm)	Particle size distribution % of fine earth; in µm				pH			
		<2	2-50	50-2000		1 : 2.5	KCl		
Ah	0 - 7	25	13	63		4.2	3.8		
BA	7 - 44	35	15	51		3.6	3.7		
Bws1	44 - 132	36	10	54		3.5	3.7		
Bws2	132 - 210	46	18	36		4	3.8		

Horizon	Exchangeable bases (NH_4OAc, pH7), meq/100 g					%		C/N	ppm	
	Na	K	Mg	Ca	TEB	Org. C	N total		Available P	Total P
Ah	0.1	0.6	1.8	3.1	5.5	3.8	0.27	14	12	
BA	0.0	0.1	0.2	0.5	0.8	1.2	0.09	14	1	
Bws1	0.0	0.1	0.2	0.2	0.5	0.7	0.07	10	0	
Bws2	0.0	0.1	0.2	0.5	0.8	0.6	0.06	10	0	

Horizon	meq/100 g soil		ECEC in meq/100 g		CEC in meq/100 g			%		
	Al	H	fine earth	clay	fine earth	clay	C	BS	Al Sat.	RAS
Ah	0.8	0.3	6.6	n.a.	14.7	n.a.	386	38	11	5
BA	2.6	1.6	5.0	14	9.7	28	n.a.	8	52	27
Bws1	3.3	1.4	5.3	15	11.8	33	n.a.	5	63	28
Bws2	2.8	1.9	5.4	12	12.3	27	n.a.	6	51	22

PROFILE 255

Legend unit: Am
Soil classification: Ferric Acrisol (FAO)
Typic Hapludult (Soil Taxonomy)
Description: On 11-01-96 by Gerard Hazeu
Location: About 8 km S of Meka'aIl village; 2°56'91 N and 10°41'59 E
Elevation: ????
Landform and slope: mountains; middle slope 30 - 40%
Parent material: Gneisses and/or diorite of the Precambrian shield
Vegetation: Forest
Drainage: Moderately well drained
Soil: Deep, yellowish brown to strong brown.

Depth (cm)	Hor.	Description
0- 7	Ah	dark yellowish brown (10YR3/6); slightly gravelly loam; moderate fine crumb to angular blocky; loose, friable, slightly sticky and slightly plastic; few to common, fine to medium roots; clear and smooth transition to
7- 18	BA	dark yellowish brown (10YR4/6); clay loam; weak to moderate, fine angular to subangular blocky; friable, slightly sticky and slightly plastic; few fine to medium roots; gradual and smooth transition to
18- 40	Bws1	yellowish brown (10YR5/6); slightly gravelly clay loam; few small hard spherical iron concretions; weak to moderate fine angular to subangular blocky; friable, slightly sticky and slightly plastic; very few to few, fine to coarse roots; gradual and smooth transition to
40- 60/80	Bc	yellowish brown (10YR5/6); gravelly clay loam; few to frequent, small to large, soft to hard, irregular to spherical iron concretions; weak to moderate fine angular to subangular blocky; friable, slightly sticky and slightly plastic; very few very fine roots; gradual and irregular transition to
60/80-125	BC	yellowish brown (10YR5/8); gravelly, slightly stony, slightly bouldery clay loam; few (5%) fine distinct clear 5YR5/8 mottles; frequent small soft irregular to angular iron concretions; weak fine angular to subangular blocky; friable, slightly sticky and slightly plastic; no roots.

Profile 255										
Horizon	Depth (cm)	Particle size distribution % of fine earth; in µm				pH				
		<2	2-50	50-2000		1 : 25	KCl			
Ah	0 - 7	20	40	40		4.7	3.8			
BA	7 - 18	27	21	53		4.1	3.9			
Bws	18 - 40	33	23	44		3.7	3.8			
Bc	40 - 60/80	36	24	41		3.5	3.9			
BC	60/80 - 125	29	34	37		3.7	3.9			
Horizon	Exchangeable bases (NH_4OAc, pH7), meq/100 g					%		C/N	ppm	
	Na	K	Mg	Ca	TEB	Org. C	N total		Available P	Total P
Ah	0.1	0.3	0.7	1.7	2.7	2.4	0.15	16	7	
BA	0.0	0.1	0.1	0.7	1.0	0.9	0.07	12	1	
Bws	0.0	0.1	0.1	0.5	0.7	0.6	0.05	11	0	
Bc	0.0	0.1	0.2	0.5	0.7	0.3	0.04	9	0	
BC	0.0	0.1	0.1	0.5	0.6	0.2	0.02	9	0	
Horizon	meq/100 g soil		ECEC in meq/100 g		CEC in meq/100 g			%		
	Al	H	fine earth	clay	fine earth	clay	C	BS	Al Sat.	RAS
Ah	0.5	0.4	3.6	n.a.	9.7	n.a.	409	28	15	6
BA	1.8	1.4	4.2	16	6.5	24	n.a.	15	44	28
Bws	1.9	1.6	4.2	13	7.7	24	n.a.	9	46	25
Bc	1.7	1.5	4.0	11	9.2	26	n.a.	8	44	19
BC	2.2	1.3	4.2	14	7.2	24	n.a.	9	53	31

PROFILE 256

Legend unit: Am
Soil classification: Xanthic Ferralsol (FAO)
Typic Hapludox (Soil Taxonomy)
Description: On 11-01-96 by Gerard Hazeu
Location: About 8 km S of Meka'aII village; 2°56'91 N and 10°41'59 E
Elevation: ????
Landform and slope: mountains; lower slope 40 - 50%
Parent material: Gneisses and/or diorite of the Precambrian shield
Vegetation: Forest
Drainage: Well drained
Soil: Very deep, yellowish brown to strong brown clay.

Depth (cm)	Hor.	Description
0- 2	Ah	strong brown (7.5YR4/6); sandy clay; weak to moderate fine granular to subangular blocky; soft, friable, slightly sticky and slightly plastic; very few to few, very fine to fine roots; clear and smooth transition to
2- 9	BA	strong brown (7.5YR5/6); clay; moderate, fine angular to subangular blocky; friable, slightly sticky and slightly plastic; very few to few, fine to medium roots; clear and smooth transition to
9- 32	Bws1	strong brown (7.5YR5/8); slightly gravelly clay; few small hard spherical iron concretions; moderate fine angular to subangular blocky; friable, slightly sticky and slightly plastic; very few to few, fine to medium roots; gradual and smooth transition to
32-118	Bws2	strong brown (7.5YR5/8); very gravelly clay; many (25%) fine faint diffuse 2.5yr5/8 mottles; frequent small hard angular iron concretions; weak to moderate fine angular to subangular blocky; friable, slightly sticky and slightly plastic; very few very fine to fine roots; gradual and smooth transition to
118-200	BC	strong brown (7.5YR5/8); gravelly clay; many (50%) fine faint diffuse 2.5YR5/8 mottles; frequent small hard angular iron concretions; weak to moderate, fine angular to subangular blocky; friable, slightly sticky and slightly plastic; very few very fine roots.

Profile 256										
Horizon	Depth (cm)	Particle size distribution % of fine earth; in µmpH								
						pH				
		<2	2-50	50-2000		1 : 2.5	KCl			
Ah	0 - 2	55	21	24		3.4	3			
BA	2 - 9	50	14	36		3.6	3.6			
Bws1	9 - 32	59	14	27		4	4			
Bws2	32 - 118	58	15	26		3.8	3.9			
BC	118 - 200	58	15	27		3.8	3.9			
Horizon	Exchangeable bases (NH_4OAc, pH7), meq/100 g					%			ppm	
	Na	K	Mg	Ca	TEB	Org. C	N total	C/N	Available P	Total P
Ah	0.1	0.6	0.5	2.5	3.7	10.0	0.83	12	13	
BA	0.0	0.2	0.2	0.7	1.1	3.3	0.23	14	2	
Bws1	0.0	0.2	0.0	0.7	0.9	1.1	0.08	14	0	
Bws2	0.0	0.0	0.0	0.2	0.3	0.7	0.06	11	0	
BC	0.0	0.0	0.2	0.2	0.4	0.5	0.05	10	0	
Horizon	meq/100 g soil		ECEC in meq/100 g		CEC in meq/100 g			%		
	Al	H	fine earth	clay	fine earth	clay	C	BS	Al Sat.	RAS
Ah	2.8	2.2	8.6	n.a.	39.1	n.a.	393	9	32	7
BA	3.5	2.3	6.9	n.a.	15.0	n.a.	455	7	51	23
Bws1	3.2	1.3	5.4	9	10.3	18	n.a.	9	58	31
Bws2	2.5	1.2	4.0	7	7.8	13	n.a.	4	62	32
BC	2.5	1.1	4.0	7	7.5	13	n.a.	6	62	33

B. Ebom soil type

PROFILE 133

Legend unit: Cu1
Soil classification: Acri-xanthic Ferralsol (FAO)
Typic Kandiudult (Soil Taxonomy)
Description: On 16-06-95 by Gerard Hazeu
Location: About 100 m N of Mebanga village; 2°48'64 N and 10°37'87 E
Elevation: 500 m
Landform and slope: undulating to rolling uplands; lower slope 5%
Parent material: Gneisses of the Precambrian shield
Vegetation: Agricultural field
Drainage: Well drained
Soil: Deep, yellowish brown clay with sandy loam topsoil.

Depth (cm)	Hor.	Description
0- 10	Ah	dark yellowish brown (10YR3/4); sandy loam; weak very fine crumb; loose, non sticky and slightly plastic; many very fine to fine roots; clear and smooth transition to
10- 21	BA	dark yellowish brown (10YR4/6); sandy clay; weak to moderate, very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; common very fine to fine roots; gradual and smooth transition to
21- 50	Bws1	yellowish brown (10YR5/6); slightly gravelly clay; weak to moderate, very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; few very fine to fine roots; clear and smooth transition to
50- 78	Bws2	yellowish brown (10YR5/6); gravelly clay; few small to large, hard irregular iron concretions; weak to moderate, very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; no roots; gradual and smooth transition to
78-114	BC	yellowish brown (10YR5/6); gravelly to very gravelly clay; frequent small to large, soft to hard irregular iron concretions; weak to moderate, very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; no roots.

Profile 133								
Horizon	Depth (cm)	Particle size distribution % of fine earth; in µm				pH	
		<2	2-50	50-2000		1 : 2.5	KCl
Ah	0-10	20	13	67		4.4	3.5
BA	10-21	39	13	49		3.8	3.5
Bws1	21-50	43	13	44		3.8	3.5
Bws2	50-78	44	13	44		3.8	3.6
BC	78-114	44	19	37		4.3	3.6

Horizon	Exchangeable bases (NH_4OAc, pH7), meq/100 g					%		C/N	ppm	
	Na	K	Mg	Ca	TEB	Org. C	N total		Available P	Total P
Ah	0.1	0.1	0.7	2.2	3.2	2.6	0.21	12	13	269
BA	0.1	0.0	0.3	0.5	0.9	0.9	0.11	8	2	206
Bws1	0.1	0.0	0.6	0.1	0.8	0.7	0.1	7	1	212
Bws2	0.1	0.0	0.2	0.1	0.4	0.6	0.08	8	1	274
BC	0.1	0.0	0.3	0.3	0.6	0.5	0.07	7	1	537

Horizon	meq/100 g soil		ECEC in meq/100 g		CEC in meq/100 g			%		
	Al	H	fine earth	clay	fine earth	clay	C	BS	Al Sat.	RAS
Ah	0.6	0.3	4.1	n.a.	5.9	n.a.	227	54	10	14
BA	3.4	0.2	4.5	12	3.5	9	n.a.	26	97	75
Bws1	3.7	0.5	4.9	11	3.8	9	n.a.	21	99	75
Bws2	3.1	0.4	3.9	9	2.3	5	n.a.	16	100	80
BC	2.0	0.5	3.1	7	1.3	3	n.a.	48	100	64

PROFILE 135

Legend unit: Bh1
Soil classification: Acri-xanthic Ferralsol (FAO)
Typic Kandiudult (Soil Taxonomy)
Description: On 24-06-95 by Gerard Hazeu
Location: About 3 km N of Esseng village; 2°49'75 N and 10°39'53 E
Elevation: 580 m
Landform and slope: isolated hill; lower slope 25%
Parent material: Gneisses of the Precambrian shield
Vegetation: Forest
Drainage: Well drained
Soil: Moderately deep to deep, yellowish brown to strong brown clay with sandy clay loam to sandy clay topsoil.

Depth (cm)	Hor.	Description
0- 7	Ah	dark yellowish brown (10YR4/4); sandy clay loam; strongly coherent; very friable, slightly sticky and slightly plastic; few very fine roots; clear and smooth transition to
7- 25	BA	yellowish brown (10YR4/6); clay; weak to moderate, fine subangular blocky; friable, slightly sticky and slightly plastic; common to many, very fine to fine roots; clear and smooth transition to
25- 40/130	Bws1	yellowish brown (10YR5/8); clay; weak, fine subangular blocky; friable, slightly sticky and slightly plastic; very few to few, fine to medium roots; abrupt and broken transition to C and gradual and smooth to Bws2
40- 130	Bws2	yellowish brown (10YR5/8); slightly gravelly clay; few (5%) fine distinct clear 7.5YR5/8 mottles; weak fine subangular blocky; friable, slightly sticky and slightly plastic; very few to few, fine to medium roots; gradual and irregular transition to CB
40/130	C(B)	

Profile 135										
Horizon	Depth (cm)	Particle size distribution % of fine earth; in µm				pH				
		<2	2-50	50-2000		1:2.5	KCl			
Ah	0 - 7	29	17	55		5.6	4.8			
BA	7 - 25	43	15	42		4.4	3.5			
Bws1	25 - 40/130	51	15	34		4.2	3.5			
Bws2	40 - 130	61	13	26		4.2	3.5			
C(B)	40/130									
Horizon	Exchangeable bases (NH_4OAc, pH7), meq/100 g					%		C/N	ppm	
	Na	K	Mg	Ca	TEB	Org. C	N total		Available P	Total P
Ah	0.1	0.4	2.1	4.9	7.5	3.3	0.21	16	8	374
BA	0.1	0.0	0.4	0.6	1.2	1.7	0.12	14	3	257
Bws1	0.1	0.0	0.6	0.6	1.3	1.1	0.11	10	1	215
Bws2	0.1	0.0	0.3	0.1	0.4	0.9	0.09	10	1	221
C(B)										
Horizon	meq/100 g soil		ECEC in meq/100 g		CEC in meq/100 g			%		
	Al	H	fine earth	clay	fine earth	C	C	BS	Al Sat.	RAS
Ah	0.0	0.4	7.9	n.a.	8.9	n.a.	270	84	0	0
BA	2.2	0.7	4.0	9	2.5	6	151	47	87	54
Bws1	3.1	0.4	4.8	10	3.2	6	290	41	96	64
Bws2	2.9	0.5	3.8	6	2.0	3	216	22	100	76
C(B)										

PROFILE 140

Legend unit: Du1
Soil classification: Plinthic Axrisol (FAO)
Typic Plinthudult (Soil Taxonomy)
Description: On 27-06-95 by Gerard Hazeu
Location: About 8 km NE of Adjap village; 2°55'99 N and 10°37'29 E
Elevation: 350 m
Landform and slope: undulating to rolling uplands; upper slope 5 - 10%
Parent material: Gneisses and/or migmatites of the Precambrian shield
Vegetation: Forest
Drainage: Moderately well drained
Soil: Very deep, yellowish brown sandy clay to clay with sandy loam to sandy clay loam topsoil.

Depth (cm)	Hor.	Description
0- 7	Ah	dark brown to brown (10YR4/3); sandy loam; weak to moderate, very fine to fine crumb to subangular blocky; very friable, slightly sticky and slightly plastic; few to common, fine to coarse roots; clear and smooth transition to
7- 17	BA	dark yellowish brown (10YR4/6); sandy clay loam; weak fine subangular blocky; friable, slightly sticky and slightly plastic; few to common, fine to medium roots; clear and smooth transition to
17- 35	Bws1	yellowish brown (10YR5/6); slightly gravelly sandy clay loam; very few small hard spherical iron concretions; weak to moderate, very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; few to common, very fine to fine roots; gradual and smooth transition to
35- 72	Bws2	brownish yellow (10YR6/6); gravelly sandy clay; very few to few, small to large, hard angular to spherical iron concretions; weak to moderate, very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; few very fine to fine roots; gradual and irregular transition to
72-170	Bv	yellow (2.5Y7/8); very gravelly sandy clay; many (25%) medium prominent diffuse 10YR4/8 and 10YR7/8 mottles; few small to large, soft to hard, angular to spherical iron concretions; weak very fine subangular blocky and moderately coherent structure; friable, slightly sticky and slightly plastic; few very fine to fine roots.

Profile 140										
Horizon	Depth (cm)	Particle size distribution % of fine earth; in µm				pH				
		<2	2-50	50-2000		1 : 2.5	KCl			
Ah	0 - 7	19	8	73		4.1	3.8			
BA	7 - 17	26	9	65		3.7	3.6			
Bws1	17 - 35	30	9	61		5.1	3.9			
Bws2	35 - 72									
Bv	72 - 150	38	17	45		4.5	3.9			
Bv	150 - 170	37	21	41		4.5	4			
Horizon	Exchangeable bases (NH_4OAc, pH7), meq/100 g					%		C/N	ppm	
	Na	K	Mg	Ca	TEB	Org. C	N total		Available P	Total P
Ah	0.1	0.3	1.0	2.7	4.0	3.6	0.20	18	17	
BA	0.1	0.3	0.0	1.0	1.4	1.2	0.09	13	8	
Bws1	0.0	0.1	0.0	0.4	0.5	0.8	0.09	8	3	
Bws2										
Bv	0.1	0.1	0.0	0.4	0.5	0.5	0.05	9	1	
Bv	0.1	0.1	0.0	0.7	0.9	0.2	0.03	6	3	
Horizon	meq/100 g soil		ECEC in meq/100 g		CEC in meq/100 g			%		
	Al	H	fine earth	clay	fine earth	clay	C	BS	Al Sat.	RAS
Ah	0.5	0.5	4.9	n.a.	8.1	n.a.	224	51	6	9
BA	2.7	0.4	4.6	17	4.8	18	396	29	57	60
Bws1	2.4	0.6	3.6	12	4.6	15	n.a.	11	53	68
Bws2										
Bv	1.7	0.9	3.1	8	5.7	15	n.a.	9	29	54
Bv	0.5	1.0	2.4	6	4.5	12	n.a.	20	11	21

PROFILE 141

Legend unit: Du1
Soil classification: Acri-xanthic Ferralsol (FAO)
Typic Kandiudult (Soil Taxonomy)
Description: On 27-06-95 by Gerard Hazeu
Location: About 8 km NE of Adjap village; 2°55'99 N and 10°37'29 E
Elevation: 350 m
Landform and slope: undulating to rolling uplands; lower slope 10 - 15%
Parent material: Gneisses and/or migmatites of the Precambrian shield
Vegetation: Forest
Drainage: Well drained
Soil: Very deep, yellowish brown sandy clay to clay with loamy sand to sandy clay loam topsoil.

Depth (cm)	Hor.	Description
0- 5	Ah	dark yellowish brown (10YR3/4); sandy loam; weak fine crumb; very friable, non sticky and slightly plastic; common to many, very fine to medium roots; clear and smooth transition to
5- 15	BA	dark yellowish brown (10YR3/6); sandy clay loam; weak to moderate, very fine to fine crumb to subangular blocky; friable, slightly sticky and slightly plastic; few very fine to fine roots; gradual and smooth transition to
15- 55	Bws1	yellowish brown (10YR5/6); sandy clay; moderate very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; common fine to medium roots; gradual and smooth transition to
55-136	Bws2	yellowish brown (10YR5/8); slightly gravelly sandy clay; very few (2%) fine faint diffuse 7.5YR5/8 mottles; moderate very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; few to common, fine to medium roots; gradual and irregular transition to
136-167	Bws3	yellowish brown (10YR5/8); gravelly sandy clay; few (10%) fine faint diffuse 7.5YR5/8 mottles; few small hard spherical iron concretions; weak to moderate, very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; few fine to medium roots; clear and smooth transition to
167-185	Bv	yellowish brown (10YR5/8); gravelly sandy clay; many (15%) fine distinct clear 2.5YR4/8 mottles; frequent small to large, hard angular to spherical iron concretions; weak to moderate, very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; very few very fine to fine roots.

Profile 141										
Horizon	Depth (cm)	Particle size distribution % of fine earth; in µm				pH				
		<2	2-50	50-2000		1 : 2.5	KCl			
Ah	0 - 7	12	8	79		3.9	3.5			
BA	7 - 17	31	9	60		3.9	3.5			
Bws1	17 - 35	37	9	53		4.1	3.8			
Bws2	35 - 72	42	10	48		4.1	3.7			
Bws3	72 - 150	42	9	49		4.3	3.8			
Bv	150 - 170	44	11	45		4.4	3.8			
Horizon	Exchangeable bases (NH_4OAc, pH7), meq/100 g					%		C/N	ppm	
	Na	K	Mg	Ca	TEB	Org. C	N total		Available P	Total P
Ah	0.1	0.3	0.0	1.4	1.7	2.0	0.14	14	10	106
BA	0.0	0.1	0.0	0.7	0.9	1.2	0.08	15	4	143
Bws1	0.0	0.1	0.0	0.4	0.5	0.8	0.07	11	2	116
Bws2	0.0	0.0	0.0	0.4	0.5	0.6	0.05	13	2	135
Bws3	0.1	0.1	0.0	0.1	0.3	0.5	0.03	17	1	148
Bv	0.0	0.1	0.0	0.0	0.1	0.3	0.04	7	1	134
Horizon	meq/100 g soil		ECEC in meq/100 g		CEC in meq/100 g			%		
	Al	H	fine earth	clay	fine earth	clay	C	BS	Al Sat.	RAS
Ah	2.1	0.3	4.1	n.a.	7.8	n.a.	402	22	26	50
BA	2.7	0.5	4.1	13	6.7	22	574	13	41	67
Bws1	2.0	0.5	3.0	8	4.3	12	568	12	47	67
Bws2	2.6	1.0	4.1	10	5.3	12	n.a.	9	50	64
Bws3	2.5	0.7	3.4	8	7.7	18	n.a.	3	32	73
Bv	1.1	0.6	1.8	4	6.6	15	n.a.	2	17	62

PROFILE 147

Legend unit: Cu1
Soil classification: Acri-xanthic Ferralsol (FAO)
Typic Kandiudult (Soil Taxonomy)
Description: On 28-06-95 by Gerard Hazeu
Location: About 8 km NE of Adjap village; 2°55'99 N and 10°37'29 E
Elevation: 380 m
Landform and slope: undulating to rolling uplands; summit 0 - 5%
Parent material: Gneisses of the Precambrian shield
Vegetation: Forest
Drainage: Well drained
Soil: Very deep, yellowish brown clay with sandy clay loam topsoil

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Depth (cm)	Hor.	Description
0- 10	Ah	dark yellowish brown (10YR3/4); sandy clay loam; weak to moderate, very fine to fine subangular blocky; very friable, slightly sticky and slightly plastic; very few to many, very fine to coarse roots; clear and smooth transition to
10- 21	BA	dark yellowish brown (10YR3/6); sandy clay loam; weak very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; few to many, very fine to fine roots; gradual and smooth transition to
21- 87	Bws1	yellowish brown (10YR5/8); sandy clay; moderate very fine to fine crumb to subangular blocky; friable, slightly sticky and slightly plastic; few to common, very fine to fine roots; gradual and smooth transition to
87-160	Bws2	brownish yellow (10YR6/8); sandy clay; weak to moderate, very fine to fine crumb to subangular blocky; friable, slightly sticky and slightly plastic; few to common, fine to medium roots; gradual and smooth transition to
160-220	Bws3	brownish yellow (10YR6/8); slightly gravelly sandy clay; weak very fine to fine crumb to subangular blocky; friable, slightly sticky and slightly plastic; few very fine to fine roots.

Profile 147										
Horizon	Depth (cm)	Particle size distribution % of fine earth; in µm				pH				
		<2	2-50	50-2000		1:2.5	KCl			
Ah	0-10	26	10	63		4	3.5			
BA	10-21	24	8	68		4.1	3.6			
Bws1	21-87	41	8	51		4.1	3.7			
Bws2	87-160	42	8	49		4.4	3.9			
Bws3	160-220	40	10	49		4.6	4.0			
Horizon	Exchangeable bases (NH_4OAc, pH7), meq/100 g					%		C/N	ppm	
	Na	K	Mg	Ca	TEB	Org. C	N total		Available P	Total P
Ah	0.1	0.9	0.4	3.5	4.8	3.7	0.25	15	23	
BA	0.1	0.2	0.0	0.4	0.6	1.4	0.1	14	6	
Bws1	0.0	0.1	0.0	0.1	0.2	0.9	0.05	18	2	
Bws2	0.1	0.1	0.0	0.1	0.2	0.5	0.04	14	2	
Bws3	0.0	0.0	0.0	0.0	0.1	0.4	0.04	10	2	
Horizon	meq/100 g soil		ECEC in meq/100 g		CEC in meq/100 g			%		
	Al	H	fine earth	clay	fine earth	clay	C	BS	Al Sat.	RAS
Ah	1.4	0.4	6.7	n.a.	13.0	n.a.	351	37	11	21
BA	2.7	0.4	3.8	n.a.	6.7	n.a.	465	10	41	72
Bws1	2.1	0.5	2.8	7	5.8	14	n.a.	3	36	74
Bws2	1.2	0.4	1.8	4	5.8	14	n.a.	4	20	63
Bws3	1.9	0.5	2.5	6	5.5	14	n.a.	2	33	70

PROFILE 152

Legend unit:	Du2
Soil classification:	Acri-xanthic Ferralsol (FAO) Typic Kandiudult (Soil Taxonomy)
Description:	On 12-07-95 by Gerard Hazeu
Location:	About 900 m SW of Melen village; 3°02'80 N and 10°31'64 E
Elevation:	900 m
Landform and slope:	rolling uplands; summit 5%
Parent material:	Gneisses of the Precambrian shield
Vegetation:	Secondary forest
Drainage:	Well drained
Soil:	Deep, yellowish brown to strong brown clay with sandy clay loam to sandy clay topsoil.

Depth (cm)	Hor.	Description
0- 3	Ah	dark yellowish brown (10YR4/4); sandy clay loam; strong to moderate, fine crumb to subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; common very fine to fine roots; abrupt and smooth transition to
3- 16	BA	yellowish brown (10YR5/6); sandy clay; moderate fine subangular blocky; hard, friable, slightly sticky and slightly plastic; few to common, very fine to medium roots; gradual and smooth transition to
16-45/65	Bws1	strong brown (7.5YR5/8); slightly gravelly clay; few (2%) fine distinct diffuse 2.5YR5/8 mottles; very few small soft irregular iron concretions; weak to moderate, fine to medium subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; very few to few, very fine to coarse roots; gradual and wavy transition to
45/65-101	Bws2	strong brown (7.5YR5/8); gravelly clay; few (10%) fine distinct diffuse 2.5YR5/8 mottles; few small hard spherical iron concretions; weak to moderate, fine angular to subangular blocky; friable, slightly sticky and slightly plastic; very few very fine roots; gradual and broken transition to
101- 130	BC	yellow (10YR7/8); gravelly, bouldery clay; many (25%) medium distinct diffuse 2.5YR5/8 mottles; few small soft to hard, irregular to spherical iron concretions; weak to moderate, medium angular to subangular blocky; firm, slightly sticky and slightly plastic; very few very fine roots.

Profile 152										
Horizon	Depth (cm)	Particle size distribution % of fine earth; in µm				pH				
		<2	2-50	50-2000		1:2.5	KCl			
Ah	0 - 3	31	27	42		5.7	4.8			
BA	3 - 16	41	14	45		4.9	4			
Bws1	16 - 45/65	54	12	34		4.5	3.8			
Bws2	45/65 - 101	53	17	30		5	3.7			
BC	101 - 130	65	16	19		5.1	3.8			
Horizon	Exchangeable bases (NH_4OAc, pH7), meq/100 g					%		C/N	ppm	
	Na	K	Mg	Ca	TEB	Org. C	N total		Available P	Total P
Ah	0.2	0.3	4.7	5.8	11.0	4.8	0.39	12	9	282
BA	0.1	0.1	0.8	1.9	2.9	0.8	0.1	8	1	139
Bws1	0.1	0.1	0.8	0.9	1.8	0.5	0.05	9	0	127
Bws2	0.2	0.1	1.0	0.6	1.8	0.3	0.03	11	0	107
BC	0.2	0.1	1.5	3.3	5.0	0.2	0.05	4	0	85
Horizon	meq/100 g soil		ECEC in meq/100 g		CEC in meq/100 g			%		
	Al	H	fine earth	clay	fine earth	clay	C	BS	Al Sat.	RAS
Ah	0.0	0.5	11.5	n.a.	15.2	n.a.	314	73	0	0
BA	1.9	0.4	5.2	13	5.7	14	n.a.	50	32	36
Bws1	3.3	0.5	5.6	10	5.5	10	n.a.	33	60	58
Bws2	1.6	0.3	3.7	7	5.9	11	n.a.	31	27	43
BC	1.5	0.4	6.9	11	9.2	14	n.a.	55	16	22

PROFILE 153

Legend unit: Du2
Soil classification: Haplic Acrisol (FAO)
Typic Kandiudult (Soil Taxonomy)
Description: On 12-07-95 by Gerard Hazeu
Location: About 900 m SW of Melen village; 3°02'80 N and 10°31'64 E
Elevation: 700 m
Landform and slope: rolling uplands; middle slope 70%
Parent material: Gneisses of the Precambrian shield
Vegetation: Secondary forest
Drainage: Well drained
Soil: Very deep, yellowish brown clay with sandy clay loam to sandy clay topsoil.

Depth (cm)	Hor.	Description
0- 7	Ah	dark brown (10YR3/3); clay loam; strong to moderate, fine crumb to subangular blocky; friable, slightly sticky and slightly plastic; common fine to medium roots; clear and smooth transition to
7- 32	BA	dark yellowish brown (10YR4/6); clay loam; moderate to strong, fine to medium, angular to subangular blocky; firm, slightly sticky and slightly plastic; few to many, fine to medium roots; gradual and wavy transition to
32-112	Bws1	yellowish brown (10Y5/8); slightly gravelly clay; moderate fine to medium angular to subangular blocky; firm, slightly sticky and slightly plastic; common very fine to fine roots; gradual and smooth transition to
112-150	Bws2	brownish yellow (10YR6/8); slightly gravelly clay loam; weak very fine to fine, angular to subangular blocky and strongly coherent porous massive structure; friable, slightly sticky and slightly plastic; very few to few, very fine to fine roots; gradual and smooth transition to
150-180	BC	brownish yellow (10YR6/8); sandy clay loam; weak fine subangular blocky and strongly coherent porous massive; friable, slightly sticky and slightly plastic; no roots.

Profile 153								
Horizon	Depth (cm)	Particle size distribution % of fine earth; in µm				pH	
		<2	2-50	50-2000		1:2.5	KCl
Ah	0 - 7	30	31	39		6.2	5.9
BA	7 - 32	35	24	41		5.3	4.5
Bws1	32 - 112	48	25	27		5.1	3.6
Bws2	112 - 150	32	26	42		5.4	3.8
BC	150 - 180	26	31	43		5.5	4.4

Horizon	Exchangeable bases (NH_4OAc, pH7), meq/100 g					%		C/N	ppm	
	Na	K	Mg	Ca	TEB	Org. C	N total		Available P	Total P
Ah	0.2	0.6	10.7	9.1	20.5	6.3	0.44	14	11	432
BA	0.2	0.1	3.1	1.5	4.8	0.7	0.05	14	1	130
Bws1	0.2	0.0	3.4	1.5	5.1	0.4	0.04	9	0	111
Bws2	0.3	0.0	3.3	1.5	5.1	0.3	0.04	9	1	71
BC	0.4	0.0	3.3	1.5	5.2	0.0	0.03	1	0	75

Horizon	meq/100 g soil		ECEC in meq/100 g		CEC in meq/100 g			%		
	Al	H	fine earth	clay	fine earth	clay	C	BS	Al Sat.	RAS
Ah	0.0	0.2	20.7	n.a.	26.5	n.a.	418	78	0	0
BA	0.3	0.3	5.4	16	5.2	15	n.a.	94	6	5
Bws1	1.2	0.5	6.8	14	6.4	13	n.a.	80	18	17
Bws2	0.8	0.7	6.5	20	5.4	17	n.a.	95	14	12
BC	0.4	0.4	5.9	23	4.0	15	n.a.	100	11	7

PROFILE 166

Legend unit: Cu1
Soil classification: Xanthic Ferralsol (FAO)
Typic Hapludox (Soil Taxonomy)
Description: On 22-07-95 by Gerard Hazeu
Location: About 1 km S of Ebom II village; 3°04'05 N and 10°42'59 E
Elevation: 390 m
Landform and slope: undulating to rolling uplands; summit, upper slope 10 - 15%
Parent material: Gneisses of the Precambrian shield
Vegetation: Forest
Drainage: Well drained
Soil: Very deep, yellowish brown clay with clayey topsoil.

Depth (cm)	Hor.	Description
0- 4	Ah	brown (7.5YR4/3); clay; moderate to strong, very fine crumb; loose, very friable, slightly sticky and slightly plastic; common to many, very fine to fine roots; clear and smooth transition to
4- 10	BA	strong brown (7.5YR4/6); clay; moderate to strong, fine subangular blocky; friable, slightly sticky and slightly plastic; few to common, fine to medium roots; clear and smooth transition to
10- 23	Bws1	strong brown (7.5YR5/6); clay; moderate to strong, fine to medium subangular blocky; friable, slightly sticky and slightly plastic; few to common, fine to medium roots; gradual and smooth transition to
23- 60	Bws2	strong brown (7.5YR5/8); clay; moderate fine subangular blocky; friable, slightly sticky and slightly plastic; common very fine to fine roots; diffuse and smooth transition to
60-200	Bws3	strong brown (7.5YR5/8); clay; few (5%) fine faint diffuse 5YR5/8 mottles; moderate very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; few very fine to fine roots.

Profile 166							
Horizon	Depth (cm)	Particle size distribution % of fine earth; in µm				pH	
		<2	2-50	50-2000		1:2.5	KCl
Ah	0-4	48	16	35		4.9	3.8
BA	4-10	50	12	38		3.4	3
Bws1	10-23	52	14	34		3.6	3.2
Bws2	23-60	56	13	32		3.6	3.4
Bws3	60-200(100)	60	11	30		4	3.6
Bws3	60-200(150)	59	13	29		4	3.6

Horizon	Exchangeable bases (NH_4OAc, pH7), meq/100 g					%		C/N	ppm	
	Na	K	Mg	Ca	TEB	Org. C	N total		Available P	Total P
Ah	0.2	0.2	1.3	0.5	2.2	7.2	0.59	12	26	498
BA	0.0	0.0	0.2	0.0	0.3	2.4	0.2	12	7	352
Bws1	0.1	0.0	0.2	0.0	0.3	1.6	0.15	11	2	353
Bws2	0.1	0.0	0.1	0.0	0.2	1.0	0.11	9	1	317
Bws3	0.1	0.0	0.0	0.4	0.5	0.7	0.07	9	1	431
Bws3	0.1	0.0	0.1	0.0	0.1	0.6	0.06	9	1	345

Horizon	meq/100 g soil		ECEC in meq/100 g		CEC in meq/100 g			%		
	Al	H	fine earth	clay	fine earth	clay	C	BS	Al Sat.	RAS
Ah	1.5	0.6	4.4	n.a.	26.1	n.a.	364	8	6	35
BA	6.1	0.5	6.8	n.a.	12.3	n.a.	511	2	50	89
Bws1	5.5	0.5	6.2	n.a.	13.6	n.a.	853	2	40	88
Bws2	4.9	0.5	5.6	10	9.3	17	n.a.	2	53	87
Bws3	2.8	0.4	3.7	6	7.2	12	n.a.	7	39	77
Bws3	2.2	0.4	2.7	5	11.7	20	n.a.	1	19	80

PROFILE 167

Legend unit: Cu1
Soil classification: Xanthic Ferralsol (FAO)
Typic Hapludox (Soil Taxonomy)
Description: On 22-07-95 by Gerard Hazeu
Location: About 1 km S of Ebom II village; 3°04'05 N and 10°42'59 E
Elevation: 370 m
Landform and slope: undulating to rolling uplands; lower slope 10 - 15%
Parent material: Gneisses of the Precambrian shield
Vegetation: Forest
Drainage: Well drained
Soil: Very deep, yellowish brown clay with sandy clay topsoil.

Depth (cm)	Hor.	Description
0- 6	Ah	dark yellowish brown (10YRYR4/4); sandy clay; moderate to strong, very fine crumb to subangular blocky; loose, very friable, slightly sticky and slightly plastic; common to abundant, fine to medium roots; clear and smooth transition to
6- 15	AB	dark yellowish brown (10YR4/6); sandy clay; moderate very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; few to common, fine to medium roots; gradual and smooth transition to
15- 28	BA	yellowish brown (10YR5/6); clay; moderate very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; few to many, fine to coarse roots; gradual and smooth transition to
28-118	Bws1	yellowish brown (10YR5/8); clay; weak to moderate, very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; few to many, very fine to fine roots; gradual and smooth transition to
118-200	Bws2	yellowish brown (10YR5/8); clay; few (15%) fine faint diffuse 2.5YR4/8 mottles; weak to moderate, very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; few very fine to fine roots.

Profile 167

Horizon	Depth (cm)	Particle size distribution % of fine earth; in µm				pH	
		<2	2-50	50-2000		1:2.5	KCl
Ah	0 - 6	38	16	46		4.1	3.9
AB	6 - 15	36	12	52		4	3.2
BA	15 - 28	40	16	44		4.2	3.4
Bws1	28 - 118	45	16	39		4	3.7
Bws2	118 - 200	47	16	37		4	3.4

Horizon	Exchangeable bases (NH_4OAc, pH7), meq/100 g					%		C/N	ppm	
	Na	K	Mg	Ca	TEB	Org. C	N total		Available P	Total P
Ah	0.1	0.2	1.1	2.0	3.4	7.9	0.55	14	28	489
AB	0.1	0.0	0.2	0.0	0.3	2.7	0.2	13	7	284
BA	0.1	0.0	0.0	0.2	0.3	1.3	0.11	11	2	226
Bws1	0.1	0.0	0.0	0.0	0.1	0.9	0.06	14	1	207
Bws2	0.1	0.0	0.2	0.0	0.3	0.9	0.07	12	1	260

Horizon	meq/100 g soil		ECEC in meq/100 g		CEC in meq/100 g			%		
	Al	H	fine earth	clay	fine earth	clay	C	BS	Al Sat.	RAS
Ah	1.6	0.2	5.2	n.a.	25.3	n.a.	321	14	6	30
AB	4.4	0.4	5.0	n.a.	9.1	n.a.	342	3	48	88
BA	3.9	0.5	4.7	12	3.7	9	296	7	100	84
Bws1	3.1	0.4	3.7	8	5.0	11	n.a.	3	63	84
Bws2	2.7	0.3	3.3	7	3.4	7	n.a.	8	79	82

PROFILE 181

Legend unit: Cu2/Du1
Soil classification: Acri-xanthic Ferralsol (FAO)
Typic Kandiudult (Soil Taxonomy)
Description: On 26-07-95 by Gerard Hazeu
Location: About 2 km NE of Obo'otomba village; 3°04'11 N and 10°35'68 E
Elevation: unknown
Landform and slope: rolling uplands; summit, upper slope 10%
Parent material: Gneisses and/or migmatites of the Precambrian shield
Vegetation: Forest
Drainage: Well drained
Soil: Deep, yellowish brown clay with sandy clay loam to sandy clay topsoil

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Depth (cm)	Hor.	Description
0- 3	Ah	dark brown (10YR3/3); sandy clay loam; moderate very fine to fine crumb to subangular blocky; very friable, slightly sticky and slightly plastic; few to abundant, very fine to medium roots; abrupt and smooth transition to
3- 15	BA	dark yellowish brown (10YR4/6); sandy clay loam; weak to moderate, fine angular to subangular blocky; friable, slightly sticky and slightly plastic; very few to common, fine to medium roots; gradual and wavy transition to
15- 30	Bws1	yellowish brown (10YR5/6); sandy clay to clay; moderate fine subangular blocky; firm, slightly sticky and slightly plastic; very few to common, fine to medium roots; gradual and smooth transition to
30- 71	Bws2	yellowish brown (10YR5/8); slightly gravelly clay; very few small soft irregular iron concretions; weak to moderate, fine subangular blocky; firm, slightly sticky and slightly plastic; few to common, fine to medium roots; gradual and smooth transition to
71-145	Bws3	yellowish brown (10YR5/8); gravelly to very gravelly, slightly stony clay; few (5%) fine faint diffuse 7.5YR5/8 mottles; very few to few, small soft to hard, irregular to spherical iron concretions; weak very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; few very fine roots; diffuse and smooth transition to
145-175	Bv	yellowish brown (10YR5/8); gravelly clay; few to frequent, small soft to hard, irregular to spherical iron concretions; weak very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; few very fine roots.

Profile 181									
Horizon	Depth (cm)	Particle size distribution % of fine earth; in µm				pH			
		<2	2-50	50-2000		1:2.5	KCl		
Ah	0-3	31	20	49		4.6	3.8		
BA	3-15	30	16	54		4.5	3.7		
Bws1	15-30	41	14	45		3.9	3.6		
Bws2	30-71	43	14	44		4.3	3.8		
Bws3	71-145	46	15	39		4.8	3.8		
Bv	145-175	49	16	34		4.7	3.9		
Horizon	Exchangeable bases (NH_4OAc, pH7), meq/100 g					%		C/N	ppm	
	Na	K	Mg	Ca	TEB	Org. C	N total		Available P	Total P
Ah	0.1	0.9	1.6	4.0	6.5	6.6	0.46	14	14	161
BA	0.1	0.3	0.1	1.0	1.4	1.3	0.11	11	4	85
Bws1	0.0	0.2	0.0	0.4	0.6	0.6	0.07	9	2	86
Bws2	0.0	0.1	0.0	0.4	0.6	0.6	0.08	7	3	105
Bws3	0.0	0.0	0.0	0.1	0.2	0.1	0.06	2	1	71
Bv	0.1	0.1	0.0	0.4	0.6	0.2	0.06	3	5	74
Horizon	meq/100 g soil		ECEC in meq/100 g		CEC in meq/100 g			%		
	Al	H	fine earth	clay	fine earth	clay	C	BS	Al Sat.	RAS
Ah	1.0	0.6	8.1	n.a.	18.0	n.a.	274	36	6	13
BA	2.6	0.4	4.4	n.a.	6.5	n.a.	513	22	40	58
Bws1	2.9	0.3	3.7	9	5.8	14	n.a.	10	50	77
Bws2	2.7	0.5	3.8	9	5.3	12	n.a.	12	51	71
Bws3	1.6	0.6	2.4	5	5.8	13	n.a.	3	28	68
Bv	2.2	0.4	3.1	6	10.6	21	n.a.	5	20	70

PROFILE 182

Legend unit: Cu2/Du1
Soil classification: Haplic Acrisol (FAO)
Typic Paleudult (Soil Taxonomy)
Description: On 26-07-95 by Gerard Hazeu
Location: About 2 km NE of Obo'otomba village; 3°04'11 N and 10°35'68 E
Elevation: ???? m
Landform and slope: undulating to rolling uplands; middle slope 20 - 25%
Parent material: Gneisses and/or migmatites of the Precambrian shield
Vegetation: Forest
Drainage: Moderately well drained
Soil: Very deep, yellowish brown clay with sandy clay loam to sandy clay topsoil

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Depth (cm)	Hor.	Description
0- 2	Ah	brown (10YR5/3); loamy sand; weakly coherent single grain; loose to very friable, non sticky and slightly plastic; few fine to medium roots; clear and smooth transition to
2- 12	BA	yellowish brown (10YR5/6); sandy clay loam; weak very fine to fine subangular blocky; very friable, slightly sticky and slightly plastic; few fine to medium roots; clear and smooth transition to
12- 32	Bws1	brownish yellow (10YR6/8); very gravelly sandy clay; many (15%) fine faint diffuse 7.5YR5/8 mottles; frequent small to large, hard irregular to angular iron concretions; weak very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; few fine to medium roots; diffuse and irregular transition to
32- 130	Bv	brownish yellow (10YR6/8); gravelly, slightly stony clay; many (25%) fine distinct diffuse 7.5.YR5/8 mottles; few to frequent, small to large, soft to hard, irregular to angular iron concretions; weak very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; few very fine to fine roots; gradual and smooth transition to
130- 170	BC	brownish yellow (10YR6/8); gravelly, slightly stony clay; many (25%) medium distinct diffuse 7.5YR5/8 mottles; few to frequent, small to large, soft to hard, irregular to angular iron concretions; weak very fine subangular blocky and strongly coherent porous massive structure; friable, slightly sticky and slightly plastic; few very fine to fine roots.

Profile 182									
Horizon	Depth (cm)	Particle size distribution % of fine earth; in µm				pH			
		<2	2-50	50-2000		1:2.5	KCl		
Ah	0 - 2	6	13	82		4.5	3.8		
BA	2 - 12	29	14	57		4.7	3.8		
Bws	12 - 32	37	15	48		4.5	3.8		
Bv	32 - 100	52	15	33		4.2	3.8		
Bv	100 - 130	54	17	28		4.7	4		
Bc	130 - 170	55	18	27		4.6	3.9		
Horizon	Exchangeable bases (NH_4OAc, pH7), meq/100 g					%		C/N	ppm	
	Na	K	Mg	Ca	TEB	Org. C	N total		Available P	Total P
Ah	0.1	0.6	1.2	3.7	5.5	2.8	0.21	13	22	
BA	0.0	0.1	0.0	0.1	0.2	0.6	0.07	9	4	
Bws	0.0	0.0	0.0	0.1	0.2	0.5	0.06	8	2	
Bv	0.1	0.1	0.1	0.5	0.7	0.5	0.08	6	2	
Bv	0.1	0.1	0.1	0.4	0.7	0.2	0.08	2	1	
Bc	0.1	0.2	0.0	0.7	1.0	0.2	0.05	4	2	
Horizon	meq/100 g soil		ECEC in meq/100 g		CEC in meq/100 g			%		
	Al	H	fine earth	clay	fine earth	clay	C	BS	Al Sat.	RAS
Ah	0.1	0.2	5.8	n.a.	10.0	n.a.	355	55	1	2
BA	0.9	0.5	1.5	5	3.8	13	608	6	22	56
Bws	1.6	0.3	2.1	6	5.8	15	n.a.	3	28	78
Bv	2.0	0.5	3.3	6	13.9	27	n.a.	5	15	62
Bv	1.7	0.5	2.9	5	12.3	23	n.a.	5	14	60
Bc	1.5	0.3	2.8	5	9.3	17	n.a.	10	16	54

PROFILE 201

Legend unit: Cu2
Soil classification: Acri-xanthic Ferralsol (FAO)
Typic Kandiudox (Soil Taxonomy)
Description: On 10-08-95 by Gerard Hazeu
Location: About 1.5 km S of Engomba village; 3°04'84 N and 10°39'45 E
Elevation: 390 m
Landform and slope: rolling uplands; summit, upper slope 10 - 15%
Parent material: Gneisses of the Precambrian shield
Vegetation: Forest
Drainage: Well drained
Soil: Very deep, yellowish brown clay with sandy clay loam to sandy clay topsoil

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Depth (cm)	Hor.	Description
0- 5	Ah	very dark brown (7.5YR2.5/3); sandy clay loam; moderate to strong, very fine to fine crumb to subangular blocky; very friable, slightly sticky and slightly plastic; common to many, very fine to fine roots; clear and smooth transition to
5- 18	BA	dark yellowish brown (10YR4/6); sandy clay to clay; moderate to strong, very fine to fine crumb to subangular blocky; friable, slightly sticky and slightly plastic; few to common, fine to coarse roots; clear and smooth transition to
18- 61	Bws1	yellowish brown (10YR5/6); clay; moderate very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; few to common, fine to medium roots; gradual and wavy transition to
61- 95	Bws2	yellowish brown (10YR5/8); slightly gravelly clay; few small hard spherical iron concretions; weak to moderate, fine to medium subangular blocky; friable, slightly sticky and slightly plastic; very few to few, very fine to fine roots; gradual and wavy transition to
95-152	Bws3	yellowish brown (10YR5/8); slightly gravelly clay; very few (<5%) fine distinct diffuse 2.5YR4/8 mottles; few small hard spherical iron concretions; weak fine to medium subangular blocky; friable, slightly sticky and slightly plastic; very few to few, fine to medium roots; gradual and smooth transition to
152-185	Bws4	yellowish brown (10YR5/8); gravelly clay; many (25%) fine to medium, distinct diffuse 2.5YR4/8 mottles; few small to large, hard irregular to spherical iron concretions; weak fine to medium subangular blocky; friable, slightly sticky and slightly plastic; very few very fine to fine roots.

Profile 201										
Horizon	Depth (cm)	Particle size distribution % of fine earth; in µm				pH				
		<2	2-50	50-2000		1:2.5	KCl			
Ah	0-5	33	16	51		3.8	3.3			
BA	5-18	42	15	43		3.7	3.4			
Bws1	18-61	55	11	34		4.1	3.5			
Bws2	61-95	39	9	52		4.2	3.9			
Bws3	95-152	52	15	33		4	3.6			
Bws4	152-185	45	15	40		2.9	3.6			
Horizon	Exchangeable bases (NH_4OAc, pH7), meq/100 g					%		C/N	ppm	
	Na	K	Mg	Ca	TEB	Org. C	N total		Available P	Total P
Ah	0.1	0.9	1.2	4.5	6.7	6.6	0.53	12	23	221
BA	0.1	0.2	0.0	0.7	1.0	1.5	0.11	14	6	105
Bws1	0.0	0.1	0.0	0.4	0.5	0.5	0.05	11	2	90
Bws2	0.0	0.1	0.0	0.4	0.5	0.8	0.05	16	3	144
Bws3	0.0	0.1	0.0	0.1	0.2	0.7	0.07	10	3	93
Bws4	0.0	0.1	0.0	0.1	0.2	0.5	0.04	11	1	82
Horizon	meq/100 g soil		ECEC in meq/100 g		CEC in meq/100 g			%		
	Al	H	fine earth	clay	fine earth	clay	C	BS	Al Sat.	RAS
Ah	1.9	0.8	9.3	n.a.	12.8	n.a.	193	52	14	20
BA	4.3	0.6	5.9	n.a.	8.7	n.a.	563	12	50	74
Bws1	3.5	0.7	4.7	9	9.2	17	n.a.	5	38	74
Bws2	1.8	0.3	2.6	7	7.2	19	n.a.	7	25	69
Bws3	3.0	0.5	3.7	7	8.2	16	n.a.	3	36	81
Bws4	2.7	0.4	3.2	7	8.2	18	n.a.	2	33	84

PROFILE 202

Legend unit: Cu2
Soil classification: Acri-xanthic Ferralsol (FAO)
Typic Kandiudult (Soil Taxonomy)
Description: On 10-08-95 by Gerard Hazeu
Location: About 1.5 km S of Engomba village; 3°04'84 N and 10°39'45 E
Elevation: 360 m
Landform and slope: rolling uplands; lower slope 15 - 20%
Parent material: Gneisses of the Precambrian shield
Vegetation: Forest
Drainage: Well drained
Soil: Very deep, yellowish brown clay with sandy clay loam to sandy clay topsoil.

Depth (cm)	Hor.	Description
0- 9	Ah	dark brown (10YR3/3); sandy clay loam; moderate fine crumb to subangular blocky; very friable, slightly sticky and slightly plastic; common fine to medium roots; clear and smooth transition to
9- 20	BA	dark yellowish brown (10YR4/4); sandy clay loam; moderate fine subangular blocky; friable, slightly sticky and slightly plastic; very few to common, fine to medium roots; clear and wavy transition to
20- 57	Bws1	yellowish brown (10YR5/6); sandy clay; few (5%) medium faint to distinct, diffuse 5YR5/8 mottles; weak to moderate, very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; patchy thin clay and humus cutans; very few to common, fine to coarse roots; gradual and wavy transition to
57-160	Bws2	yellowish brown (10YR5/8); slightly gravelly clay; few medium faint diffuse 5YR5/8 mottles; very few (<5%) small hard spherical iron concretions; weak very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; patchy thin clay and humus cutans; few to common, very fine to fine roots; gradual and smooth transition to
160-200	Bv	yellowish brown (10YR5/8); gravelly clay; many (35%) medium faint diffuse 2.5YR4/8 mottles; frequent small soft irregular iron concretions; weak very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; very few to common, very fine to medium roots.

Profile 202									
Horizon	Depth (cm)	Particle size distribution % of fine earth; in µm				pH			
		<2	2-50	50-2000		1:2.5	KCl		
Ah	0 - 9	22	5	73		4	3.5		
BA	9 - 20	28	13	60		4.2	3.6		
Bws1	20 - 57	38	14	48		4.2	3.7		
Bws2	57 - 160	43	13	44		4.5	3.9		
Bv	160 - 200	47	13	39		4.9	3.8		

Horizon	Exchangeable bases (NH_4OAc, pH7), meq/100 g					%		C/N	ppm	
	Na	K	Mg	Ca	TEB	Org. C	N total		Available P	Total P
Ah	0.1	0.7	0.5	2.9	4.2	5.0	0.31	16	15	
BA	0.0	0.2	0.0	0.7	0.9	1.3	0.09	14	4	
Bws1	0.0	0.2	0.0	1.0	1.3	0.8	0.08	10	2	
Bws2	0.1	0.4	0.0	1.6	2.1	0.6	0.09	7	9	
Bv	0.0	0.2	0.0	0.7	0.9	0.3	0.02	16	1	

Horizon	meq/100 g soil		ECEC in meq/100 g		CEC in meq/100 g			%		
	Al	H	fine earth	clay	fine earth	clay	C	BS	Al Sat.	RAS
Ah	1.0	0.9	6.0	n.a.	15.4	n.a.	305	27	6	16
BA	1.7	0.6	3.1	11	5.7	21	456	15	29	54
Bws1	1.7	0.7	3.7	10	6.2	17	n.a.	20	27	47
Bws2	1.8	0.3	4.2	10	6.2	15	n.a.	33	28	42
Bv	1.5	0.4	2.8	6	5.8	12	n.a.	16	26	54

PROFILE 204

Legend unit: Cu2
Soil classification: Acri-xanthic Ferralsol (FAO)
Typic kandiudult (Soil Taxonomy)
Description: On 10-08-95 by Gerard Hazeu
Location: About 1 km S of Engomba village; 3°04'84 N and 10°39'45 E
Elevation: 390 m
Landform and slope: rolling uplands; upper slope 10 - 15%
Parent material: Gneisses of the Precambrian shield
Vegetation: Forest
Drainage: Well drained
Soil: Very deep, yellowish brown clay with sandy clay loam to sandy clay topsoil.

Depth (cm)	Hor.	Description
0- 6	Ah	dark yellowish brown (10YR3/4); sandy clay loam; moderate to strong, very fine crumb to subangular blocky; very friable, slightly sticky and slightly plastic; common to many, very fine to fine roots; clear and smooth transition to
6- 16	BA	yellowish brown (10YR5/6); sandy clay; weak to moderate, very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; few to common, very fine to fine roots; clear and smooth transition to
16- 47	Bws1	yellowish brown (10YR5/8); clay; few (5%) fine to medium, faint, diffuse 7.5YR6/8 mottles; weak very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; patchy thin clay cutans; few to common, fine to coarse roots; diffuse and smooth transition to
47-200	Bws2	yellowish brown (10YR5/8); clay; few (10%) medium distinct diffuse 7.5YR6/8 mottles; weak very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; few very fine to fine roots.

Profile 204									
Horizon	Depth (cm)	Particle size distribution % of fine earth; in µm				pH			
		<2	2-50	50-2000		1:2.5	KCl		
Ah	0 - 6	23	16	61		4	3.2		
BA	6 - 16	33	13	54		4	3.4		
Bws1	16 - 47	46	12	42		4.6	3.9		
Bws2	47 - 150	48	14	39		4.7	2.8		
Bws2	150 - 200	50	13	37		4.3	3.8		
Horizon	Exchangeable bases (NH_4OAc, pH7), meq/100 g					%		C/N	ppm	
	Na	K	Mg	Ca	TEB	Org. C	N total		Available P	Total P
Ah	0.1	0.4	0.6	2.0	3.0	5.7	0.33	17	22	
BA	0.0	0.2	0.0	0.7	0.9	1.1	0.1	11	4	
Bws1	0.1	0.1	0.0	0.7	0.9	0.5	0.05	9	1	
Bws2	0.0	0.1	0.0	0.4	0.5	0.4	0.05	7	1	
Bws2	0.1	0.2	0.0	1.0	1.3	0.3	0.05	6	2	
Horizon	meq/100 g soil		ECEC in meq/100 g		CEC in meq/100 g			%		
	Al	H	fine earth	clay	fine earth	clay	C	BS	Al Sat.	RAS
Ah	2.6	0.5	6.1	n.a.	16.5	n.a.	288	18	16	42
BA	2.7	0.5	4.1	13	6.8	21	625	13	40	66
Bws1	2.2	0.6	3.7	8	6.7	15	n.a.	13	33	61
Bws2	2.2	0.6	3.3	7	5.3	11	n.a.	10	41	66
Bws2	2.1	0.3	3.6	7	5.5	11	n.a.	23	37	57

PROFILE 213

Legend unit: Bh2
Soil classification: Acri-xanthic Ferralsol (FAO)
Typic Kandiudult (Soil Taxonomy)
Description: On 12-08-95 by Gerard Hazeu
Location: About 1 km S of Ma'amenyin village; 3°03'58 N and 10°46'42 E
Elevation: 520 m
Landform and slope: complex of hills; middle slope 20 - 25%
Parent material: Gneisses of the Precambrian shield
Vegetation: Forest
Drainage: Well drained
Soil: Deep, yellowish brown sandy clay to clay with sandy loam to sandy clay loam topsoil.

Depth (cm)	Hor.	Description
0 - 4	Ah	dark yellowish brown (10YR3/6); sandy loam; weak very fine subangular blocky and moderately coherent single grain; very friable, slightly sticky and slightly plastic; few to common, very fine to medium roots; clear and smooth transition to
4 - 17	BA	yellowish brown (10YR5/6); sandy clay; weak very fine subangular blocky; friable, slightly sticky and slightly plastic; patchy thin clay cutans; few very fine to fine roots; gradual and smooth transition to
17 -73	Bws1	yellowish brown (10YR5/8); clay; weak to moderate, very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; very few to few, fine to coarse roots; clear and smooth transition to
73 - 108/120	Bws2	yellowish brown (10YR5/8); very gravelly sandy clay; few small to large, hard angular to spherical iron concretions; weak to moderate, very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; few very fine roots; gradual and wavy transition to
108/120 - 145	BC	yellowish brown (10YR5/8); gravelly clay; many (15%) fine to medium, distinct diffuse 5YR6/8 mottles; very few small to large, soft to hard, irregular to angular iron concretions; weak very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; very few very fine roots.

Profile 213									
Horizon	Depth (cm)	Particle size distribution % of fine earth; in µm				pH			
		<2	2-50	50-2000		1:2.5	KCl		
Ah	0 - 4	13	8	79		5.8	4.9		
BA	4 - 17	40	12	48		4.5	3.5		
Bws1	17 - 73	48	12	40		4	3.5		
Bws2	73 - 108/120	37	18	45		4.5	3.5		
BC	108/120 - 145	48	14	39		4.6	3.6		
Horizon	Exchangeable bases (NH_4OAc, pH7), meq/100 g					%		C/N	ppm	
	Na	K	Mg	Ca	TEB	Org. C	N total		Available P	Total P
Ah	0.1	0.5	1.7	5.1	7.4	3.5	0.29	12	15	320
BA	0.2	0.1	0.4	0.6	1.3	1.1	0.11	10	2	222
Bws1	0.1	0.1	0.4	0.5	1.0	0.7	0.08	8	1	84
Bws2	0.0	0.1	0.1	0.3	0.5	0.5	0.09	5	1	97
BC	0.1	0.1	0.0	0.9	1.0	0.7	0.07	10	1	100
Horizon	meq/100 g soil		ECEC in meq/100 g		CEC in meq/100 g			%		
	Al	H	fine earth	clay	fine earth	clay	C	BS	Al Sat.	RAS
Ah	0.0	0.4	7.8	n.a.	8.4	n.a.	237	88	0	0
BA	2.0	0.5	3.7	9	2.3	6	202	55	87	53
Bws1	2.6	0.5	4.1	9	3.8	8	n.a.	26	70	64
Bws2	1.8	0.4	2.7	7	3.5	10	n.a.	14	51	66
BC	1.5	0.4	3.0	6	5.2	11	n.a.	19	29	52

PROFILE 216

Legend unit:	Bh2
Soil classification:	Acri-xanthic Ferralsol (FAO) Typic Kandiudult (Soil Taxonomy)
Description:	On 12-08-95 by Gerard Hazeu
Location:	About 1 km S of Ma'amenyin village; 3°03'58 N and 10°46'42 E
Elevation:	450 m
Landform and slope:	complex of hills; lower slope 25 - 35%
Parent material:	Gneisses of the Precambrian shield
Vegetation:	Forest
Drainage:	Well drained
Soil:	Very deep, yellowish brown clay with sandy clay loam to sandy clay topsoil.

Depth (cm)	Hor.	Description
0- 6	Ah	very dark brown (7.5YR2.5/3); sandy clay loam to sandy clay; moderate very fine to fine crumb to subangular blocky; friable, slightly sticky and slightly plastic; few to many, fine to coarse roots; clear and smooth transition to
6- 20	BA	dark yellowish brown (10YR4/6); sandy clay; moderate very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; few to many, fine to medium roots; gradual and smooth transition to
20- 45	Bws1	yellowish brown (10YR5/6); clay; weak to moderate, very fine subangular blocky; friable, slightly sticky and slightly plastic; very few to many, fine to coarse roots; clear and smooth transition to
45-120	Bws2	yellowish brown (10YR5/8); clay; very few (2%) fine faint diffuse 5YR5/8 mottles; weak to moderate, very fine subangular blocky; friable, slightly sticky and slightly plastic; few to common, very fine to fine roots; clear and wavy transition to
120-200	BC	yellowish brown (10YR5/8); gravelly, slightly stony clay; many (15%) fine faint diffuse 5YR5/8 mottles; few small to large, hard irregular to angular iron concretions; weak very fine subangular blocky; friable, slightly sticky and slightly plastic; very few very fine to fine roots.

Profile 216

Horizon	Depth (cm)	Particle size distribution % of fine earth; in µm				pH	
		<2	2-50	50-2000		1:2.5	KCl
Ah	0-6	35	12	53		4	3.4
BA	6-20	37	14	49		3.9	3.6
Bws1	20-45	47	13	40		3.9	3.4
Bws2	45-120	49	12	39		4	3.7
BC	120-200	46	12	41		4.7	3.9

Horizon	Exchangeable bases (NH_4OAc, pH7), meq/100 g					%		C/N	ppm	
	Na	K	Mg	Ca	TEB	Org. C	N total		Available P	Total P
Ah	0.2	0.3	1.0	0.6	2.1	7.7	0.5	15	16	338
BA	0.1	0.1	0.1	0.5	0.8	1.7	0.11	15	3	209
Bws1	0.0	0.0	0.0	0.2	0.3	1.1	0.08	14	1	146
Bws2	0.0	0.0	0.4	0.4	0.9	0.7	0.05	15	0	203
BC	0.0	0.0	0.0	0.6	0.6	0.4	0.03	14	0	227

Horizon	meq/100 g soil		ECEC in meq/100 g		CEC in meq/100 g			%		
	Al	H	fine earth	clay	fine earth	clay	C	BS	Al Sat.	RAS
Ah	3.4	0.5	6.0	n.a.	16.9	n.a.	218	13	20	57
BA	4.3	0.5	5.6	n.a.	8.2	n.a.	487	10	53	77
Bws1	4.4	0.5	5.1	11	9.3	20	n.a.	3	47	85
Bws2	3.3	0.5	4.6	9	9.4	19	n.a.	9	35	72
BC	1.7	0.4	2.6	6	11.4	24	n.a.	5	15	64

C. Ebimimbang soil type

PROFILE 23

Legend unit: Dpd
Soil classification: Acri-plinthic Ferralsol (FAO)
Plinthudult (Soil Taxonomy)
Description: On 23-03-95 by Gerard Hazeu and Arie van Kekem
Location: About 4 km W of Ebimimbang village; 3°03'20 N and 10°26'26 E
Elevation: 110 m
Landform and slope: undulating to rolling dissected erosional plain; upper slope 15%
Parent material: Gneisses and migmatites of the Precambrian shield
Vegetation: Agricultural fields
Drainage: Moderately well drained
Soil: Deep, yellowish brown sandy clay to clay with sandy loam to loamy sand topsoil.

Depth (cm)	Hor.	Description
0-5/10	Ah	black (10YR2/1); sandy loam; weak medium granular; very friable, non sticky and slightly plastic; few to many, fine to medium roots; clear and irregular transition to
5/10- 17	BA	dark brown to brown (10YR4/3); sandy clay loam; weak fine to medium subangular blocky; friable, slightly sticky and slightly plastic; few to common, fine to medium roots; gradual and smooth transition to
17- 34/44	Bws1	yellowish brown (10YR5/6); sandy clay; weak to moderate, fine to medium subangular blocky; friable, slightly sticky and slightly plastic; patchy thin clay cutans; common very fine to fine roots; diffuse and irregular transition to
34/44-50/75	Bws2	yellowish brown (10YR5/8); slightly gravelly sandy clay; very few (<5%) small hard irregular iron concretions; weak fine to medium subangular blocky; friable, slightly sticky and slightly plastic; patchy to broken thin clay cutans; few very fine to fine roots; clear and irregular transition to
50/75-115	Bc	yellowish brown (10YR5/8); very gravelly sandy clay; many (20%) medium faint diffuse 5YR5/6 mottles; few small hard irregular iron concretions; weak fine subangular blocky; friable, slightly sticky and slightly plastic; broken thin clay cutans; few very fine to fine roots; gradual and irregular transition to
115- 150	Bv	yellowish brown (10YR5/6); very gravelly sandy clay; abundant (60%) coarse diffuse clear 5YR5/6 mottles; few small hard irregular to spherical iron concretions; moderately coherent massive structure; firm, slightly sticky and slightly plastic; very few very fine to fine roots.

Profile 23											
Horizon	Depth (cm)	Particle size distribution % of fine earth; in µm				pH					
		<2	2-50	50-2000		1:2.5	KCl				
Ah	0-5/10	19	8	73		5.8	5.0				
BA	5/10-17	22	8	70		5.7	5.1				
Bws1	17-34/44	38	8	54		5.2	4.5				
Bws2	34/44-50/75	46	8	46		5.3	4.4				
Bc	50/75-115	44	8	49		5.4	4.4				
Bv	115-150	40	12	49		5.5	4.5				
Horizon	Exchangeable bases (NH_4OAc, pH7), meq/100 g					%		C/N	ppm		
	Na	K	Mg	Ca	TEB	Org. C	N total		Available P	Total P	
Ah	0.1	0.7	0.5	8.6	9.9	2.5	0.17	15	4		
BA	0.1	0.2	0.0	2.5	2.8	0.6	0.06	11	1		
Bws1	0.1	0.1	0.1	1.0	1.2	0.6	0.06	9	1		
Bws2	0.1	0.2	0.0	0.8	1.1	0.6	0.06	10	1		
Bc	0.1	0.1	0.0	0.6	0.8	0.3	0.05	6	1		
Bv	0.1	0.1	0.1	0.4	0.7	0.2	0.05	4	1		
Horizon	meq/100 g soil		ECEC in meq/100 g		CEC in meq/100 g			%			
	Al	H	fine earth	clay	fine earth	clay	C	BS	Al Sat.	RAS	
Ah	0.0	0.2	10.1	n.a.	9.9	n.a.	400	100	0	0	
BA	0.0	0.1	2.9	n.a.	3.6	n.a.	555	78	0	0	
Bws1	2.8	0.7	4.7	12	4.3	11	n.a.	28	67	60	
Bws2	2.0	0.5	3.6	8	3.5	8	n.a.	30	58	56	
Bc	1.9	0.5	3.2	7	2.6	6	n.a.	30	75	61	
Bv	1.4	0.6	2.8	7	3.5	9	n.a.	21	40	51	

PROFILE 24

Legend unit:	Dpd
Soil classification:	Acri-plinthic Ferralsol (FAO) Plinthudult (Soil Taxonomy)
Description:	On 23-03-95 by Gerard Hazeu and Arie van Kekem
Location:	About 4 km W of Ebimimbang village; 3°03'20 N and 10°26'26 E
Elevation:	90 m
Landform and slope:	undulating to rolling dissected erosional plain; upper slope 5%
Parent material:	Gneisses and migmatites of the Precambrian shield
Vegetation:	Agricultural fields
Drainage:	Moderately well drained
Soil:	Very deep, yellowish brown sandy clay to clay with sandy loam to loamy sand topsoil.

Depth (cm)	Hor.	Description
0- 6	Ah	dark grey (10YR4/1); loamy sand; weak fine granular; very friable, non sticky and non plastic; many fine to medium roots; clear and smooth transition to
6- 17	AE	pale brown (10YR6/3); loamy sand to sand; weak fine subangular blocky and weakly coherent single grain; very friable, non sticky and non plastic; few to common, fine to coarse roots; clear and smooth transition to
17- 62	Bt1	brownish yellow (10YR6/5); sandy clay loam; weak to moderate, fine angular to subangular blocky; friable, slightly sticky and slightly plastic; continuous moderate clay cutans; few very fine to fine roots; diffuse and smooth transition to
62-140	Bt2	brownish yellow (10YR6/6); sandy clay; many (20%) fine faint diffuse 7.5YR5/6 mottles; weak to moderate, fine angular to subangular blocky; friable, slightly sticky and slightly plastic; continuous thin clay cutans; few very fine to fine roots; clear and smooth transition to
140-165	Bv	brownish yellow (10YR6/6); slightly gravelly sandy clay; many (30%) medium distinct clear 2.5YR4/8 mottles; few small hard spherical iron concretions; weak fine subangular blocky; friable, slightly sticky and slightly plastic; patchy thin clay cutans; very few very fine roots.

Profile 24									
Horizon	Depth (cm)	Particle size distribution % of fine earth; in µm				pH			
		<2	2-50	50-2000		1:2.5	KCl		
Ah	0 - 6	10	22	68		5.7	4.8		
AE	6 - 17	9	9	82		5.8	4.8		
Bt1	17 - 62	31	7	62		5.3	4.4		
Bt2	62 - 140	41	6	54		5.1	4.2		
Bv	140 - 165	39	9	51		5.4	4.3		
Horizon	Exchangeable bases (NH_4OAc, pH7), meq/100 g					%		C/N	ppm	
	Na	K	Mg	Ca	TEB	Org. C	N total		Available P	Total P
Ah	0.1	0.1	0.0	3.4	3.7	1.7	0.16	11	5	
AE	0.1	0.1	0.2	1.4	1.8	0.8	0.07	11	3	
Bt1	0.1	0.1	0.0	0.8	1.0	0.6	0.05	11	1	
Bt2	0.1	0.1	0.0	0.5	0.6	0.4	0.05	8	1	
Bv	0.1	0.1	0.0	0.6	0.8	0.3	0.05	5	1	
Horizon	meq/100 g soil		ECEC in meq/100 g		CEC in meq/100 g			%		
	Al	H	fine earth	clay	fine earth	clay	C	BS	Al Sat.	RAS
Ah	0.0	0.1	3.7	n.a.	3.9	n.a.	231	94	0	0
AE	0.0	0.2	2.0	22	1.6	18	212	100	0	0
Bt1	1.8	0.6	3.3	11	2.3	7	420	41	77	54
Bt2	2.2	0.7	3.5	9	2.8	7	n.a.	23	78	62
Bv	2.4	0.5	3.6	9	2.3	6	n.a.	33	100	65

PROFILE 136

Legend unit: Du1
Soil classification: Haplic Acrisol (FAO)
Typic Paleudult (Soil Taxonomy)
Description: On 26-06-95 by Gerard Hazeu
Location: About 2 km NW of Toko village; 2°57'28 N and 10°29'02 E
Elevation: 120 m
Landform and slope: undulating to rolling uplands; summit 0 - 2%
Parent material: Gneisses of the Precambrian shield
Vegetation: Forest
Drainage: Well drained
Soil: Deep, yellowish brown sandy clay to clay with sandy loam to sandy clay loam topsoil.

Depth (cm)	Hor.	Description
0- 5	Ah	very dark brown (7.5YR2.5/2); sandy loam to sandy clay loam; moderate to strong, very fine to fine crumb to subangular blocky; very friable, slightly sticky and slightly plastic; few to common, very fine to medium roots; clear and smooth transition to
5- 12	BA	dark brown to brown (7.5YR4/3); sandy clay loam; weak to moderate, fine subangular blocky; friable, slightly sticky and slightly plastic; few to common, fine to medium roots; gradual and smooth transition to
12- 23	Bws1	strong brown (7.5YR5/6); sandy clay loam; weak to moderate, very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; very few to common, fine to medium roots; gradual and smooth transition to
23- 47	Bws2	strong brown (7.5YR5/8); gravelly clay loam; few (10%) fine faint diffuse 5YR5/8 mottles; few small hard angular iron concretions; weak fine subangular blocky; friable, slightly sticky and slightly plastic; very few to few, fine to medium roots; diffuse and smooth transition to
47-160	BC	strong brown (7.5YR5/8); slightly gravelly clay loam; few (10%) fine faint diffuse 5YR5/8 mottles; very few small hard angular iron concretions; weak fine subangular blocky; friable, slightly sticky and slightly plastic; very few to few, fine to medium roots.

Profile 136									
Horizon	Depth (cm)	Particle size distribution % of fine earth; in µm				pH			
		<2	2-50	50-2000		1:2.5	KCl		
Ah	0 - 5	20	13	67		5	4.4		
BA	5 - 12	26	12	62		3.8	3.4		
Bws1	12 - 23	28	12	60		4	3.5		
Bws2	23 - 47	34	18	47		5	4.5		
BC	47 - 100	39	30	31		5.1	4.6		
BC	100 - 160	33	39	28		5.4	4.5		
Horizon	Exchangeable bases (NH_4OAc, pH7), meq/100 g					%		C/N	ppm	
	Na	K	Mg	Ca	TEB	Org. C	N total		Available P	Total P
Ah	0.0	0.4	2.1	5.2	7.7	4.7	0.28	17	13	246
BA	0.0	0.1	0.4	0.5	1.0	1.9	0.12	16	6	174
Bws1	0.0	0.1	0.0	0.5	0.6	1.0	0.06	16	2	149
Bws2	0.1	0.0	0.0	0.5	0.6	0.7	0.06	11	1	144
BC	0.1	0.0	0.0	0.5	0.6	0.3	0.03	10	0	150
BC	0.1	0.0	0.1	0.4	0.7	0.1	0.02	7	0	155
Horizon	meq/100 g soil		ECEC in meq/100 g		CEC in meq/100 g			%		
	Al	H	fine earth	clay	fine earth	clay	C	BS	Al Sat.	RAS
Ah	0.2	0.2	8.1	na.	13.8	n.a.	298	56	1	2
BA	3.2	0.5	4.8	18	7.5	29	387	13	43	68
Bws1	2.5	0.4	3.5	12	7.3	26	n.a.	8	35	72
Bws2	2.0	0.5	3.1	9	4.9	14	n.a.	12	40	64
BC	2.0	0.5	3.1	8	9.8	25	n.a.	6	20	64
BC	0.5	0.7	1.9	6	10.8	33	n.a.	6	5	26

PROFILE 13

Legend unit: Du1
Soil classification: Ferrali ferric Acrisol (FAO)
Typic Kandiudult (Soil Taxonomy)
Description: On 26-06-95 by Gerard Hazeu
Location: About 2 km NW of Toko village; 2°57'28 N and 10°29'02 E
Elevation: 110 m
Landform and slope: undulating to rolling uplands; middle slope 5 - 10%
Parent material: Gneisses of the Precambrian shield
Vegetation: Forest
Drainage: Moderately well drained
Soil: Very deep, yellowish brown sandy clay to clay with loamy sand to sandy loam topsoil.

Depth (cm)	Hor.	Description
0- 6	Ah	dark yellowish brown (10YR4/4); loamy sand to sandy loam; weak very fine granular and weakly coherent structure; loose to very friable, non sticky and slightly plastic; common, very fine to fine roots; clear and smooth transition to
6- 22	BA	yellowish brown (10YR5/6); sandy clay loam; weak to moderate, very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; few to common, fine to coarse roots; gradual and smooth transition to
22- 74	Bws1	yellowish brown (10YR5/8); sandy clay loam; few (10%) fine faint diffuse 7.5YR5/8 mottles; weak to moderate, very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; few to many, fine to medium roots; gradual and smooth transition to
74-127	Bws2	yellowish brown (10YR5/8); very gravelly, stony sandy clay loam; few (15%) fine faint diffuse 7.5YR5/8 mottles; few to frequent, small to large, soft to hard, irregular to spherical iron concretions; weak to moderate, very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; few, very fine to fine roots; gradual and smooth transition to
127-170	Bv1	yellowish brown (10YR5/8); slightly gravelly clay loam; many (20%) medium prominent clear 5YR5/8 mottles; very few to few, small soft to hard, spherical iron concretions; weak fine subangular blocky; friable, slightly sticky and slightly plastic; very few very fine to fine roots; gradual and smooth transition to
170-200	Bv2	yellowish brown (10YR5/8); gravelly clay loam; many (35%) medium prominent clear 2.5YR4/8 mottles; very few to frequent, small soft to hard, irregular to spherical iron concretions; weak fine subangular blocky; friable, slightly sticky and slightly plastic; no roots.

Profile 137									
Horizon	Depth (cm)	Particle size distribution % of fine earth; in µm				pH			
		<2	2-50	50-2000		1:2.5	KCl		
Ah	0 - 6	12	12	76		5.7	4.8		
BA	6 - 22	23	12	66		5.3	4.2		
Bws1	22 - 74	32	13	55		5.3	4.4		
Bws2	74 - 127	33	29	38		5.5	4.7		
Bv1	127 - 170	42	27	32		4.9	3.7		
Bv2	170 - 200	38	33	29		5.2	4.5		
Horizon	Exchangeable bases (NH_4OAc, pH7), meq/100 g					%		C/N	ppm	
	Na	K	Mg	Ca	TEB	Org. C	N total		Available P	Total P
Ah	0.2	0.3	1.1	3.1	4.6	3.0	0.28	11	21	208
BA	0.1	0.2	0.0	1.1	1.4	0.7	0.05	14	3	107
Bws1	0.1	0.0	0.0	0.4	0.6	0.4	0.03	13	1	83
Bws2	0.2	0.1	0.0	1.0	1.3	0.3	0.03	9	1	79
Bv1	0.0	0.0	0.0	0.7	0.7	0.2	0.03	8	1	75
Bv2	0.1	0.0	0.9	0.7	1.7	0.2	0.02	11	1	83
Horizon	meq/100 g soil		ECEC in meq/100 g		CEC in meq/100 g			%		
	Al	H	fine earth	clay	fine earth	clay	C	BS	Al Sat.	RAS
Ah	0.0	0.3	4.9	n.a.	5.6	n.a.	187	82	0	0
BA	1.3	0.4	3.0	13	2.2	9	304	64	58	41
Bws1	1.0	0.5	2.1	6	2.7	8	n.a.	21	39	50
Bws2	0.5	0.6	2.3	7	4.1	12	n.a.	31	12	21
Bv1	0.5	0.6	1.9	5	3.0	7	n.a.	24	17	28
Bv2	0.9	0.7	3.2	8	4.9	13	n.a.	34	18	27

PROFILE 139

Legend unit:	Du1
Soil classification:	Acri-xanthic Ferralsol (FAO) Typic Kandiudult (Soil Taxonomy)
Description:	On 26-06-95 by Gerard Hazeu
Location:	About 1 km NW of Toko village; 2°56'59 N and 10°29'84 E
Elevation:	140 m
Landform and slope:	undulating to rolling uplands; lower slope 10%
Parent material:	Gneisses of the Precambrian shield
Vegetation:	Forest
Drainage:	Moderately well to well drained
Soil:	Very deep, yellowish brown sandy clay to clay with loamy sand to sandy loam topsoil.

Depth (cm)	Hor.	Description
0- 7	Ah	dark brown (10YR3/3); sandy loam; moderate very fine to fine crumb to subangular blocky; very friable, non sticky, slightly plastic and weakly smeary; common to many, very fine to fine roots; clear and smooth transition to
7- 17	BA	dark yellowish brown (10YR4/6); sandy clay loam; weak to moderate, very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; very few, fine to medium roots; clear and smooth transition to
17- 42	Bws1	yellowish brown (10YR5/6); sandy clay loam; moderate very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; very few to few, very fine to fine roots; gradual and smooth transition to
42- 82	Bws2	yellowish brown (10YR5/8); sandy clay; few (2-5%) fine faint diffuse 7.5YR5/8 mottles; weak to moderate, very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; few very fine to fine roots; gradual and smooth transition to
82-157	Bws3	yellowish brown (10YR5/8); sandy clay to clay; few (10%) fine faint diffuse 5YR5/8 mottles; weak to moderate, very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; very few very fine roots; gradual and smooth transition to
157-205	Bv	yellowish brown (10YR5/8); slightly gravelly sandy clay to clay; many (25%) medium distinct clear 2.5YR4/8 mottles; very few to few, small soft to hard, spherical to irregular iron concretions; weak fine subangular blocky; friable, slightly sticky and slightly plastic; no roots.

Profile 139										
Horizon	Depth (cm)	Particle size distribution % of fine earth; in µm				pH				
		<2	2-50	50-2000		1:2.5	KCl			
Ah	0-7	18	19	63		4.8	3.7			
BA	7-17	27	12	61		4	3.4			
Bws1	17-42	32	13	55		4	3.5			
Bws2	42-82	35	12	53		4.8	3.5			
Bws3	82-157	39	13	48		5.0	4.0			
Bv	157-205	41	14	45		5.2	4.7			
Horizon	Exchangeable bases (NH_4OAc, pH7), meq/100 g					%		C/N	ppm	
	Na	K	Mg	Ca	TEB	Org. C	N total		Available P	Total P
Ah	0.2	0.3	0.9	3.3	4.7	4.0	0.32	12	29	244
BA	0.1	0.1	0.3	1.0	1.5	1.0	0.06	16	3	128
Bws1	0.1	0.0	0.0	1.6	1.7	0.6	0.04	16	2	108
Bws2	0.1	0.0	0.0	1.2	1.3	0.5	0.03	18	1	111
Bws3	0.1	0.0	0.2	0.6	1.0	0.2	0.02	11	1	106
Bv	0.1	0.0	0.5	0.6	1.2	0.1	0.03	4	1	109
Horizon	meq/100 g soil		ECEC in meq/100 g		CEC in meq/100 g			%		
	Al	H	fine earth	clay	fine earth	clay	C	BS	Al Sat.	RAS
Ah	0.7	0.3	5.7	n.a.	12.0	n.a.	301	39	6	13
BA	2.6	0.3	4.3	n.a.	5.5	n.a.	571	26	46	59
Bws1	2.2	0.0	3.9	12	3.4	11	n.a.	51	64	55
Bws2	1.3	0.7	3.3	9	3.2	9	n.a.	40	42	40
Bws3	1.2	0.7	2.9	7	3.4	9	n.a.	28	36	43
Bv	1.3	0.5	3.0	7	2.3	6	n.a.	52	59	44

PROFILE 150

Legend unit:	Dpd
Soil classification:	Acri-plinthic Ferralsol (FAO) Plinthudult (Soil Taxonomy)
Description:	On 11-07-95 by Gerard Hazeu
Location:	About 300 m NE of Melen village; 3°02'80 N and 10°31'64 E
Elevation:	120 m
Landform and slope:	undulating dissected erosional plain; lower slope 0 - 5%
Parent material:	Gneisses and/or migmatites of the Precambrian shield
Vegetation:	Cacao plantation
Drainage:	Moderately well drained
Soil:	Deep, yellowish brown sandy clay to clay with loamy sand to sandy loam topsoil.

Depth (cm)	Hor.	Description
0- 6	Ah	dark greyish brown (10YR4/1); loamy sand; weakly coherent single grain; loose, loose, non sticky and non plastic; very few to few, fine to medium roots; abrupt and smooth transition to
6- 17	BA	very pale brown (10YR8/3); slightly gravelly loamy sand to sandy loam; moderately coherent single grain and porous massive; loose, loose, non sticky and non plastic; few very fine to fine roots; clear and smooth transition to
17- 48	Bws	yellow (10YR7/8); very gravelly sandy clay; many (20%) fine faint diffuse 5YR5/8 mottles; few small hard spherical iron concretions; weak fine subangular blocky and strongly coherent porous massive; friable, slightly sticky and slightly plastic; very few very fine to fine roots; gradual and smooth transition to
48- 78	Bv1	yellow (10YR7/6); very gravelly clay; many (20%) medium distinct diffuse 2.5YR4/8 mottles; very few to frequent, small to large, soft to hard, irregular to spherical iron concretions; weak very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; very few fine roots; diffuse and smooth transition to
78-160	Bv2	light yellowish brown (10YR6/4); gravelly clay; many (20%) medium prominent diffuse 2.5YR4/8 mottles; few to frequent, small to large, soft to hard, irregular to spherical iron concretions; weak very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; very few fine roots; diffuse and broken transition to
160	CB	

Profile 150										
Horizon	Depth (cm)	Particle size distribution % of fine earth; in µm				pH				
		<2	2-50	50-2000		1:2.5	KCl			
Ah	0-6	11	9	80		5.7	4.7			
BA	6-17	16	3	82		5.6	4.8			
Bws	17-48	39	13	48		5.2	4.6			
Bv1	48-78	49	13	38		4.9	3.5			
Bv2	78-160(100)	64	10	26		4.5	3.6			
Bv2	78-160(130)	52	13	35		4.6	3.5			
Horizon	Exchangeable bases (NH_4OAc, pH7), meq/100 g					%		C/N	ppm	
	Na	K	Mg	Ca	TEB	Org. C	N total		Available P	Total P
Ah	0.1	0.2	1.4	5.1	6.8	1.9	0.17	11	13	187
BA	0.1	0.1	0.5	1.9	2.6	0.4	0.04	9	2	61
Bws	0.1	0.1	0.6	1.4	2.2	0.2	0.03	7	1	84
Bv1	0.0	0.1	0.6	1.2	2.0	0.2	0.03	6	0	98
Bv2	0.2	0.1	0.5	1.8	2.6	0.1	0.04	3	1	159
Bv2	0.1	0.0	0.1	1.5	1.7	0.0	0.03	n.a.	0	141
Horizon	meq/100 g soil		ECEC in meq/100 g		CEC in meq/100 g			%		
	Al	H	fine earth	clay	fine earth	clay	C	BS	Al Sat.	RAS
Ah	0.0	0.2	7.1	n.a.	5.7	n.a.	301	100	0	0
BA	0.0	0.2	2.8	n.a.	3.5	n.a.	941	74	0	0
Bws	0.4	0.4	3.0	8	3.0	8	n.a.	72	12	12
Bv1	1.3	0.4	3.6	7	4.5	9	n.a.	44	28	35
Bv2	2.6	0.4	5.6	9	9.4	15	n.a.	27	27	46
Bv2	2.2	0.4	4.3	8	6.1	12	n.a.	28	36	51

PROFILE 151

Legend unit:	Dpd
Soil classification:	Ferrali haplic Acrisol (FAO) Typic Kandiudult (Soil Taxonomy)
Description:	On 11-07-95 by Gerard Hazeu
Location:	About 200 m SW of Melen village; 3°02'80 N and 10°31'64 E
Elevation:	120 m
Landform and slope:	undulating dissected erosional plain; lower slope 0 - 5%
Parent material:	Gneisses and/or migmatites of the Precambrian shield
Vegetation:	Secondary forest
Drainage:	Well drained
Soil:	Deep, yellowish brown sandy clay loam with loamy sand to sand topsoil.

Depth (cm)	Hor.	Description
0- 7	Ah	dark greyish brown (10YR4/1); loamy sand; weakly coherent single grain; loose, loose, non sticky and non plastic; many very fine to fine roots; clear and smooth transition to
7- 15	AB	brown (10YR5/3); sand; moderately coherent porous massive; loose, non sticky and slightly plastic; few to common, fine to medium roots; clear and smooth transition to
15- 38	BA	pale yellow (2.5Y7/4); loamy sand; weak very fine subangular blocky and moderately coherent porous massive; very friable, non sticky and non plastic; few to common, fine to medium roots; gradual and smooth transition to
38- 80	Bws1	brownish yellow (10YR6/6); slightly gravelly sandy clay loam; few (2%) fine faint diffuse 5YR5/8 mottles; weak very fine to fine subangular blocky; very friable, slightly sticky and slightly plastic; few very fine to fine roots; clear and wavy transition to
80-120	Bws2	brownish yellow (10YR6/6); very gravelly, stony sandy clay loam; few (5%) fine faint diffuse 5YR5/8 mottles; few small to large, hard irregular iron concretions; weak fine subangular blocky; friable, slightly sticky and slightly plastic; few very fine to fine roots; diffuse and broken transition to
120	CB	

Profile 151										
Horizon	Depth (cm)	Particle size distribution % of fine earth; in µm				pH				
		<2	2-50	50-2000		1:2.5	KCl			
Ah	0-7	11	12	77		5.7	4.8			
AB	7-15	6	8	86		5	4			
BA	15-38	9	10	80		5	4			
Bws1	38-80	25	9	66		4.8	2.9			
Bws2	80-120	29	10	61		4.7	3.1			
Horizon	Exchangeable bases (NH_4OAc, pH7), meq/100 g					%		C/N	ppm	
	Na	K	Mg	Ca	TEB	Org. C	N total		Available P	Total P
Ah	0.2	0.2	1.4	2.9	4.6	2.9	0.24	12	20	188
AB	0.1	0.1	0.0	0.7	0.9	0.6	0.05	12	12	49
BA	0.1	0.0	0.1	0.7	1.0	0.2	0.02	11	4	41
Bws1	0.1	0.0	0.4	0.2	0.7	0.2	0.02	8	2	54
Bws2	0.2	0.1	0.1	1.4	1.8	0.2	0.02	8	2	62
Horizon	meq/100 g soil		ECEC in meq/100 g		CEC in meq/100 g			%		
	Al	H	fine earth	clay	fine earth	clay	C	BS	Al Sat.	RAS
Ah	0.0	0.3	5.0	n.a.	9.8	n.a.	333	48	0	0
AB	0.3	0.2	1.4	n.a.	2.7	n.a.	453	34	10	19
BA	0.4	0.1	1.5	16	2.0	21	n.a.	49	19	26
Bws1	0.9	0.6	2.2	9	1.1	4	n.a.	69	80	40
Bws2	1.0	0.8	3.6	12	1.2	4	n.a.	100	89	29

PROFILE 217

Legend unit:	Du2
Soil classification:	Haplic Acrisol (FAO) Typic Paleudult (Soil Taxonomy)
Description:	On 14-08-95 by Gerard Hazeu
Location:	About 2.5 km SW of Melen village; 3°02'80 N and 10°31'64 E
Elevation:	170 m
Landform and slope:	rolling uplands; lower slope 20%
Parent material:	Gneisses and/or migmatites of the Precambrian shield
Vegetation:	Forest
Drainage:	Moderately well drained
Soil:	Very deep, yellowish brown sandy clay to clay with sandy loam to loamy sand topsoil.

Depth (cm)	Hor.	Description
0- 4	Ah	very dark brown (10YR2/2); sandy loam; weak very fine crumb and weakly coherent single grain; loose, non sticky and slightly plastic; common to many, fine to medium roots; clear and smooth transition to
4- 16	AE	yellowish brown (10YR5/4); loamy sand; weak very fine subangular blocky and weakly coherent single grain; very friable, non sticky and non plastic; few to common, very fine to fine roots; gradual and smooth transition to
16- 36	Bws1	yellowish brown (10YR5/6); sandy loam; few (5 -10%) fine distinct diffuse 7.5YR5/8 mottles; weak fine subangular blocky and weakly coherent single grain; very friable, non sticky and slightly plastic; few very fine to fine roots; gradual and wavy transition to
36-100	Bws2	yellowish brown (10YR5/8); gravelly sandy clay loam; few (10%) fine to medium, distinct diffuse 7.5YR5/8 mottles; few small hard spherical iron concretions; weak to moderate, very fine to fine angular to subangular blocky; friable, slightly sticky and slightly plastic; very few very fine to fine roots; gradual and wavy transition to
100-160	Bv	yellowish brown (10YR5/8); gravelly clay; many (30%) medium distinct to prominent, clear 10YR7/8 mottles; few to frequent, small soft to hard, irregular to spherical iron concretions; weak to moderate, very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; very few very fine to fine roots.

Profile 217

Horizon	Depth (cm)	Particle size distribution % of fine earth; in µm				pH	
		<2	2-50	50-2000		1:2.5	KCl
Ah	0 - 4	20	10	70		5.6	5
AE	4 - 16	8	13	80		6.4	4.5
Bws1	16 - 36	15	12	72		5	4
Bws2	36 - 100	32	13	55		4.8	3.8
Bv	100 - 160	46	15	39		4.8	3.8

Horizon	Exchangeable bases (NH_4OAc, pH7), meq/100 g					%		C/N	ppm	
	Na	K	Mg	Ca	TEB	Org. C	N total		Available P	Total P
Ah	0.2	0.2	3.6	13.3	17.3	4.5	0.33	14	17	255
AE	0.1	0.0	0.5	0.5	1.1	0.5	0.05	11	2	412
Bws1	0.2	0.0	0.3	0.4	0.9	0.3	0.03	11	1	398
Bws2	0.5	0.0	0.4	0.0	0.9	0.4	0.04	10	1	198
Bv	0.3	0.0	0.2	0.0	0.5	0.3	0.04	9	0	159

Horizon	meq/100 g soil		ECEC in meq/100 g		CEC in meq/100 g			%		
	Al	H	fine earth	clay	fine earth	clay	C	BS	Al Sat.	RAS
Ah	0.0	0.2	17.5	n.a.	17.6	n.a.	392	98	0	0
AE	0.0	0.3	1.4	19	3.3	44	615	33	1	3
Bws1	0.1	0.1	1.1	7	7.2	47	n.a.	12	2	11
Bws2	0.9	0.6	2.5	8	7.5	24	n.a.	12	12	38
Bv	1.4	0.8	2.7	6	6.1	13	n.a.	9	22	51

PROFILE 218

Legend unit:	Du2
Soil classification:	Ferralic plinthic Acrisol (FAO) Plinthudult (Soil Taxonomy)
Description:	On 14-08-95 by Gerard Hazeu
Location:	About 2.5 km SW of Melen village; 3°02'80 N and 10°31'64 E
Elevation:	220 m
Landform and slope:	rolling uplands; upper slope 15%
Parent material:	Gneisses and/or migmatites of the Precambrian shield
Vegetation:	Forest
Drainage:	Moderately well drained
Soil:	Deep, yellowish brown, sandy clay to clay with sandy loam to loamy sand topsoil.

Depth (cm)	Hor.	Description
0- 3	Ah	very dark greyish brown (10YR3/2); loamy sand; weak very fine crumb and weakly coherent single grain; loose, non sticky and non plastic; common to many, very fine to fine roots; clear and smooth transition to
3-16/25	AE	yellowish brown (10YR5/4); sandy loam; weak very fine subangular blocky and moderately coherent single grain; very friable, non sticky and slightly plastic; few to common, fine to medium roots; gradual and wavy transition to
16/25-80	Bws1	brownish yellow (10YR6/8); gravelly sandy clay loam; many (15 - 25%) medium faint to distinct, diffuse 7.5YR5/8 mottles; few small hard spherical iron concretions; weak to moderate, very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; very few to common, fine to medium roots; gradual and smooth transition to
80- 118	Bv	light yellowish brown (10YR6/4); very gravelly sandy clay; many (25 - 40%) medium distinct diffuse 7.5YR6/8 mottles; frequent small hard spherical iron concretions; weak to moderate, very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; very few very fine to fine roots; gradual and smooth transition to
118-130	BC	light yellowish brown (10YR6/4); very gravelly sandy clay; many (25 - 40%) medium distinct diffuse 7.5YR6/8 mottles; few small to large, soft irregular to angular iron concretions; weak very fine subangular blocky and moderately coherent massive; friable, slightly sticky and slightly plastic; no roots.

Profile 218

Horizon	Depth (cm)	Particle size distribution % of fine earth; in µm				pH	
		<2	2-50	50-2000		1:2.5	KCl
Ah	0-3	9	6	85		4.9	4.2
Ae	3-16/25	18	11	71		4.6	3.6
Bws1	16/25-80	33	13	54		4.7	3.6
Bv	80-118	40	12	48		4.7	3.9
BC	118-130	40	12	47		4.4	3.8

Horizon	Exchangeable bases (NH_4OAc, pH7), meq/100 g					%		C/N	ppm	
	Na	K	Mg	Ca	TEB	Org. C	N total		Available P	Total P
Ah	0.1	0.3	1	2.8	4.2	2.9	0.21	14	13	
Ae	0.1	0.1	0.0	0.1	0.3	0.4	0.04	9	3	
Bws1	0.0	0.1	0.0	0.1	0.2	0.2	0.05	4	2	
Bv	0.1	0.2	0.0	0.7	0.9	0.1	0.04	2	1	
BC	0.1	0.1	0.0	0.4	0.6	0.1	0.04	2	1	

Horizon	meq/10 g soil		ECEC in meq/100 g		CEC in meq/100 g			%		
	Al	H	fine earth	clay	fine earth	clay	C	BS	Al Sat.	RAS
Ah	0.2	0.2	4.6	n.a.	9.8	n.a.	341	43	2	4
Ae	0.7	0.4	1.4	8	3.4	19	n.a.	8	21	52
Bws1	1.7	0.6	2.5	8	4.3	13	n.a.	5	40	69
Bv	1.1	0.7	2.7	7	7.2	18	n.a.	13	15	40
BC	1.5	0.6	2.7	7	5.3	13	n.a.	11	29	56

PROFILE 219

Legend unit: Du2
Soil classification: Acri-xanthic Ferralsol (FAO)
ypic Kandiudult (Soil Taxonomy)
Description: On 14-08-95 by Gerard Hazeu
Location: About 2.5 km SW of Melen village; 3°02'80 N and 10°31'64 E
Elevation: 220 m
Landform and slope: rolling uplands; upper slope 15%
Parent material: Gneisses and/or migmatites of the Precambrian shield
Vegetation: Forest
Drainage: Well drained
Soil: Moderately deep, yellowish brown sandy clay to clay with sandy loam to loamy sand topsoil.

Depth (cm)	Hor.	Description
0 - 3	Ah	dark brown (10YR3/3); sandy loam; weak very fine crumb to subangular blocky; very friable, slightly sticky and slightly plastic; common to many, very fine to fine roots; clear and smooth transition
3 - 14	BA	dark yellowish brown (10YR4/6); sandy clay loam; weak very fine to fine subangular blocky; very friable, slightly sticky and slightly plastic; few to many, fine to medium roots; gradual and smooth transition to
14 - 79	Bws	yellowish brown (10YR5/8); clay; moderate fine subangular blocky; friable, slightly sticky and slightly plastic; few to common, very fine to fine roots; gradual and smooth transition to
79	CB	

Profile 219										
Horizon	Depth (cm)	Particle size distribution % of fine earth; in µm				pH				
		<2	2-50	50-2000		1:2.5	KCl			
Ah	0 - 3	19	11	70		5.7	4.8			
BA	3 - 14	24	15	64		5.4	4.7			
Bws	14 - 79	48	14	38		5.2	4			
CB	79									
Horizon	Exchangeable bases (NH_4OAc, pH7), meq/100 g					%		C/N	ppm	
	Na	K	Mg	Ca	TEB	Org. C	N total		Available P	Total P
Ah	0.2	0.2	0.8	2.1	3.2	2.6	0.21	13	10	421
BA	0.1	0.0	0.2	0.6	0.9	0.7	0.07	10	3	438
Bws	0.1	0.0	0.4	0.0	0.5	0.5	0.05	9	1	488
CB										
Horizon	meq/100 g soil		ECEC in meq/100 g		CEC in meq/100 g			%		
	Al	H	fine earth	clay	fine earth	clay	C	BS	Al Sat.	RAS
Ah	0.0	0.2	3.4	n.a.	5.6	n.a.	213	57	0	0
BA	0.3	0.2	1.5	6	3.1	13	442	29	11	22
Bws	0.7	0.9	2.0	4	4.9	10	n.a.	10	13	33
CB										

D. Valley bottom soil type

PROFILE 20

Legend unit: E in Dpd
Soil classification: Dystric Fluvisol (FAO)
Psammaquent (Soil Taxonomy)
Description: On 23-03-95 by Gerard Hazeu and Arie van Kekem
Location: About 4 km W of Ebimimbang village; 3°03'20 N and 10°26'26 E
Elevation: 70 m
Landform and slope: undulating to rolling dissected erosional plain; valley bottom
Parent material: Alluvial deposits derived from gneisses of the Precambrian shield
Vegetation: Forest
Drainage: Poorly drained
Soil: Deep, white sand with humic topsoil.

Depth (cm)	Hor.	Description
0 - 4	Ah	reddish black (5YR2.5/1); sandy clay loam; non sticky, non plastic and moderately smeary; few to abundant, very fine to medium roots; abrupt and smooth transition to
4 - 16	Cr1	light grey (10YR7/2); slightly gravelly medium to coarse sand; weakly coherent single grain; loose to very friable, non sticky and non plastic; very few fine roots; clear and smooth transition to
16 - 60	Cr2	white (2.5Y8/1); slightly gravelly medium to coarse sand; weakly coherent single grain; loose, non sticky and non plastic; no roots.

Profile 20										
Horizon	Depth (cm)	Particle size distribution % of fine earth; in µm				pH				
		<2	2-50	50-2000		1:2.5	KCl			
Ah	0-4	25	33	42		5.3	4.4			
Cr1	4-16	3	2	95		5.7	4.8			
Cr2	16-60	2	5	93		5.6	4.8			
Horizon	Exchangeable bases (NH_4OAc, pH7), meq/100 g					%		C/N	ppm	
	Na	K	Mg	Ca	TEB	Org. C	N total		Available P	Total P
Ah	0.3	0.5	0.6	2.9	4.4	3.7	0.29	13	30	
Cr1	0.1	0.1	0.1	0.4	0.7	0.3	0.02	14	1	
Cr2	0.1	0.0	0.1	0.3	0.4	0.1	0.01	8	1	
Horizon	meq/100 g soil		ECEC in meq/100 g		CEC in meq/100 g			%		
	Al	H	fine earth	clay	fine earth	clay	C	BS	Al Sat.	RAS
Ah	0.3	0.7	5.4	22	10.4	42	285	43	3	6
Cr1	0.0	0.1	0.8	29	1.2	45	414	54	0	0
Cr2	0.0	0.1	0.6	36	1.2	78	n.a.	37	0	0

PROFILE 138

Legend unit: E in Du1
Soil classification: Ferrali-gleyic Cambisol (FAO)
Oxyaquic Dystropept (Soil Taxonomy)
Description: On 26-06-95 by Gerard Hazeu
Location: About 2 km NW of Toko village; 2°57'28 N and 10°29'02 E
Elevation: 100 m
Landform and slope: undulating to rolling uplands; valley bottom
Parent material:Alluvial deposists derived from gneisses of the Precambrian shield
Vegetation: Forest
Drainage: Poorly to imperfectly drained
Soil: Moderately deep, yellow loamy sand to sandy loam with humic topsoil.

Depth (cm)Hor.Description

Depth (cm)	Hor.	Description
0 - 5	Ah	very dark brown (10YR2/2); loamy sand; weakly coherent structure and weak very fine to fine crumb to subangular blocky; loose, non sticky, slightly plastic; many, very fine to fine roots; clear and smooth transition to
5 - 12	BA	yellowish brown (10YR5/4); loamy sand; weak very fine to fine subangular blocky; non sticky and slightly plastic; few to many, fine to medium roots; gradual and smooth transition to
12 - 75	Bws	yellow (10YR7/8); sandy loam; weak very fine to fine subangular blocky; slightly sticky and slightly plastic; very few to few, fine to medium roots; clear and smooth transition to
75 - 100	Bo/r	yellow (2.5Y7/6); gravelly loamy sand; few (15%) medium prominent clear 7.5YR5/8 mottles; moderately coherent structure; few fine roots; gradual and smooth transition to
100 - 135	Cr	grey (1G6/5GY); fine sand; few (5%) medium distinct diffuse 7.5YR5/8 mottles; weakly to moderately coherent structure; few fine roots.

Profile 138

Horizon	Depth (cm)	Particle size distribution % of fine earth; in µm				pH	
		<2	2-50	50-2000		1:2.5	KCl
Ah	0-5	12	18	71		5.3	4.3
BA	5-12	12	10	79		4.8	3.8
Bws	12-75	18	10	72		5	4.1
Bo/r	75-100	8	12	80		5.4	4
Cr	100-135	1	47	52		5.2	3.9

Horizon	Exchangeable bases (NH_4OAc, pH7), meq/100 g					%		C/N	ppm	
	Na	K	Mg	Ca	TEB	Org. C	N total		Available P	Total P
Ah	0.6	0.5	0.3	4.7	6.0	4.9	0.39	13	43	341
BA	0.1	0.0	0.2	0.9	1.2	1.0	0.05	19	7	74
Bws	0.1	0.0	0.3	0.4	0.7	0.3	0.03	10	1	26
Bo/r	0.1	0.0	0.0	0.5	0.6	0.2	0.02	11	2	26
Cr	0.1	0.0	0.0	0.3	0.4	0.0	0.01	2	2	41

Horizon	meq/100 g soil		ECEC in meq/100 g		CEC in meq/100 g			%		
	Al	H	fine earth	clay	fine earth	clay	C	BS	Al Sat.	RAS
Ah	0.2	0.3	6.4	n.a.	16.9	n.a.	344	36	1	3
BA	0.9	0.4	2.5	21	4.6	40	478	26	19	36
Bws	0.7	0.1	1.5	8	2.1	12	714	33	33	46
Bo/r	0.4	0.1	1.1	14	1.0	12	452	64	42	35
Cr	0.6	0.5	1.4	n.a.	1.0	n.a.	n.a.	37	58	41

PROFILE 165

Legend unit:	E in Cu1
Soil classification:	Gleyic Cambisol (FAO)
	Aquic Dystropept (Soil Taxonomy)
Description:	On 22-07-95 by Gerard Hazeu
Location:	About 1 km S of Ebom II village; 3°04'05 N and 10°42'59 E
Elevation:	370 m
Landform and slope:	undulating to rolling uplands; valley bottom
Parent material:	Alluvial deposits derived from gneisses of the Precambrian shield
Vegetation:	Forest
Drainage:	Poorly drained
Soil:	Deep, yellow to white sandy loam to loamy sand with very dark brown topsoil.

Depth (cm)	Hor.	Description
0 - 5	Ah	very dark brown (7.5YR2.5/2); sandy loam; very friable, non sticky, slightly plastic and weakly smeary; few fine to medium roots; clear and smooth transition to
5 - 9	BA	dark brown to brown (10YR4/3); sandy loam; weak very fine subangular blocky and moderately coherent single grain; very friable, slightly sticky and slightly plastic; few fine to medium roots; clear and wavy transition to
9 - 27	Bws	light olive brown (2.5Y5/6); sandy loam; few (10%) medium distinct diffuse 5YR5/8 mottles; weak very fine to fine subangular blocky; very friable, slightly sticky and slightly plastic; very few to few, very fine to fine roots; clear and smooth transition to
27 - 51	Bo/r	light yellowish brown (2.5Y6/4); slightly gravelly sandy loam; many (20%) medium prominent diffuse 5YR5/8 mottles; weak very fine subangular blocky; friable, slightly sticky and slightly plastic; very few to few, very fine to fine roots; gradual and smooth transition to
51 - 66	BCr	greyish brown (10YR5/2); slightly gravelly coarse sand; few (5%) fine faint diffuse 5YR5/8 mottles; weakly coherent single grain; loose, non sticky and slightly plastic; very few to few, very fine to fine roots; clear and smooth transition to
66 - 100	Cr	white (10YR8/1); gravelly sandy clay loam; moderately coherent massive; friable, slightly sticky and slightly plastic; no roots.

Profile 165										
Horizon	Depth (cm)	Particle size distribution % of fine earth; in µm				pH				
		<2	2-50	50-2000		1:2.5	KCl			
Ah	0-5	13	14	73		4	3.3			
BA	5-9	11	13	75		4.7	3.7			
Bws	9-27	18	14	67		4.3	4			
Bo/r	27-51	17	13	69		4.6	3.7			
BCr	51-66	7	8	85		4.7	4			
Cr	66-100	31	30	39		3.1	2.8			
Horizon	Exchangeable bases (NH_4OAc, pH7), meq/100 g					%		C/N	ppm	
	Na	K	Mg	Ca	TEB	Org. C	N total		Available P	Total P
Ah	0.2	0.2	1.5	1.5	3.5	3.8	0.29	13	55	309
BA	0.1	0.1	0.0	1.1	1.3	2.4	0.19	13	49	389
Bws	0.0	0.0	0.0	0.2	0.2	0.7	0.07	10	40	369
Bo/r	0.1	0.0	0.0	0.1	0.1	0.4	0.05	8	16	315
BCr	0.1	0.0	0.0	0.0	0.1	0.5	0.04	12	33	136
Cr	0.0	0.0	0.1	0.0	0.1	0.5	0.03	18	15	95
Horizon	meq/100 g soil		ECEC in meq/100 g		CEC in meq/100 g			%		
	Al	H	fine earth	clay	fine earth	clay	C	BS	Al Sat.	RAS
Ah	2.6	0.2	6.3	n.a.	16.6	n.a.	442	21	16	42
BA	1.3	0.4	2.9	n.a.	10.4	n.a.	433	12	12	45
Bws	0.8	0.4	1.4	8	8.9	49	n.a.	3	9	55
Bo/r	0.7	0.4	1.2	7	5.2	30	n.a.	3	14	60
BCr	0.4	0.2	0.7	10	1.8	24	391	4	24	61
Cr	3.8	0.3	4.2	13	3.6	11	667	3	100	90

PROFILE 183

Legend unit:	E in Dpd
Soil classification:	Dystric Fluvisol (FAO) Fluvaquent (Soil Taxonomy)
Description:	On 26-07-95 by Gerard Hazeu
Location:	About 2 km NE of Obo'otomba village; 3°04'11 N and 10°35'68 E
Elevation:	unknown
Landform and slope:	undulating dissected erosional plain; valley bottom
Parent material:	Alluvial deposits derived from gneisses and/or migmatites of the Precambrian shield
Vegetation:	Forest
Drainage:	Poorly drained
Soil:	Moderately deep, grey to white sand with very dark brown topsoil.

Depth (cm)Hor.Description

0 - 3	Ah	very dark brown (10YR2/2); sandy clay loam; moderately coherent; very friable, non sticky, slightly plastic and weakly smeary; few fine to medium roots; clear and smooth transition to
3 - 15	BA	light yellowish grey (10YR6/2); slightly gravelly coarse sand; weakly coherent single grain; loose, non sticky and non plastic; few very fine to fine roots; clear and smooth transition to
15 - 47	C	dark yellowish brown (10YR3/4); slightly gravelly loamy sand; moderately coherent; very friable, slightly sticky and slightly plastic; no roots; abrupt and smooth transition to
47 - 70	Cr	(1G7/5GY); slightly gravelly, slightly stony sandy loam; strongly coherent porous massive structure; friable, slightly sticky and slightly plastic; no roots.

Profile 183										
Horizon	Depth (cm)	Particle size distribution % of fine earth; in µm				pH				
		<2	2-50	50-2000		1:2.5	KCl			
Ah	0 - 3	23	20	58		4.9	4.1			
BA	3 - 15	2	3	96		5.1	4.3			
H	15 - 47	5	11	84		4.6	3.9			
Cr	47 - 70	12	37	60		5.4	3.9			
Horizon	Exchangeable bases (NH_4OAc, pH7), meq/100 g					%		C/N	ppm	
	Na	K	Mg	Ca	TEB	Org. C	N total		Available P	Total P
Ah	0.1	0.7	1.9	4.7	7.4	4.5	0.35	13	39	
BA	0.0	0.1	0.0	0.4	0.5	0.9	0.06	15	6	
H	0.0	0.1	0.6	0.7	1.4	3.9	0.2	19	2	
Cr	0.0	0.3	0.3	1.3	2.0	0.5	0.03	18	29	
Horizon	meq/100 g soil		ECEC in meq/100 g		CEC in meq/100 g			%		
	Al	H	fine earth	clay	fine earth	clay	C	BS	Al Sat.	RAS
Ah	0.0	0.4	7.8	34	14.5	64	320	51	0	0
BA	0.0	0.2	0.7	42	1.4	87	160	35	0	0
H	0.1	0.3	1.8	41	5.8	128	149	24	2	7
Cr	0.0	0.2	2.2	19	4.8	41	n.a.	41	0	0

PROFILE 184

Legend unit:	E in Dpd
Soil classification:	Dystric Fluvisol (FAO)
	Psammaquent (Soil Taxonomy)
Description:	On 26-07-95 by Gerard Hazeu
Location:	About 2 km NE of Obo'otomba village; 3°04'11 N and 10°35'68 E
Elevation:	unknown
Landform and slope:	undulating dissected erosional plain; valley bottom
Parent material:	Alluvial deposits derived from gneisses and/or migmatites of the Precambrian shield
Vegetation:	Forest
Drainage:	Poorly drained
Soil:	Deep, grey to white sand with very dark brown topsoil.

Depth (cm)	Hor.	Description
0 - 3	Ah	very dark brown (10YR2/2); sandy loam; moderately coherent; slightly sticky, slightly plastic and weakly smeary; many to abundant, very fine to fine roots; clear and smooth transition to
3 - 13	ACr	grey (10YR5/1); loamy fine sand; weakly coherent single grain; very friable, non sticky and slightly plastic; very few to few, very fine to fine roots; gradual and wavy transition to
13 - 43	Cr1	white (10YR8/1); slightly gravelly loamy medium sand; weakly coherent single grain; very friable, non sticky and non plastic; no roots; gradual and smooth transition to
43 - 66	Cr2	light grey (10YR7/1); slightly gravelly, slightly stony loamy coarse sand; weakly coherent single grain; very friable, non sticky and slightly plastic; no roots.

Profile 184										
Horizon	Depth (cm)	Particle size distribution % of fine earth; in um				pH				
		<2	2-50	50-2000		1:2.5	KCl			
Ah	0-3	17	36	47		5	3.6			
ACr	3-13	5	27	69		5.2	3.7			
Cr1	13-43	9	22	70		5.3	3.4			
Cr2	43-66	0	0	0		4.7	3.4			
Horizon	Exchangeable bases (NH_4OAc, pH7), meq/100 g					%		C/N	ppm	
	Na	K	Mg	Ca	TEB	Org. C	N total		Available P	Total P
Ah	0.1	0.2	0.0	4.2	4.5	6.7	0.67	10	90	
ACr	0.0	0.1	0.0	0.4	0.6	0.6	0.08	8	8	
Cr1	0.1	0.1	0.2	0.7	1.1	0.1	0.03	4	2	
Cr2	0.0	0.1	0.1	0.4	0.6	0.4	0.07	5	2	
Horizon	meq/100 g soil		ECEC in meq/100 g		CEC in meq/100 g			%		
	Al	H	fine earth	clay	fine earth	clay	C	BS	Al Sat.	RAS
Ah	0.9	0.3	5.7	n.a.	15.4	n.a.	231	29	6	15
ACr	0.3	0.3	1.1	24	3.3	71	535	17	8	23
Cr1	0.0	0.3	1.4	15	2.6	30	n.a.	40	0	0
Cr2	0.5	0.5	1.6	n.a.	2.9	n.a.	n.a.	21	17	31

PROFILE 203

Legend unit:	E in Cu2
Soil classification:	Dystric Fluvisol (FAO)
	Lythic Endoaquent (Soil Taxonomy)
Description:	On 10-08-95 by Gerard Hazeu
Location:	About 1.5 km S of Engomba village; 3°04'84 N and 10°39'45 E
Elevation:	340 m
Landform and slope:	rolling uplands; valley bottom
Parent material:	Alluvial deposits derived from gneisses of the Precambrian shield
Vegetation:	Forest
Drainage:	Poorly drained
Soil:	Moderately deep, grey sandy loam with very dark brown topsoil.

Depth (cm)	Hor.	Description
0 - 4	Ah	very dark brown (10YR2/2); sand; moderately coherent; very friable, slightly sticky, slightly plastic and weakly smeary; common to many, very fine to fine roots; clear and smooth transition to
4 - 15	BA	light yellowish brown (2.5Y6/4); slightly gravelly sandy loam; weak very fine subangular blocky; friable, slightly sticky and slightly plastic; few to common, very fine to coarse roots; clear and smooth transition to
15 - 43	Bo/r	light yellowish brown (2.5Y6/3); gravelly and slightly stony sandy loam; few (10%) fine to medium, distinct clear 7.5YR6/8 mottles; weak very fine subangular blocky; friable, slightly sticky and slightly plastic; few to common, very fine to coarse roots; abrupt and irregular transition to
43 - 68	CB	grey (2.5Y6/1); gravelly, sandy loam and rock boulders; many (25%) medium distinct clear 7.5YR5/8 mottles; moderately coherent porous massive structure; no roots.

Profile 203										
Horizon	Depth (cm)	Particle size distribution % of fine earth; in µm				pH				
		<2	2-50	50-2000		1:2.5	KCl			
Ah	0-4	4	9	87		5.8	4.8			
BA	4-15	14	16	69		4.6	3.9			
Bo/r	15-43	15	17	69		4.8	3.9			
CB	43-68	14	19	68		5.3	4			
Horizon	Exchangeable bases (NH_4OAc, pH7), meq/100 g					%		C/N	ppm	
	Na	K	Mg	Ca	TEB	Org. C	N total		Available P	Total P
Ah	0.0	0.1	0.3	0.5	0.9	1.0	0.1	10	3	
BA	0.1	0.1	0.1	0.7	1.0	1.0	0.09	11	6	
Bo/r	0.0	0.1	0.1	0.4	0.7	0.4	0.05	8	10	
CB	0.1	0.1	0.2	0.4	0.7	0.3	0.02	14	7	
Horizon	meq/100 g soil		ECEC in meq/100 g		CEC in meq/100 g			%		
	Al	H	fine earth	clay	fine earth	clay	C	BS	Al Sat.	RAS
Ah	0.0	0.1	0.9	n.a.	4.9	n.a.	486	17	0	0
BA	0.7	0.3	2.0	14	5.0	35	487	21	13	33
Bo/r	0.2	0.1	1.0	7	3.8	26	n.a.	18	5	19
CB	0.1	0.1	0.9	7	4.3	32	n.a.	17	2	9

Annex V Vegetation data

A List of identified plant species recorded in the TCP research area
B Summary table of the plant communities in the TCP research area

A. List of identified plant species recorded in the TCP research area

Families, and genera and species within each family, are listed in alphabetical order. Nomenclature follows Flore du Cameroun (1963-1991), Flore du Gabon (1961-1992), and Flora of West Tropical Africa (1954-1972). Of species indicated with '+' plant material has been collected. Collected material is stored in the Tropenbos field herbarium in Kribi, Cameroon.

Family	Genus	Species	Author	Collectio
	Brachystephanus	*jaundensis*	Lindau	+
	Justicia	*extensa*	T. Anders	+
	Thomandersia	*congolana*	De Wild. & Th. Dur.	+
Agavaceae	*Dracaena*	*camerooniana*	Bak.	+
	Dracaena	*phrynioides*	Hook.	+
	Draceana	*aubryana*	Brongn. ex C.J. Morren	+
	Draceana	*cerasifera*	Hua	+
Anacardiaceae	*Antrocaryon*	*klaineanum*	Pierre	
	Lannea	*welwitschii*	(Hiern.) Engl.	
	Mangifera	*indica*	Linn.	
	Pseudospondias	*macrocera*	(A. Rich.) Engl.	+
	Pseudospondias	*microcarpa*	(Engl.) Keay	
	Sorindeia	*grandifolia*	Engl.	
	Sorindeia	*juglandifolia*	(A. Rich.) Planch ex Oliv.	+
	Spondias	*cytherea*	Sonner.	
	Trichoscypha	*acuminata*	Engl.	
	Trichoscypha	*arborea*	(A. Chev.) A. Chev.	
	Trichoscypha	*ferruginea*	Engl.	
Annonaceae	*Anonidium*	*mannii*	(Oliv.) Engl. & Diels	
	Cleistopholis	*glauca*	Pierre ex Engl. & Diels	
	Cleistopholis	*patens*	(Benth.) Engl. & Diels	
	Enantia	*chlorantha*	Oliv.	+
	Hexalobus	*crispiflorus*	A. Rich.	
	Isolona	*hexaloba*	(Pierre) Engl. & Diels	
	Meiocarpidium	*lepidotum*	(Oliv.) Engl. & Diels	+
	Monodora	*myristica*	(Gaertn.) Dunal	+
	Pachypondanthium	*barteri*	(Benth.) Hutch. & Dalz.	
	Pachypondanthium	*staudtii*	Engl. & Diels	
	Piptostigma	*preussii*	Engl. & diels	
	Polyalthia	*suaveolens*	Engl. & Diels	
	Polyceratocarpus	*parviflorus*	(Bak. f.) Ghesq.	+
	Uvariastrum	*pierreanum*	Engl.	
	Xylopia	*aethiopica*	(Dunal) A. Rich.	
	Xylopia	*parviflora*	(A. Rich.) Benth.	

Family	Genus	Species	Author	Collectio
	Xylopia	*quintasii*	Engl. & Diels	
	Xylopia	*staudtii*	Engl. & Diels	+
Apocynaceae	*Alstonia*	*boonei*	De Wild.	
	Alstonia	*congensis*	Engl.	
	Funtumia	*elastica*	(Preuss) Stapf	+
	Hunteria	*umbellata*	(K. Schum.) Hallier f.	+
	Picralima	*nitida*	(Stapf) Th. & H. Dur.	
	Rauvolfia	*macrophylla*	Stapf	
	Rauvolfia	*vomitoria*	Afzel.	+
	Strophantus	*gratus*	(Hook.) Franch.	
	Tabernaemontana	*crassa*	Benth.	
	Tabernaemontana	*pachysiphon*	Stapf.	
	Voacanga	*africana*	Stapf	
	Voacanga	*thouarsii*	Roem. & Schult.	
Araceae	*Anchomanes*	*difformis*	(Blume) Engler	
	Anubias	*hastifolia*	Engl.	+
	Cercestis	*congoensis*	Engl.	+
	Cercestis	*ivorensis*	A. Chev.	+
	Cercestis	*kamerunianus*	(Engl.) N.E.Br.	+
	Culcasia	*barombensis*	N. E. Br.	+
	Culcasia	*dinklagei*	Engl.	+
	Rhektophylium	*mirabile*	N. E. Br.	+
	Stylochiton	*zenkeri*	Engl.	+
	Colocasia	*esculenta*	(Linn.) Schott & Endlicher	
Asclepiadaceae	*Tylophora*	*cameroonica*	N. E. Br.	+
Begoniaceae	*Begonia*	*elatostemmoides*	Hook. f.	+
	Begonia	*macrocarpa*	Warb.	+
	Begonia	*sciaphila*	Gilg ex Engl.	+
Bignoniaceae	*Markhamia*	*tomentosa*	(Benth.) K. Schum. ex Engl.	+
	Newbouldia	*laevis*	(P.Beauv.) Seemann ex	
	Spathodea	*campanulata*	P. Beauv.	
Bombacaceae	*Ceiba*	*pentandra*	(Linn.) Gaertn.	
Boraginaceae	*Cordia*	*plathythyrsa*	Bak.	
Burseraceae	*Canarium*	*schweinfurthii*	Engl.	
	Dacryodes	*edulis*	(G. Don) H.J. Lam.	+
	Dacryodes	*klaineana*	(Pierre) Lam	
	Dacryodes	*macrophylla*	(Oliv.) Lam	
	Santiria	*trimera*	(Oliv.) Aubrev.	+
Caesalpiniaceae	*Afzelia*	*pachyloba*	Harms	
	Amphimas	*pterocarpoides*	Harms	
	Anthonotha	*ferruginea*	(Harms) J. Leonard	

Family	Genus	Species	Author	Collectio
	Anthonotha	*fragrans*	(Bak. f.) Exell & Hillcoat	+
	Anthonotha	*macrophylla*	P. Beauv.	+
	Aphanocalyx	*margininervatus*	J. Leonard	+
	Baikiea	*insignis*	Benth.	+
	Berlinia	*bracteosa*	Benth.	
	Berlinia	*confusa*	Hoyle	
	Brachystegia	*cynometroides*	Harms	+
	Brachystegia	*eurycoma*	Harms	
	Brachystegia	*mildbraedii*	Harms	
	Cynometra	*hankei*	Harms	
	Detarium	*macrocarpum*	Harms	
	Dialium	*bipendense*	Harms	+
	Dialium	*dinklagei*	Harms	+
	Dialium	*guineense*	Willd.	
	Dialium	*tessmannii*	Harms	+
	Didelotia	*brevipaniculata*	J. Leonard	
	Didelotia	*unifoliata*	J. Leonard	
	Distemonanthus	*benthamianus*	Baill.	
	Duparquetia	*orchidacea*	Baill.	+
	Erythrophleum	*ivorense*	A. Chev.	
	Erythroxylum	*mannii*	Oliv.	+
	Gilbertiodendron	*brachystegioides*	(Harms) J. Leonard	
	Gilbertiodendron	*dewevrei*	(De Wild.) J. Leonard	+
	Gilbertiodendron	*grandiflorum*	(De Wild.) J. Leonard	
	Gilbertiodendron	*ogoouense*	(Pellegr.) J. Leonard	
	Gossweilerodendron	*balsamiferum*	(Verm.) Harms	
	Gossweilerodendron	*joueri*	Norm ex Aubr.	
	Guibourtia	*tessmannii*	(Harms) J. Leonard	
	Hylodendron	*gabunense*	Toub.	+
	Hymenostegia	*afzelii*	(Oliv.) Harms	
	Hymenostegia	*breteleri*	Aubr.	+
	Monopetalanthus	*letestui*	Pellegr.	
	Monopetalanthus	*microphyllus*	Harms	+
	Plagiosiphon	*gabonensis*	(A. Chev.) J. Leonard	+
	Plagiosiphon	*longitubus*	(Harms) J. Leonard	+
	Plagiosiphon	*multijugus*	(Harms) J. Leonard	+
	Scorodophloeus	*zenkeri*	Harms	+
	Swartzia	*fistuloides*	Harms	
	Tetraberlinia	*bifoliata*	(Harms) Hauman	+
	Toubaouate	*brevipaniculata*	(J. Leonard) Aubr. &	
Capperidaceae	*Buchholzia*	*coriacea*	Engl.	+

Family	Genus	Species	Author	Collectio
Caricaceae	*Carica*	*papaya*	Linn.	
Celastraceae	*Salacia*	*longipes*	(Oliv.) Halle	
	Salacia	*staudtiana*	Loes.	
Chrysobalanaceae	*Acioa*	*staudtii*	Engl.	+
	Maranthes	*chrysophylla*	(Oliv.) Prance	
	Maranthes	*glabra*	(Oliv.) Prance	
Combretaceae	*Pteleopsis*	*hylodendron*	Mildbr.	
	Terminalia	*superba*	Engl. & Diels	
Commelinaceae	*Aneilema*	*umbrosum*	(Vahl) Kunth	
	Commelina	*cameroonensis*	J.K. Morton	+
	Palisota	*ambigua*	(P. Beauv.) C.B.Cl.	+
	Palisota	*hirsuta*	(Thunb.) K. Schum.	+
	Palisota	*mannii*	C.B.Cl.	+
	Pollia	*condensata*	C. B. Cl.	+
	Standfieldiella	*imperforata*	(C. B. Cl.) Brenan	+
Compositae	*Aspillia*	*africana*	(Pers.) C.D. Adams	+
	Chromolaena	*odorata*	(Linn.) R. King & H.	
	Vernonia	*conferta*	Benth.	+
Conneraceae	*Ageleae*	*hirsuta*	De Wild.	+
	Cnestis	*grisea*	Bak.	+
	Jollydora	*duparquetiana*	(Baill.) Pierre	+
Cyperaceae	*Cyperus*	*diffusus*	Vahl.	+
	Mapania	*amplivaginata*	K. Schum.	+
	Mapania	*macrantha*	(Bak.) Pfeiffer	+
	Mapania	*mannii*	C. B. Cl.	+
	Scleria	*barteri*	Boeck.	+
Dichapetalaceae	*Tapura*	*africana*	Oliv.	
Dioscoraceae	*Dioscorea*	*bulbifera*	Linn.	+
	Dioscorea	*burkilliana*	J. Miege	+
Ebenaceae	*Diospyros*	*bipindensis*	Gurke	+
	Diospyros	*canaliculata*	De Wild.	+
	Diospyros	*cinnabarina*	(Gurke) F. White	+
	Diospyros	*conocarpa*	Gurke & K. Schum.	+
	Diospyros	*crassiflora*	Hiern.	
	Diospyros	*dendo*	Welw. ex Hiern	+
	Diospyros	*hoyleana*	F. White	+
	Diospyros	*kamerunensis*	Gurke	+
	Diospyros	*mimfiensis*	Gurke	+
	Diospyros	*obliguifolia*	(Hiern. ex Gurke) F. White	+
	Diospyros	*physocalycina*	Gurke	+
	Diospyros	*preussii*	Gurke	+

Family	Genus	Species	Author	Collectio
	Diospyros	*simulans*	F. White	+
	Diospyros	*suaveolens*	Gurke	+
Euphorbiaceae	*Alchornea*	*cordifolia*	(Schum. & Thonn.) Mull.	
	Alchornea	*floribunda*	Mull. Arg.	+
	Alchornea	*hirtella*	Benth.	+
	Antidesma	*laciantum*	Mull. Arg.	+
	Antidesma	*venosum*	Tul.	
	Bridelia	*micrantha*	(Hochst.) Baill.	
	Crotonogyne	*manniana*	Mull. Arg.	+
	Crotonogyne	*preussii*	Pax	+
	Dichostemma	*glaucescens*	Pierre	
	Discoglypremna	*caloneura*	(Pax) Prain	+
	Drypetes	*gabonensis*	(Pierre) Hutch.	+
	Drypetes	*gossweileri*	S. Moore	
	Drypetes	*leonensis*	Pax	+
	Drypetes	*molunduana*	Pax & K. Hoffm.	+
	Drypetes	*preussii*	(Pax) Hutch.	+
	Drypetes	*principum*	(Mull. Arg.) Hutch.	+
	Drypetes	*similis*	Hutch.	
	Drypetes	*staudtii*	(Pax) Hutch.	
	Grossera	*macrantha*	Pax	+
	Grossera	*paniculata*	Pax	+
	Hamikoa	*zenkeri*	(Pax) Prain	+
	Hymenocardia	*heudelottii*	Mull. Arg.	
	Macaranga	*barteri*	Mull. Arg.	
	Macaranga	*heudelotii*	Baill.	
	Macaranga	*hurifolia*	Beille	
	Macaranga	*occidentalis*	(Mull. Arg.) Mull. Arg.	
	Macaranga	*saccifera*	Pax	
	Macaranga	*spinosa*	Mull. Arg.	
	Maesobotrya	*barteri*	(Baill.) Hutch.	+
	Maesobotrya	*dusenii*	(Pax) Hutch.	
	Maesobotrya	*staudtii*	(Pax) Hutch.	+
	Manihot	*esculenta*	Crantz	
	Mareya	*brevipes*	Pax	+
	Mareyopsis	*longifolia*	(Pax) Pax & K. Hoffm.	+
	Oldfieldia	*africana*	Benth. & Hook. f.	
	Phyllanthus	*discoideus*	(Baill.) Mull.	
	Phyllanthus	*muellerianus*	(O. Ktze.) Exell	+
	Plagiostyles	*africana*	(Mull. Arg.) Prain	
	Protomegabaria	*stapfiana*	(Beille) Hutch.	+

Family	Genus	Species	Author	Collectio
	Pycnocoma	*macrophylla*	Benth.	+
	Ricinodendron	*heudelotii*	(Baill.) Pierre ex Pax	
	Sapium	*ellipticum*	(Hochst.) Pax	+
	Tetrorchidium	*didymostemon*	(Baill.) Pax & K. Hoffm.	+
	Uapaca	*acuminata*	(Hutch.) Pax & K. Hoffm.	
	Uapaca	*guineensis*	Mull. Arg.	+
	Uapaca	*staudtii*	Pax	
	Uapaca	*vanhouttei*	De Wild.	+
Flacourtiaceae	*Caloncoba*	*brevipes*	(Stapf.) Gilg	
	Caloncoba	*gilgiana*	(Sprague) Gilg	
	Caloncoba	*glauca*	(P. Beauv.) Gilg	
	Caloncoba	*welwitschii*	(Oliv.) Gilg	+
	Homalium	*dolichophyllum*	Gilg	+
	Scottellia	*mimfiensis*	Gilg	
Gramineae	*Acroceras*	*zizanioides*	(Kunth) Dandy	+
	Bambusa	*vulgaris*	Schrad. ex Wendel.	+
	Centotheca	*lappacea*	(Linn.) Desv.	+
	Gauduella	*densiflora*	Pilg.	+
	Gauduella	*ledermannii*	Pilg.	+
	Leptaspis	*cochleata*	Thwaites	+
	Microcalamus	*barbinoides*	Franch.	+
	Olyra	*latifolia*	Linn.	+
	Pseudochinolaena	*polystachya*	(Kunth) Stapf	+
	Puelia	*schumanniana*	Pilg.	+
	Setaria	*megaphylla*	(Steud.) Th. Dur. & Schinz	+
Guttiferae	*Allanblackia*	*floribunda*	Oliv.	
	Allanblackia	*kisonghi*	Vermoesen	
	Allanblackia	*monitcola*	Mildbr. ex Engl.	
	Garcinia	*kola*	Heckel	
	Garcinia	*lucida*	Vesque	+
	Garcinia	*mannii*	Oliv.	+
	Garcinia	*polyantha*	Oliv.	
	Garcinia	*staudtii*	Engl.	
	Mammea	*africana*	Sabine	+
	Pentadesma	*butyracea*	Sabine	+
	Symphonia	*globulifera*	Linn. f.	
Huaceae	*Afrostyrax*	*kamerunensis*	Perkins & Gilg	
Humiriaceae	*Sacoglottis*	*gabonensis*	(Baill.) Urb.	+
Hypericaceae	*Harungana*	*madagascariensis*	Lam. ex Poir.	
Icacinaceae	*Desmostachys*	*tenuifolius*	Oliv.	+
	Iodes	*kamerunensis*	Engl.	

Family	Genus	Species	Author	Collectio
	Lasianthera	*africana*	P. Beauv.	+
	Lavigeria	*macrocarpa*	(Oliv.) Pierre	+
	Leptaulus	*daphnoides*	Benth.	
	Leptaulus	*zenkeri*	Engl.	+
Irvingiaceae	*Desbordesia*	*glaucescens*	(Engl.) Van Tiegh.	
	Irvingia	*gabonensis*	(Aubry-Leconte ex	+
	Irvingia	*grandifolia*	(Engl.) Engl.	
	Irvingia	*robur*	Mildbr.	
	Klainedoxa	*gabonensis*	Pierre ex Engl.	+
	Klainedoxa	*microphylla*	(Pellegr.) A.H. Gentry	
Lauraceae	*Beilschmiedia*	*anacardioides*	(Engl. & Krause) Robyns &	+
	Beilschmiedia	*gabonensis*	(Meisn.) Benth. & Hook. f.	+
	Beilschmiedia	*obscura*	(Stapf) Engl. ex Chevalier	+
	Hypodaphnis	*zenkeri*	(Engl.) Stapf	
	Persea	*americana*	Miller	+
Lecythidaceae	*Petersianthus*	*africanus*	(Welw. ex Benth. & Hook.	
	Petersianthus	*macrocarpus*	(P. Beauv.) Liben	
Leeaceae	*Leea*	*guineensis*	G.Don	+
Loganiaceae	*Anthocleista*	*schweinfurthii*	Gilg.	
	Anthocleista	*vogelii*	Planch.	
	Mostuea	*brunonis*	Didr.	+
	Strychnos	*aculeata*	Solered.	
	Strychnos	*congolana*	Gilg	+
	Strychnos	*dolichothyrsa*	Gilg ex Onochie & Hepper	+
	Strychnos	*elaeocarpa*	Gilg ex Leeuwenb.	+
	Strychnos	*phaeothricha*	Gilg	+
	Strychnos	*staudtii*	Gilg.	+
Marantaceae	*Halopegia*	*azurea*	(K. Schum.) K. Schum.	+
	Haumania	*danckelmanniana*	(J. Braun & K. Schum.)	+
	Marantochloa	*leucantha*	(K. Schum.) M.-Redh.	+
	Megaphrynium	*macrostachyum*	(Benth.) Milne-Redh.	+
	Sarcophrynium	*prionogonius*	(K. Schum.) K. Schum.	+
	Thaumantococcus	*danielii*	(Bennet) Benth.	+
	Trachyphrynium	*braunianum*	(K. Schum.) Bak.	+
Medusandraceae	*Soyauxia*	*gabunensis*	Oliv.	+
	Soyauxia	*talbottii*	Bak. f.	+
Melastomataceae	*Dinophora*	*spenneroides*	Benth.	+
	Dissotis	*erecta*	(Guill. & Perr.) Dandy	+
	Medinilla	*mirabilis*	(Gilg) Jacq.-Fel.	+
	Sakersia	*africana*	Hook. f.	+
Meliaceae	*Carapa*	*grandiflora*	Sprague	

Family	Genus	Species	Author	Collectio
	Carapa	*procera*	DC.	+
	Entandophragma	*angolense*	(Welw.) C. DC.	
	Entandophragma	*candollei*	Harms	
	Entandophragma	*cylindricum*	(Sprague) Sprague	
	Entandrophragma	*utile*	(Dave & Sprague) Sprague	
	Guarea	*cedrata*	(A. Chev.) Pellegr.	+
	Guarea	*glomerulata*	Harms	+
	Guarea	*thompsonii*	Sprague & Hutch.	+
	Khaya	*ivorensis*	A. Chev.	
	Lovoa	*trichilioides*	Harms	
	Trichilia	*emetica*	Vahl	
	Trichilia	*heudelotii*	Planch. ex Oliv.	+
	Trichilia	*rubescens*	Oliv.	
	Trichilia	*welwitschii*	C.DC.	
	Turraeanthus	*africanus*	(Welw. ex C.DC.) Pellegr.	+
Menispermaceae	*Jateorhiza*	*macrantha*	(Hook. f.) Excell &	+
	Penianthus	*longifolius*	Miers	+
Mimosaceae	*Acacia*	*pennata*	(Linn.) Willd.	
	Albizia	*adianthifolia*	(Schum.) W.F. Wight	
	Albizia	*glaberrima*	(Schum. & Thonn.) Benth.	
	Albizia	*zygia*	(DC.) J.F. Macbr.	+
	Calpocalyx	*dinklagei*	Harms	+
	Cylicodiscus	*gabunensis*	Harms	
	Entada	*gigas*	(Linn.) Fawcett & Rendle	+
	Fillaeopsis	*discophora*	Harms	
	Newtonia	*griffoniana*	(Baill.) E. D. Bak.	
	Parkia	*bicolor*	A. Chev.	+
	Parkia	*filicoidea*	Welw. ex Oliv.	
	Pentaclethra	*eetveldeana*	De Wild. Th. Dur.	+
	Pentaclethra	*macrophylla*	Benth.	
	Piptadeniastrum	*africanum*	(Hook.f.) Brenan	+
	Tetrapleura	*tetraptera*	(Schum & Thonn.) Toub.	
Monimiaceae	*Glossocalyx*	*brevipes*	Bentham ex Bentham &	+
Moraceae	*Bosqueia*	*angolensis*	Ficalho	+
	Dorstenia	*barteri*	Bureau	+
	Dorstenia	*picta*	Bureau	+
	Dorstenia	*subtriangularis*	Engl.	+
	Dorstenia	*turbinata*	Engl.	+
	Ficus	*exasperata*	Vahl.	+
	Ficus	*mucuso*	Ficalho	+
	Milicia	*excelsa*	(Welw.) C.C. Berg	

Family	Genus	Species	Author	Collectio
	Musanga	*cecropioides*	R.Brown ex Tedlie	
	Myrianthus	*arboreus*	P. Beauv.	+
	Myrianthus	*serratus*	(Trecul) Benth.	+
	Treculia	*africana*	Decue	
	Treculia	*obovoidea*	N.E.Br.	+
Musaceae	*Musa*	*paradisiaca*	Linn.	
	Musa	*sapientium*	Linn.	
Myristicaceae	*Coelocaryon*	*preussii*	Warb.	+
	Pycnanthus	*angolensis*	(Welw.) Warb.	
	Scyphocephalium	*mannii*	(Benth.) Warb.	
	Staudtia	*kamerunensis*	Warb.	
Myrtaceae	*Syzigium*	*guineense*	(Willd.) DC.	+
	Syzigium	*rowlandii*	Sprague	
Ochnaceae	*Lophira*	*alata*	Banks ex Gaertn. F.	+
	Ochna	*calodendron*	Gilg & Mildbr.	
	Ochna	*membranacea*	Oliv.	+
	Ouratea	*flava*	(Schum. & Thonn.) Hutch.	+
Octoknemaceae	*Octoknema*	*affinis*	Pierre	
Olacaceae	*Aptandra*	*zenkeri*	Engl.	
	Coula	*edulis*	Baill.	+
	Olax	*gambecola*	Baill.	+
	Olax	*latifolia*	Engl.	+
	Olax	*mannii*	Oliv.	+
	Olax	*staudtii*	Engl.	+
	Olax	*subscorpioidea*	Oliv.	+
	Ongokea	*gore*	(Hua) Pierre	
	Ptychopetalum	*petiolatum*	Oliv.	
	Strombosia	*grandifolia*	Hook. f. ex Benth.	+
	Strombosia	*pustulata*	Oliv.	+
	Strombosia	*scheffleri*	Engl.	+
	Strombosia	*zenkeri*	Engl.	
	Strombosiopsis	*tetandra*	Engl.	+
Palmae	*Ancistrophyllum*	*secundiflorum*	(P. Beauv.) Wendl.	
	Calamus	*deeratus*	Mann & Wendl.	+
	Elaeis	*guineensis*	Jacq.	
	Podococcus	*barteri*	Mann & Wendl.	
	Raphia	*regalis*	Becc.	+
	Sclerosperma	*mannii*	Wendl.	
Pandaceae	*Panda*	*oleosa*	Pierre	
	Pandanus	*candelabrum*	P. Beauv.	
Papilionaceae	*Angylocalyx*	*oligophyllus*	(Bak.) Bak. f.	+

Family	Genus	Species	Author	Collectio
	Angylocalyx	*zenkeri*	Harms	
	Baphia	*laurifolia*	Baill.	
	Baphia	*leptobotrys*	Harms	+
	Millettia	*macrophylla*	Benth.	+
	Mucuna	*flagellipes*	Hook. f.	+
	Pterocarpus	*soyauxii*	Taub.	
Passifloraceae	*Barteria*	*fistulosa*	Mast.	+
Piperaceae	*Piper*	*umbellatum*	Linn.	+
Polygalaceae	*Carpolobia*	*lutea*	G. Don.	+
Pteridophyta	*Cyathea*	*manniana*	Hook.	
Rhamnaceae	*Maesopsis*	*eminii*	Engl.	
Rhizophoraceae	*Anisophyllea*	*polyneura*	Floret	+
	Anopyxis	*klaineana*	(Pierre) Engl.	
	Poga	*oleosa*	Pierre	
Rubiaceae	*Aida*	*micrantha*	(K. Schum.) Bullock	+
	Aulacocalyx	*caudata*	(Hiern.) Keay	+
	Aulacocalyx	*talbotii*	(Wernh.) Keay	+
	Bertiera	*aethiopica*	Hiern.	+
	Bertiera	*batesii*	Wernh.	+
	Bertiera	*laxa*	Benth.	+
	Brenania	*brieyi*	(De Wild.) Petit	
	Canthium	*arnoldianum*	(De Wild. & Th. Dur.)	
	Canthium	*palma*	(K. Schum.) Good	
	Chassalia	*coffeosperma*	(K. Schum.) Verdc.	+
	Chassalia	*domatiicola*	(De Wild.) Petit & Verdc.	+
	Chassalia	*zenkeri*	K. Schum. & K. Kr.	+
	Craterispermum	*cerinanthum*	Hiern	+
	Craterispermum	*laurinum*	(Poir.) Benth.	+
	Lasianthus	*batangensis*	K. Schum.	+
	Lasianthus	*repens*	Hepper.	+
	Massularia	*acuminata*	(G. Don) Bullock ex Hoyle	+
	Mitragyna	*stipulosa*	(DC.) O. Ktze.	+
	Nauclea	*diderrichii*	(De Wild. & Th. Dur.)	+
	Oxyanthus	*suppunctatus*	(Hiern) Keay	+
	Pausinystalia	*johimbe*	(K. Schum.) Pierre ex Beille	
	Pavetta	*rigida*	Hiern	+
	Poecilocalyx	*schumannii*	Bremek.	+
	Porterandia	*cladantha*	(K. Schum.) Keay	
	Pseudosabicea	*medusela*	(Wernh.) N. Halle	+
	Rothmannia	*lujae*	(De Wild.) Keay	
	Sabicea	*calycina*	Benth.	+

Family	Genus	Species	Author	Collectio
	Schumanniophyton	*magnificum*	(K. Schum.) Harms	
	Stipularia	*africana*	P. de Beauv.	+
Rutaceae	*Araliopsis*	*soyauxii*	Engl.	
	Oricia	*lecomteana*	Pierre	
	Oricia	*trifoliolata*	(Engl.) Verdoorn	
	Zanthoxylum	*gilletii*	(De Wild.) Waterman	
	Zanthoxylum	*heitzii*	(Aubr. & Pellegr.)	+
	Zanthoxylum	*tessmannii*	(Engl.) R. Let.	
Sapindaceae	*Allophylus*	*africanus*	P.B.	
	Blighia	*sapida*	Koenig	+
	Blighia	*welwitschii*	(Hiern) Radlk.	+
	Chytranthus	*mortelhanii*	(De Wild.) De Vold. ex	+
	Chytranthus	*talbottii*	(Bak. f.) Keay	+
	Eriocoelum	*macrocarpum*	Gilg	+
	Laccodiscus	*ferrugineus*	(Bak.) Radlk.	+
	Lecaniodiscus	*cupanioides*	Planch. ex Benth.	+
	Majidea	*fosteri*	(Sprague) Radlk.	
Sapotaceae	*Afrosersalisia*	*cerasifera*	(Welw.) Aubr.	
	Aningeria	*robusta*	(A. Chev.) Aubr. & Pellegr.	
	Baillonella	*toxisperma*	Pierre	
	Gambeya	*africana*	(Bak.) Pierre	+
	Gambeya	*beguei*	(Aubr. & Pellegr.) Aubr. &	
	Gambeya	*perpulchra*	(Mildbr.) Aubr. & Pellegr.	
Scytopetalaceae	*Brazzeia*	*soyauxii*	(Oliv.) Van Tiegh.	
	Oubangia	*africana*	Baillon	
	Oubanguia	*alata*	Bak. f.	+
	Scytopetalum	*klaineanum*	Pierre ex Engl.	
Simaroubaceae	*Nonthospondias*	*staudtii*	Engl.	
Sterculiaceae	*Cola*	*acuminata*	(P. Beauv.) Schott & Endl.	+
	Cola	*attiensis*	(Pellegr.) N. Halle	+
	Cola	*brevipes*	(Pellegr.) N. Halle	+
	Cola	*cauliflora*	Mast.	
	Cola	*cordifolia*	(Cav.) R. Br.	+
	Cola	*ficifolia*	Mast.	+
	Cola	*lepidota*	K. Schum.	
	Cola	*marsupium*	K. Schum.	+
	Cola	*nitida*	(Vent.) Schott & Endl.	
	Cola	*rostrata*	K. Schum.	+
	Cola	*verticilata*	(Thonn.) Stapf ex A. Chev.	+
	Eribroma	*oblonga*	(Mast.) Bodard.	+
	Octolobus	*angustatus*	Hutch.	+

Family	Genus	Species	Author	Collectio
	Scaphopetalum	*blackii*	Masters	+
	Sterculia	*subviolacea*	K. Schum.	
	Sterculia	*tragacantha*	Lindl.	
	Theobroma	*cacao*	Linn.	
Thymelaceae	*Craterosiphon*	*scandens*	Engl. & Gilg	+
	Dicranolepis	*buchholzii*	Engl. & Gilg	+
Tiliaceae	*Duboscia*	*macrocarpa*	Bocq.	
	Glyphaea	*brevis*	(Spreng.) Monachino	+
	Grewia	*coriacea*	Mast.	+
	Triumfetta	*cordifolia*	A. Rich.	+
Ulmaceae	*Celtis*	*mildbraedii*	Engl.	
	Celtis	*tessmannii*	Rendle	
	Celtis	*zenkeri*	Engl.	+
	Trema	*orientalis*	(Linn.) Blume	
Urticaceae	*Urera*	*cameroonensis*	Wedd.	
Verbenaceae	*Vitex*	*ciliata*	Pierre ex Pellegr.	+
	Vitex	*grandifolia*	Gurke	
	Vitex	*rivularis*	Gurke	
Violaceae	*Rinorea*	*dentata*	(P. Beauv.) O. Ktze	+
	Rinorea	*exappendiculata*	Engl.	+
	Rinorea	*kamerunensis*	Engl.	+
Vitaceae	*Cissus*	*aralioides*	(Welw. ex Bak.) Planch.	+
	Cissus	*quadrangularis*	Linn.	+
Zingiberaceae	*Aframomum*	*albo-violaceum*	K. Schum.	+
	Costus	*afer*	Ker Gawler	+
	Costus	*dinklagei*	K. Schum.	+
	Costus	*engleranus*	K. Schum.	+
	Costus	*phaeotrichus*	Loes.	+
	Costus	*violaceus*	Koechl.	+
	Curcuma	*longa*	Linn.	+
	Renealmia	*cincinnata*	(K. Schum.) Bak.	+
	Zingiber	*officinale*	Rose	+

B. Summary table of the plant communities in the TCP research area

Distribution of plant species in the different plant communities in the TCP research area. The first part concerns the differential species of the plant communities. In the second part, the distribution of the non-differentiating species is presented in alphabetical order. Species presence is indicated as relative frequency; i.e. number of relevés in the plant community in which the species is found. The lists of both differential and non-differential species include taxonomic entities which are in fact clusters of species. These clusters are indicated by the suffix `group' (gr).

Plant communities: I = *Maranthes-Anisophyllea* community; IIa = *Podococcus-Polyalthia* community; IIb = *Strombosia-Polyalthia* community; IIc = *Diospyros-Polyalthia* community; III = *Carapa-Mitragyna* community; IV = *Xylopia-Musanga* community; and V = *Macaranga-Chromolaena* community. Frequency classes: r=1x; +=1-9%; I=10-19%; II=20-39%; III=40-59%; IV=60-79% and V=80-100%. An indication of the growth form is added: LT=large tree (diameter at breast height (dbh) > 60cm; total height (H) > 40m); MT=medium-sized tree (dbh 20-60cm; H 15-40m); ST=small tree (dbh 5-20cm; H < 15m); S=shrub (dbh< 5; H< 10; often multiple stems); WC=woody climber; NC=non-woody climber or vine; PL=palmoid liana; H=terrestrial herb (broadleaved); GH=graminoid herb; P=(acaulescent) palm; TF=tree fern.

1. Differential species

Vegetation type	Ia	II	IIb	IIc	III	IV	V	Growth form
Number of relevés	11	13	23	21	12	16	18	
Differential species of the Maranthes-Anisophyllea community (I)								
Drypetes gr1	V	II	I	+	+	.	.	ST
Anisophyllea polyneura	V	II	II	r	.	+	+	LT
Scorodophloeus zenkeri	IV	II	+	+	.	+	+	LT
Maranthes glabra	IV	.	.	.	.	.	.	MT
Gambeya gr1	IV	II	I	I	.	I	.	MT
Baphia leptobotrys	III	I	I	I	+	I	.	MT
Cola attiensis	III	+	.	.	+	+	.	ST
Diospyros hoyleana	III	+	I	+	.	.	.	ST
Garcinia lucida	II	.	r	r	.	.	.	ST
Anopyxis klaineana	II	.	.	.	.	.	.	LT
Polyceratocarpus parviflorus	II	+	r	.	.	.	.	MT
Agelaea hirsuta	II	+	.	.	.	.	.	WL
Diospyros crassiflora	II	.	+	r	.	.	.	MT
Xylopia quintasii	I	.	r	.	.	.	.	MT
Pachypodanthum barteri	I	.	.	.	.	.	.	LT
Majidea fosteri	I	.	.	.	.	.	.	MT
Strychnos hirsuta	I	.	.	.	.	.	.	WC
Polia condensata	I	.	.	.	.	.	.	H
Olax subscopioidea	I	.	.	.	.	+	.	MT
Dicranolepis sp1	I	.	.	.	+	.	.	ST
Differential species of the Maranthes-Anisophyllea community (I) and the Podococcus-Polyalthia community (IIa)								
Monopetalanthus gr1	IV	III	II	I	II	+	.	
Raphia sp1 (cf. regalis)	IV	IV	+	+	.	.	.	P
Geophila sp1	II	II	.	r	.	+	.	H
Acioa staudtii	II	I	r	.	.	.	.	MT
Drypetes leonensis	II	I	.	.	.	.	.	ST
Mapania amplivaginata	II	I	.	.	.	.	.	GH

Vegetation type	Ia	II	IIb	IIc	III	IV	V	Growth form
Number of relevés	11	13	23	21	12	16	18	
Toubaouate brevipaniculata	I	I	.	+	.	.	.	LT
Begonia gr1	I	I	r	.	+	.	.	H
Differential species of the Podococcus-Polyalthi community (IIa)								
Hymenostegia afzelii	.	IV	I	r	.	.	.	MT
Podococcus barteri	+	III	I	+	I	I	.	P
Crotonogyne preussii	+	II	.	r	.	.	.	S
Tabernaemontana sp1	+	II	r	.	.	+	.	ST
Culcasia dinklagei	+	II	.	.	.	.	.	H
Duboscia macrocarpa	+	II	r	r	.	.	+	LT
Petersianthus africanus	.	II	r	r	.	+	.	LT
Rhaptopetalum sp1	.	I	.	.	.	.	.	ST
Differential species of the Maranthes-Anisophyllea community (I), the Podococcus-Polyalthia community (IIa), and the Strombosia-Polyalthia community (IIb)								
Treculia obovoidea	V	III	V	.	+	I	+	MT
Calpocalyx gr1	II	I	I	r	.	.	.	
Differential species of the Maranthes-Anisophyllea community (I), and the Polyalthia community group (II)								
Ptychopetalum petiolatum	III	IV	III	III	+	II	I	MT
Sorindeia sp1	II	II	II	II	.	+	.	
Symphonia globulifera	I	I	+	I	.	.	.	MT
Dichostemma glaucescens	I	III	II	I	.	+	.	MT
Differential species of the Polyalthia community group (II)								
Polyalthia suaveolens	I	IV	IV	IV	II	I	.	MT
Grossera gr1	II	IV	IV	IV	I	III	+	
Scaphopetalum blackii	II	IV	IV	III	II	+	I	ST
Plagiostyles africana	II	IV	IV	IV	III	I	+	MT
Dialium gr1	II	III	IV	IV	.	II	+	
Agelaea sp1	I	II	II	III	+	+	.	
Tricalysia gr1	.	III	I	III	.	+	+	S
Desbordesia glaucescens	.	II	I	III	+	+	+	LT
Diospyros bipindensis	.	II	II	II	.	+	.	
Diospyros obliquifolia	+	II	II	I	.	+	.	ST
Guarea gr1	.	II	I	I	.	.	.	
Differential species of the Podococcus-Polyalthia community (IIa) and the StrombosiaPolyalthia community (IIb)								
Carpolobia gr1	+	II	II	+	.	+	I	ST
Antidesma laciantum	.	I	II	.	+	.	.	MT
Erythrophleum ivorense	.	II	III	+	.	+	.	LT
Differential species of the Strombosia-Polyalthia community (IIb)								
Grewia coriacea	+	.	II	r	+	I	.	MT
Saccoglottis gabonensis	.	.	I	r	+	+	.	LT
Differential species of the Strombosia-Polyalthia community (IIb) and the Diospyros-Polyalthia community (IIc)								
Calpocalyx dinklagei	.	I	III	III	I	I	+	MT
Rinorea kamerunensis	II	I	III	IV	+	I	.	ST

Vegetation type	Ia	II	IIb	IIc	III	IV	V	Growth form
Number of relevés	11	13	23	21	12	16	18	
Olax staudtii	+	.	II	I	+	+	.	ST
Chrytranthus talbotii	.	.	II	II	I	+	+	MT
Klainedoxa gabonensis	.	.	I	II	.	.	I	LT
Lasianthera africana	+	I	II	III	I	I	+	S
Differential species of the Diospyros-Polyalthia community (IIc)								
Diospyros suaveolens	+	II	I	IV	III	I	+	MT
Dracaena gr1	+	+	.	II	I	.	.	
Picralina nitida	.	+	I	II	.	.	.	MT
Lasianthera sp2	+	.	r	I	.	.	.	
Marantaceae sp1	.	.	.	I	.	.	.	H
Pycnocoma macrophylla	.	.	.	I	.	+	.	S
Differential species of the Maranthes-Anisophyllea community (I), the Polyalthia community group (II), and the Carapa-Mitragyna community (III)								
Cola ficifolia	I	+	II	I	I	.	.	MT
Strombosia pustulata	I	II	IV	III	II	.	.	MT
Mammea africana	II	+	II	r	I	.	.	LT
Halopegia gr1	III	IV	IV	III	IV	.	.	H
Beilschmiedia gr2	I	II	II	II	II	+	.	
Aphanocalyx gr1	I	II	I	II	I	+	.	
Santiria trimera	III	III	III	II	II	+	.	MT
Differential species of all forest communities (I, II, III and IV)								
Calamus deëratus	III	IV	IV	III	III	III	.	PL
Palisota mannii	III	IV	IV	II	IV	II	.	H
Strombosia gr1	III	IV	II	III	III	II	.	
Scaphopetalum thonneri	II	IV	III	II	II	I	.	S
Staudtia kamerunensis	II	III	IV	V	I	IV	+	LT
Coula edulis	II	II	III	II	+	I	.	MT
Rubiaceae sp1	I	III	III	II	II	I	.	
Beilschmiedia gr1	I	I	I	II	II	I	.	
Rubiaceae gr2	III	IV	II	II	I	II	+	
Tetraberlinia bifoliata	III	+	II	II	II	I	.	LT
Dracaena phrynioides	II	I	+	I	II	+	.	
Glossocalyx brevipes	II	+	III	I	II	+	.	ST
Dacryodes gr1	II	II	II	+	I	I	.	
Voacanga gr1	II	III	II	+	+	I	.	
Diospyros gr2	I	II	III	II	+	II	.	
Blighia welwitschii	+	II	I	I	+	II	.	LT
Diospyros gr1	II	III	I	I	+	II	.	
Costus engleranus	I	I	I	+	+	+	.	H
Stipularia africana	+	+	II	r	I	II	.	H
Differential species of all plant communities except the Maranthes - Anisophyllea community (I)								
Scyphocephalium mannii	.	II	I	I	II	I	.	LT
Piptadeniastrum africanum	.	I	II	III	II	III	+	LT
Pterocarpus gr1	.	II	I	II	II	I	I	
Nephthytis sp1	+	II	II	+	II	I	I	H
Lophira alata	.	I	II	II	II	II	III	LT

Vegetation type	Ia	II	IIb	IIc	III	IV	V	Growth form
Number of relevés	11	13	23	21	12	16	18	
Differential species of the Carapa - Mitragyna community (III), the Xylopia - Musanga community (IV), and the Macaranga - Chromolaena community (V)								
Sterculia tragacantha	.	.	.	.	I	I	II	MT
Leea guineensis	+	.	.	.	II	I	II	S
Palisota hirsuta	.	+	.	.	I	I	I	H
Elaeis guineensis	.	.	.	+	III	II	III	P
Caloncoba welwitschii	.	+	r	r	I	I	II	MT
Raphia sp2	.	.	+	+	III	II	II	P
Differential species of the Carapa - Mytragyna community (III)								
Mitragyna stipulosa	.	.	r	.	V	+	+	MT
Carapa sp1	.	.	.	.	III	.	.	MT
Trichilia heudelotii	.	+	I	+	III	I	I	ST
Diospyros preussii	+	.	r	.	II	.	.	MT
Rubiaceae sp2	.	.	.	.	II	.	.	
Cyathea manniana	.	.	.	.	II	.	+	TF
Curcuma longa	.	.	.	.	II	.	.	GH
Differential species of the Xylopia - Musanga community (IV)								
Palisota ambigua	I	+	II	II	III	IV	II	H
Xylopia gr1	I	+	II	I	II	IV	II	
Zanthoxylum gillettii	+	II	II	I	II	IV	III	MT
Thaumatococcus danielii	.	.	I	I	I	IV	II	H
Megaphrynium macrostachyum?	.	.	r	I	I	III	II	H
Ancistrophyllum secundiflorum	I	+	I	r	II	III	.	PL
Phyllanthus discoideus	.	II	I	I	.	III	I	MT
Ricinodendron heudelotti	.	+	.	I	+	II	+	LT
Massularia acuminata	+	+	.	.	.	I	.	ST
Caloncoba brevipes	.	.	.	.	.	I	.	MT
Differential species of the Diospyros - Polyalthia community (IIc), the Xylopia - Musanga community (IV), and the Macaranga - Chromolaena community (V)								
Hylodendron gr1	II	III	II	IV	+	IV	I	
Ouratea flava	.	.	+	II	+	III	+	ST
Eribroma gr1	.	+	.	III	+	II	III	
Terminalia superba	.	.	.	II	+	II	I	LT
Myrianthus arboreus	.	.	r	II	.	II	I	MT
Differential species of the Xylopia - Musanga community (IV) and the Macaranga - Chromolaena community (V)								
Musanga cecropioides	+	+	.	r	II	IV	IV	MT
Funtumia elastica	.	I	r	r	.	III	III	MT
Rauvolfia macrophylla	.	.	.	r	+	II	II	MT
Vernonia conferta	.	.	.	.	.	II	I	ST
Macaranga gr2	.	.	.	.	.	I	II	ST
Anthocleista schweinfurthii	.	.	.	.	.	I	I	MT
Hamikoa gr1	.	.	.	r	+	I	II	S
Mareya brevipes	.	.	r	.	.	I	+	
Melastomataceae gr2	.	.	r	r	.	I	II	

Anthocleista vogelii	.	.	.	.	.	I	II	MT

Vegetation type	Ia	II	IIb	IIc	III	IV	V	Growth form
Number of relevés	11	13	23	21	12	16	18	
Differential species of the Macaranga - Chromolaena community (V)								
Macaranga gr1	.	.	.	.	.	II	IV	ST
Chromolaena odorata	.	.	.	.	.	+	IV	H
Fern gr1	.	I	II	II	+	II	IV	H
Costus violaceus	.	.	.	.	II	.	III	H
Trifolium sp1 (cultivated)	.	.	.	.	.	.	III	H
Milicia excelsa	.	.	.	r	.	.	III	LT
Manihot esculenta (cult.)	.	.	.	.	.	+	III	S
Anchomanes sp1 (cult.)	.	.	.	.	.	+	III	H
Ceiba pentandra	.	+	.	r	.	+	III	LT
Rauvolfia vomitoria	.	.	.	.	.	I	III	ST
Albizia zygia	.	I	+	I	I	II	III	LT
Dioscorea bulbifera	.	.	.	.	.	.	II	NL
Trema orientalis	.	.	.	.	.	.	II	ST
Scleria barteri	.	.	.	.	.	.	II	GH
Dioscorea burkeliana	.	.	.	.	.	.	II	WC
Colocasia esculenta (cult.)	.	.	.	.	.	.	II	H
Musa gr1 (cultivated)	.	.	.	.	.	.	II	H/S
Jateorhiza macrantha	.	.	.	.	.	.	II	NL
Trifolium sp1 (cult.)	.	.	.	.	.	+	II	
Brucea sp1	.	.	.	r	.	+	II	
Millettia macrophylla	.	.	r	r	+	.	II	MT
Tetrorchidium didymost.	.	.	r	.	.	+	II	
Harungana madagasc.	.	.	r	.	.	.	I	MT
Theobroma cacao (cult.)	.	.	.	.	.	.	I	ST

2. Non-differential species

Vegetation type	Ia	IIa	IIb	IIc	IIIa	IVa	Va	Growth form
Carapa gr1	III	II	III	II	II	II	I	
Uapaca guineensis	III	IV	III	II	III	II	II	LT
Coelocaryon preussii	III	III	IV	V	V	IV	II	LT
Pentaclethra macrophylla	II	III	IV	I	II	III	I	MT
Cercestis ivorensis	II	II	III	IV	II	III	II	H
Tabernaemontana crassa	II	III	III	IV	I	IV	I	MT
Rubiaceae gr3	II	III	III	II	III	III	I	S
Trachyphrynium sp1	II	II	I	II	II	III	II	
Haumania danckelmanniana	I	IV	IV	V	III	V	III	PL
Pycnanthus angolensis	I	IV	II	IV	III	IV	III	LT
Rhektophyllum gr1	I	II	V	IV	IV	V	II	H
Enantia chlorantha	I	II	II	I	I	I	I	MT
Anthonotha macrophylla	+	II	II	IV	III	III	II	MT
Homalium delicophyllus	III	II	I	I	I	I	II	LT

Guaduella gr1	III	I	II	III	I	I	I	GH
Alchornea floribunda	I	II	I	I	+	III	I	WC
Acacia pennata	.	+	I	+	+	I	I	WC
Acroceras zizanioides	.	.	.	.	.	.	I	
Aframomum gr1	.	+	.	I	I	II	II	H
Afrosersalisia cerasifera	+	.	.	.	.	.	.	
Dracaena sp1	+	.	.	r	I	.	.	H

Vegetation type	Ia	IIa	IIb	IIc	IIIa	IVa	Va	Growth form
Albizia adianthifolia	.	+	r	.	.	I	+	LT
Albizia glaberrima	.	.	.	.	.	.	+	LT
Alchornea cordifolia	.	.	.	.	.	I	+	WC
Alchornea hirtella	I	+	r	r	.	.	.	S
Allanblackia floribunda	.	+	r	.	.	.	.	MT
Allanblackia kisongui	III	+	III	II	I	II	+	MT
Allanblackia montana	+	.	.	.	.	.	.	LT
Allophyllus africanus	.	.	.	r	.	+	.	ST
Alstonia boonei	.	.	.	.	+	+	.	LT
Alstonia congensis	+	II	I	+	I	II	II	LT
Angylocalyx oligophyllus	+	.	.	.	.	.	.	MT
Angylocalyx zenkeri	+	+	+	.	.	.	.	MT
Antidesma venosum	.	+	+	r	.	.	.	MT
Antrocaryon klaineanum	.	+	r	r	.	II	+	LT
Anubias hastifolia	.	.	.	.	+	.	.	H
Aptandra zenkeri	.	.	.	.	.	.	.	ST
Araliopsis soyauxii	+	.	+	.	.	.	.	LT
Aspilia africana	.	.	I	.	+	.	I	H
Asystasia macrophylla	.	.	r	.	.	.	.	
Bambusa arundinacea	.	I	.	.	.	.	+	GH
Baphia laurifolia	.	.	.	r	.	.	.	MT
Barteria fistulosa	.	+	r	.	.	I	I	MT
Begonia macrocarpa	.	+	.	.	.	.	.	H
Begonia sciaphila	.	.	.	.	+	.	.	H
Berlinia bracteosa	.	.	+	I	II	I	.	LT
Berlinia confusa	.	.	.	.	.	+	.	LT
Blighia sapida	+	I	.	r	.	.	.	MT
Bosqueia angolensis	.	+	.	.	.	.	I	
Brachystegia cynometroides	.	+	r	.	.	.	.	LT
Brachystegia eurycoma	.	.	.	r	.	.	.	LT
Brachystegia mildbraedii	.	.	r	.	.	.	.	LT
Brachystephanus jaundensis	+	.	.	.	+	I	.	H
Brenania Brieyi	.	.	.	.	.	+	.	MT
Bridelia micrantha	.	.	.	.	.	+	.	MT
Buchholzia coriacea	.	I	+	r	.	.	.	MT
Caloncoba gilgiana	.	.	.	.	+	I	.	MT
Caloncoba glauca	.	+	.	I	.	I	I	MT
Caloncoba zygas	.	.	.	.	.	+	.	MT
Canarium schweinfurthii	+	.	+	+	I	I	I	LT
Canthium arnoldianum	.	+	.	.	.	.	.	MT
Canthium palma	.	+	.	.	.	+	.	MT
Carica papaya	.	.	.	.	.	.	I	S
Celtis gr1	+	II	I	I	+	I	.	MT
Celtis tessmannii	+	.	r	.	.	.	.	LT
Cephaëlis sp1	.	I	+	r	.	I	+	H

Cercestis congoensis	.	.	.	.	+	.	.	H
Cercestis kamerunianus	.	.	I	II	I	+	.	H
Chrytranthus seressii	.	+	r	.	.	.	.	MT
Chrytranthus sp1	.	.	r	.	.	.	.	ST
Cleistopholis glauca	.	.	.	.	.	+	.	LT
Cleistopholis patens	.	+	+	+	+	II	I	LT
Cnestis grisea	.	.	r	r	.	+	.	
Coelocaryon sp1	.	.	.	.	+	.	.	

Vegetation type	Ia	IIa	IIb	IIc	IIIa	IVa	Va	Growth form
Cola cauliflora	.	.	r	I	.	.	.	ST
Cola cordifolia	.	.	II	+	I	.	.	MT
Cola gr1	I	II	II	+	I	.	.	
Cola gr2	+	+	.	+	.	.	.	
Cola lepidota	.	+	.	+	+	.	.	ST
Cola marsupium	.	+	+	r	.	+	.	S
Cola rostrata	I	I	I	+	.	+	.	MT
Commelina cameroonensis	.	.	.	.	.	.	.	H
Commelinaceae gr1	.	.	r	.	+	+	.	H
Agelaea gr1	+	+	.	.	.	.	.	
Cnestis gr1	.	.	r	.	.	.	.	
Cordia plathythyrsa	.	.	.	.	.	.	+	LT
Costus afer	.	.	.	.	I	+	.	H
Costus dinklagei	.	.	.	.	.	.	I	H
Costus phaeotrichus	.	.	.	r	.	.	.	H
Costus sp1	.	.	r	.	.	I	.	H
Craterispermum laurinum	I	.	r	r	.	+	.	ST
Craterispermum longifolium	.	.	r	.	.	.	.	ST
Craterosiphon scandens	.	+	.	.	.	.	.	
Crotonogyne manniana	+	.	.	.	.	.	.	S
Cyliodiscus gabunensis	.	+	.	r	+	.	.	LT
Mapania gr1	.	I	I	+	.	I	.	GH
Cyperus diffusus	.	.	.	.	.	.	+	GH
Dacryodes edulis	II	II	II	I	II	.	I	MT
Dacryodes klaineana	.	.	r	.	.	.	.	MT
Detarium macrocarpum	.	.	.	.	.	+	.	LT
Didelotia brevipaniculata	.	.	r	.	.	+	.	LT
Didelotia unifoliolata	.	.	.	.	.	+	.	LT
Diospyros conocarpa	I	+	r	.	.	+	.	ST
Diospyros dendo	+	.	.	.	.	.	.	MT
Discoglypremna caloneura	.	+	+	r	.	I	+	LT
Distemonanthus bentham.	.	+	II	II	+	II	II	LT
Dorstenia picta	.	.	.	.	+	.	+	H
Dorstenia subtriangularis	.	.	.	.	+	.	.	H
Dorstenia turbinata	.	.	r	.	.	.	.	H
Dracaena cerasifera	+	.	.	.	.	.	.	H/S
Dracaena sp1	.	.	.	.	.	.	.	
Drypetes gabonensis	.	.	.	.	.	.	.	ST
Drypetes gossweileri	.	+	.	r	.	.	.	LT
Drypetes molunduana	.	.	r	.	.	.	.	MT
Drypetes sp1	.	I	r	.	.	.	.	MT
Duparquetia orchidacea	.	.	.	.	.	.	+	WC
Entandrophragma angolense	.	+	.	.	.	.	.	LT
Entandrophragma utile	.	+	.	.	.	+	.	LT

Eriocoelum macrocarpum	+	+	.	.	.	.	.	MT
Erytroxylum mannii	.	+	.	.	.	.	I	LT
Eugenia sp1	.	.	r	.	.	.	.	
Euphorbiaceae gr1	+	.	.	.	.	.	+	
Euphorbiaceae sp1	.	.	.	.	+	.	.	
Ficus exasperata	.	.	.	r	.	.	I	LT
Fillaeopsis discophora	.	.	r	.	.	.	.	LT
Flacourtiaceae sp1	.	I	+	II	II	+	II	
Gambeya perpulchra	+	.	.	.	.	.	.	MT

Vegetation type	Ia	IIa	IIb	IIc	IIIa	IVa	Va	Growth form
Garcinia kola	.	.	.	.	.	.	.	MT
Garcinia mannii	II	III	II	I	II	I	+	ST
Garcinia polyantha	.	.	r	r	.	.	.	MT
Garcinia staudtii	+	+	.	.	.	.	.	MT
Gardenia sp1	+	.	.	.	.	.	.	
Gilbertiodendron brachyst.	.	.	r	.	.	.	.	LT
Gilbertiodendron dewevrei	I	.	.	I	+	I	.	LT
Gilbertiodendron grandifl.	.	.	.	r	.	.	.	LT
Gilbertiodendron ogoouense	.	+	.	.	.	.	.	LT
Glyphaea brevis	.	.	+	.	.	I	.	ST
Gossweilerodendron balsam.	+	I	.	.	.	.	.	LT
Gossweilerodendron joueri	.	+	.	.	.	.	.	LT
Grossera macrantha	.	I	I	r	+	.	.	MT
Grossera paniculata	.	.	r	.	.	.	.	MT
Guarea cedrata	.	+	+	I	+	+	.	LT
Guibourtia tessmannii	+	.	.	.	.	.	.	LT
Heckeldora HNC 49157	.	+	.	.	.	.	.	ST
Heisteria parvifolia	.	+	+	I	.	.	+	ST
Hexalobus crispiflorus	.	+	I	r	.	I	.	MT
Hunteria umbellata	.	+	r	.	.	.	.	S
Hymenocardia heudelotii	.	.	.	.	.	.	.	ST
Hymenostegia breteleri	.	+	.	.	.	.	.	MT
Hypodaphnis zenkeri	+	.	I	.	II	II	.	MT
Hypselodelphys sp1	.	.	r	.	+	.	.	H
Iodes kamerunensis	+	+	.	.	.	.	.	WC
Irvingia gabonensis	.	+	II	II	I	+	+	LT
Irvingia grandifolia	+	+	r	.	.	+	.	LT
Irvingia robur	+	+	r	I	.	.	.	LT
Isolona hexaloba	+	.	.	.	.	+	.	MT
Justica extensa	.	.	.	.	+	.	.	H
Khaya ivorensis	+	.	r	.	.	.	.	LT
Klainedoxa microphylla	+	I	+	r	.	+	.	LT
Laccodiscus ferrugineus	.	+	r	.	.	.	.	MT
Landolphia sp1	II	+	r	.	+	.	.	NC
Lasiodiscus sp1	.	.	.	r	.	.	.	ST
Lavigeria gr1	I	I	II	III	.	I	II	WC
Lecaniodiscus cupanioides	+	.	.	.	.	.	.	MT
Leptaulus daphnoides	.	+	.	.	.	.	.	ST
Leptaulus zenkeri	+	.	+	r	.	.	.	ST
Leptonychia sp1	.	.	.	.	.	.	.	ST
Lovoa trichilioides	.	I	r	+	+	+	.	LT
Macaranga hurifolia	.	.	.	.	.	+	.	MT
Macaranga occidentalis	.	.	.	.	.	.	+	WC

Vegetation type	Ia	IIa	IIb	IIc	IIIa	IVa	Va	Growth form
Macaranga saccifera	.	.	.	.	.	.	+	WC
Maesobotrya acuminata	.	.	.	r	.	.	.	ST
Maesobotrya barteri	.	+	r	.	.	.	.	MT
Maesobotrya dusenii	.	+	r	r	.	.	.	ST
Maesobotrya staudtii	.	I	I	r	+	I	.	MT
Maesopsis eminii	+	+	.	.	.	.	+	MT
Mangifera indica	.	.	.	.	.	.	+	MT
Mapania macrantha	I	.	+	.	.	.	.	GH
Maranthes chrysophylla	.	+	.	.	.	.	.	MT
Marantochloa leucantha	I	+	.	.	+	.	.	H
Mareyopsis longifolia	II	II	II	I	I	.	I	MT
Meiocarpidium gr1	+	+	II	II	I	+	.	
Melastomataceae gr1	.	+	.	.	+	+	+	
Microcalamus barbinodis	+	+	.	.	.	.	.	GH
Microdesmis HNC 49201	+	.	.	.	.	+	.	ST
Millettia sp1	.	.	r	.	.	.	.	
Monodora myristica	+	+	.	r	.	.	.	MT
Monodora sp1	.	.	r	.	.	.	.	
Mostuea brunoniste	.	.	.	.	.	.	.	NC
Mucuna flagellipes	.	.	.	.	.	.	+	
Mussaenda sp1	.	.	.	.	.	+	.	
Myrianthus serratus	.	.	.	.	.	+	+	MT
Napoleonaea sp1	.	+	.	.	.	.	.	ST
Nauclea diderrichii	.	.	+	.	.	+	.	LT
Newbouldia laevis	I	.	I	I	I	I	II	
Newtonia griffoniana	+	.	.	.	.	.	.	LT
Nonthospondias? staudtii	.	+	.	.	.	.	+	MT
Ochna calodendron	.	.	r	.	.	.	.	MT
Ochna membranacaea	+	.	.	.	.	I	.	ST
Octoknema gr1	.	+	r	.	.	.	.	ST
Octolobus angustatus	+	I	.	.	.	.	.	MT
Olacaceae sp1	+	.	.	.	.	.	.	
Olax gambecola	.	.	r	.	.	.	.	ST
Olax latifolia	.	.	.	.	.	+	.	ST
Olax mannii	.	+	.	.	.	.	.	ST
Olax suaveolens	.	.	.	r	.	.	.	ST
Oldfieldia africana	.	.	.	.	.	.	.	LT
Olyra latifolia	.	.	.	.	+	.	.	
Ongokea gore	.	+	r	I	.	.	.	LT
Oricia lecontiana	.	I	+	.	.	.	.	S
Oricia trifoliata	+	.	.	.	.	.	.	MT
Ormocarpum sp1	.	+	.	.	.	.	.	
Oubanguia africana	+	I	r	I	.	.	.	MT
Oubanguia alata	+	I	.	r	.	.	.	MT
Ouratea HNC 40350	+	.	r	.	.	.	.	S
Pachypodanthum staudtii	I	I	I	.	+	.	.	LT
Panda oleosa	+	.	r	.	.	+	+	ST
Pandanus candelabrum	.	.	.	.	.	.	+	ST
Papilionaceae sp1	.	.	.	.	.	.	+	
Papilionaceae sp2	.	.	r	.	.	.	.	
Parinari sp1	.	+	.	r	.	.	.	
Parkia bicolor	I	II	II	r	I	I	+	LT

Parkia filicoidea	.	.	+	r	.	.	.	LT
Paullinia sapinda	.	.	.	.	.	.	+	WC
Pausinystalia johimbe	.	.	.	.	.	.	I	MT
Penianthus longifolius	.	+	.	.	.	+	.	S
Pentaclethra eetveldeana	.	.	.	r	.	+	.	MT
Pentadesma butyracea	I	.	r	.	.	.	.	MT
Pentas sp1	I	II	I	I	+	II	II	H
Persea americana	.	.	.	I	.	I	+	MT
Petersianthus macrocarpus	.	.	r	r	.	+	.	LT
Piper umbellatum	.	.	.	r	.	.	+	H
Piptostigma preussii	+	.	r	.	.	.	.	MT

Vegetation type	Ia	IIa	IIb	IIc	IIIa	IVa	Va	Growth form
Plagiosiphon gr1	+	+	r	.	.	.	.	LT
Plagiosiphon multijugus	.	.	r	.	.	.	.	LT
Poga oleosa	.	.	r	.	.	.	.	LT
Protomegabaria stapfiana	.	+	.	.	.	.	.	ST
Pseudospondias macrocera?	+	+	+	r	.	.	+	LT
Pseudospondias microcarpa	I	.	r	r	+	II	+	LT
Pteleopsis hylodendron	.	.	r	r	.	+	.	LT
Ptychopetalum rudentessi?	+	.	.	.	.	.	.	WC
Rhabdophyllum sp1	.	.	.	+	.	.	.	
Rinorea caudata	.	+	r	r	.	.	.	S
Rinorea dentata	.	II	II	I	+	I	.	ST
Rinorea exappendiculata	.	.	.	.	+	+	.	S
Rinorea sp1	.	.	.	.	+	.	.	S
Rothmannia sp1	.	.	.	.	.	.	.	
Sabicea calycina	.	.	.	.	.	+	.	
Salacia longipes	+	.	.	.	.	.	.	WC
Salacia sp1	.	.	.	r	.	.	.	
Salacia sp1	.	II	II	I	.	I	+	
Salacia staudtiana	I	+	.	.	+	+	.	WC
Sapindaceae sp1	.	+	I	+	II	.	+	
Sapium ellipticum	.	.	.	.	.	+	.	MT
Sapotaceae sp1	.	.	.	.	.	.	.	
Schumanniophyton magnificum		+	.	.	.	.	.	. ST
Sclerosperma mannii	.	.	.	r	.	.	.	P
Scottellia mimfiensis	.	.	r	.	.	.	.	MT
Scytopetalaceae sp1	+	.	.	.	.	.	.	ST
Scytopetalum klaineanum	+	.	+	.	.	.	.	MT
Setaria megaphylla	.	.	.	.	.	.	I	GH
Sorindeia grandifolia	III	II	II	I	.	I	.	MT
Sorindeia juglandifolia	+	.	.	.	.	.	.	ST
Soyauxia gabonensis	.	.	.	r	.	.	.	MT
Soyauxia talbotii	.	+	.	.	+	.	.	MT
Spathodea campanulata	.	.	.	.	.	.	+	LT
Spondias cytherea	.	+	.	.	.	.	.	ST
Standfieldiella imperforata	.	.	.	.	.	+	.	
Sterculia subviolacea	.	.	r	.	I	+	.	MT
Strombosia scheffleri	+	+	.	.	.	.	.	MT
Strombosia zenkeri	.	.	.	.	+	.	.	ST
Strophanthus gratus	.	.	+	r	.	.	+	WC
Strychnos aculeata	+	.	.	.	.	.	.	WC
Strychnos congolana	+	.	.	.	.	.	.	WC

Strychnos eleocarpa	+	+	r	.	.	.	.	WC
Strychnos phaeotricha	.	.	.	.	+	.	.	WC
Strychnos staudtii	II	I	+	r	.	I	.	WC
Swartzia fistuloides	.	.	.	r	.	.	.	LT
Syzygium guineense	.	.	r	.	.	.	.	MT
Syzygium rowlandii	+	.	.	.	.	.	.	MT
Syzygium sp1	+	.	.	.	+	.	.	
Tabernaemontana pachys.	.	.	.	.	.	.	+	ST
Tapura africana	+	+	+	.	.	.	.	LT
Tetraplaura tetraptera	.	.	.	.	+	I	+	MT
Thomandersia congolana	.	+	+	.	I	+	.	S
Trachyphrynium braunianum	.	+	.	.	I	II	.	

Vegetation type	Ia	IIa	IIb	IIc	IIIa	IVa	Va	Growth form
Treculia africana	.	.	.	r	.	.	.	MT
Treculia HNC 30012	.	.	.	r	.	.	.	
Trichilia emetica	.	.	.	.	.	+	.	ST
Trichilia rubescens	+	.	.	.	.	.	.	ST
Trichilia welwitschii	.	.	r	.	I	I	+	MT
Trichoscypha acuminata	.	+	+	r	.	.	.	MT
Trichoscypha arborea	+	+	r	r	.	.	+	LT
Trichoscypha ferruginia	+	I	r	.	.	.	+	ST
Turraeanthus africanus	I	+	II	.	+	I	.	MT
Tylophora cameroonica	.	.	.	.	.	.	+	NC
Uapaca acuminata	.	+	.	.	.	.	+	LT
Uapaca staudtii	+	+	.	.	+	I	.	MT
Uapaca vanhouttei	.	+	II	I	II	.	.	MT
Urera cameroonensis	.	.	.	.	.	.	+	NC
Uvariastrum pierreanum	.	.	r	r	.	.	.	ST
Uvariodendron sp1	+	II	r	+	II	.	+	ST
Vitex ciliata	.	+	.	.	.	.	.	LT
Vitex grandifolia	II	.	+	+	I	II	I	LT
Vitex rivularis	+	.	.	.	.	I	.	MT
Vitis aralioides	.	.	.	.	.	.	+	NC
Vitis quadricularia	.	.	.	.	.	.	+	NC
Vitis sp1	+	.	.	I	+	+	+	NC
Voacanga thouarsii	.	.	r	.	.	.	.	ST
Xylopia parviflora	.	.	r	r	.	+	.	MT
Zanthoxylum heitzii	.	I	I	r	+	II	+	LT
Zanthoxylum tessmannii	+	.	r	.	.	I	.	LT
Zingiber officinale	.	.	.	.	.	.	+	H
Zingiberaceae sp1	.	.	.	.	.	.	+	H

Annex VI List of bird species observed in the TCP research area

The listed species were recorded in the period May 1995 to November 1997. As no systematic bird survey has started yet, the list is a mere compilation of the species lists of Jan Jansen (WAU), Patrick Hommel (SC-DLO; 1995; 1996), Thom Kuyper (WAU) and Barend van Gemerden. Nomenclature follows Serle & Morel (1997).

Accipitridae	
Accipiter toussenelii	West african goshawk
Dryotriorchis spectabilis	Congo Serpent-eagle
Gyphohierax angolensis	Palm-nut vulture
Kaupifalco monogrammicus	Lizard buzzard
Macheirhamphus alcinus	Bathawk
Milvus migrans	Black kite
Polyboroides radiatus	Harrier hawk
Urotriorchis macrourus	Long-tailed hawk
?Circaetus gallicus	Short-toed eagle
?Stephanoaetus coronatus	Crowned hawk-eagle
Alcedinidae	
Alcedo quadribrachys	Shining-blue kingfisher
Ceyx picta	Pygmy kingfisher
Halycon badia	Chocolate-backed kingfisher
Halycon senegalensis	Senegal kingfisher
Apodidae	
Apus apus	European swift
Ardeidae	
Ardeola ibis	Cattle egret
Bucerotidae	
Bycanistes cylindricus cylindricus	Brown-cheeked hornbill
Bycanistes fistulator	Piping hornbill
Bycanistes subcylindricus	Black-and-white-casqued hornbill
Ceratogymna atrata	Black-casqued hornbill
Tockus camurus	Red-billed dwarf hornbill
Tockus fasciatus semifasciatus	Black-and-white-tailed hornbill
Capitonidae	
Buccanodon duchaillui	Duchaillu's yellow-spotted barbet
Gymnobucco bonapartei	Grey-throated barbet
Pogoniulus atroflavus	Red-rumped tinker-bird
Pogoniulus bilineatus	Lemon-rumped tinker-bird
Trachyphonus pupuratus	Yellow-billed barbet
Columbidae	
Treron australis	Green fruit-pigeon
Turtur afer	Red-billed wood dove

Turtur brehmeri	Blue-headed dove
Turtur tympanistria	Tambourine dove
Coraciidae	
Eurostomus gularis	Broad-billed roller
Corvidae	
Corvus albus	Pied crow
Cuculidae	
Ceuthmochares aereus	Yellowbill coucal
Chrysococcyx cupreus	Emerald cuckoo
Cuculus solitarius	Red-chested cuckoo
Dicruridae	
Dicrurus adsimilis	Glossy-backed drongo
Estrildidae	
Estrilda melpoda	Orange-cheeked waxbill
Estrilda nonnula	Black-crowned waxbill
Lonchura bicolor	Black-and-white mannikin
Nigrita canicapilla	Grey-crowned negro-finch
Nigrita fusconota	White-breasted negro-finch
Spermophaga haematina	Blue-billed weaver
Hirundinidae	
Hirundo nigrita	White-throated blue swallow
Hirundo rustica	European swallow
Psalidoprocne pristoptera	Black saw-wing
Riparia paludicola	African sand martin
Meropidae	
Merops albicollis	White-throated bee-eater
Monatchidae	
Terpsiphone rufiventer neumanni	Red-bellied paradise-flycatcher
Terpsiphone viridis	African paradise-flycatcher
Motacillidae	
Motacilla aguimp	African pied wagtail
Muscicapidae	
Artomyias fuliginosa	Dusky flycatcher
Erythrocerus mccali	Chestnut-capped flycathcer
Muscicapa striata	Cassin's grey flycatcher
Platysteira castanea	Chestnut wattle-eye
Platysteira tonsa	White-spotted wattle-eye
Musophagidae	
Corythaeola cristata	Blue plantain-eater
Tauraco persa	Green-crested touraco

Nectariniidae	
Anthreptes gabonicus	Mouse-brown sunbird
Nectarinia chloropygia	Olive-bellied sunbird
Nectarinia olivaceae	Olive sunbird
Nectarinia superba	Superb sunbird
Oriolidae	
Oriolus brachyrhynchus	Black-headed oriole
Phasianidae	
Francolinus lathami	Latham's francolin
Francolinus squamatus	Scaly francolin
Picidae	
Campethera caillautii	Green-backed woodpecker
Campethera nivosa	Buff-spotted woodpecker
Dendropicos gabonensis	Gaboon woodpecker
Mesopicos xantholophus	Golden-crowned woodpecker
Verreauxia africana	Pigmy woodpecker
Ploceidae	
Malimbus nitens	Blue-billed malimbe
Malimbus rubicollis	Red-headed malimbe
Malimbus scutatus	Red-vented malimbe
Pirenestes ostrinus	Seed-cracker
Ploceus cucullatus	Village weaver
Psittacidae	
Psittacus erythacus	Grey parrot
Pycnonotidae	
Andropadus virens	Little greenbul
Baeopopgon indicator	Honey guide greenbul
Chlorocichla simplex	Simple leaf-love
Cringiger calurus	White-bearded bulbul
Ixonotus guttatus	Spotted bulbul
Nicator chloris	West african nicitator
Phyllastrephus icterinus	Lesser icterine greenbul
Pycnonotus barbatus	Common garden bulbul
Thescelocichla leucopleurus	Swamp bulbul
Strigidae	
Ciccaba woodfordi	West African wood-owl
Sturnidae	
Lamprotornis splendidus	Splendid glossy starling
Peoptera lugubris	Narrow-tailed starling
Sylviidae	
Bathmocercus rufus	Black-faced rufous warbler
Hylia prasina	Green hyla
Prinia bairdii	Banded prinia

Sylvietta virens	Green crombec
Turdidae	
Alethe diademata	Fire-crest alethe
Cossypha niveicapilla	Snowy-crowned robin-chat
Stiphrornis erythrothorax	Forest robin
Zosteropidae	
Zosterops senegalensis	Yellow white-eye