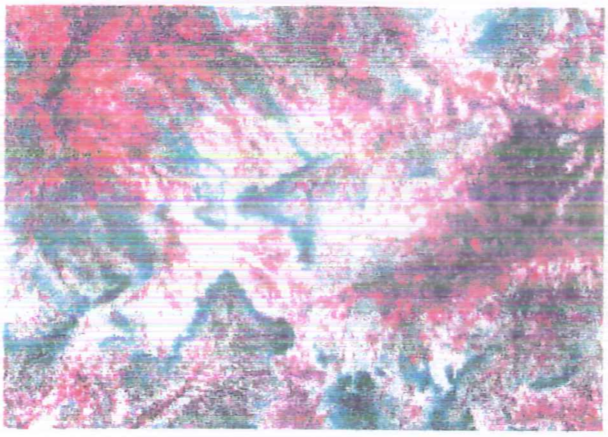
SOIL, VEGETATION, LAND USE AND EROSION RISK MAPPING IN THE NORTHERN PART OF SANMATENGA, BURKINA FASO

a guide to the physiographic and erosion risk map.

color composite 4 3 2, Sept. 20, 1988



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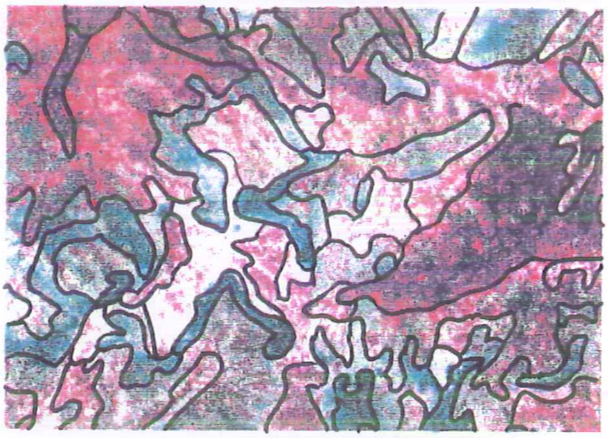
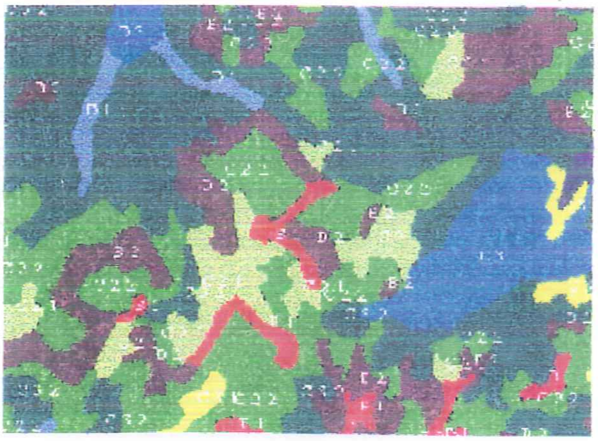


physiographic map



Antenne Sahélienne
PEDI-Kaya

January 1996

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M.J. van de Pol

Wageningen , January 1996

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PREFACE

In September 1994, we started the 'Sanmatenga project' with a team of 8 students. Our goal was to map soils, vegetation, land use and erosion risk. This assignment was in the context of our obligatory theses (Jacqueline & Piet) and obligatory practical period (Piet).

Soil, vegetation, land use and erosion risk data was gathered during four months of field work, starting October 1994. Also data from other students (disciplines) was used, e.g. remote sensing data, GPS-data and soil chemical & physical data. Co-operating with students of these other disciplines was very stimulating and educational. Their reports are strongly coherent to this report and can be found at the departments of the Wageningen Agricultural University or at the library of the Antenne Sahélienne in Ouagadougou.

The overall supervisor and promoter of this project was Dick Legger. He advised us (Piet) in the field of soil science. It was his idea to put strong emphasis on the interdisciplinary aspects of the project. A second group of students will be doing further research in 1996. We wish him good luck for the future and want to thank him for all we've learned from him. Thanks also to Pieter Ketner who was Jacqueline's supervisor in the field of vegetation and land use.
Working with satellite images was fairly new and we found out that on the scale and in the area of study, it was an excellent tool for physiographic mapping in a relatively short time. Marcel Steenis and Maarten Tromp were our brains in this field of research. Thanks both for their knowledge and help and extra thanks to Marcel for always helping us through the world of computers, for his GIS knowledge and perseverance were both fabulous.

Although this report is written by Jacqueline and Piet, the field work was carried out in a trio. Our blond Adonis Dirk Wijnalda co-operated in the field of soil science. To him this was a practical period and to us he was a helpful companion. Thanks to Dirk, who also helped analysing part of the soil data and storing it into a data base.

Paul Tholen, working at PEDI-Kaya, established the co-operation with Antenne Sahélienne and arranged all we needed during our field work. Thanks Paul, for your advises and co-operation.
For the period in Burkina we'd like to thank Joop Begemann, Maja Slingerland and Jan Willem Nibbering from Antenne Sahélienne.
Thanks also to J. de Wilde (department of Taxonomy), Ron (of the SNV and Ministry of Forestry department in Kaya), Oumou Sanon (of INERA in Dori), Boureima Diallo, Moumini Savadago, Arsèn Bambara, PEDI-driver Josef and chef cook Moïs for sharing their knowledge on the vegetation. Karle Sykora, thanks very much for helping defining the vegetation associations.
Thanks to the people of Bunasols for their co-operation and two days of excursions and thanks to PEDI in Gorom gorom for supplying the satellite data of the missing northern part of the province.
And last <u>but not least</u> we'd like to thank Anneke Fermont and Bart de Haan for their support during the stressing periods of this project and for the reading and evaluating of this report.

Jacqueline and Piet

SUMMARY

In the context of the program 'Aménagement et Gestion de l'Espace Sylvo-Pastoral au Sahel' (SPS) of the Antenne Sahélienne and in co-operation with the PEDI project in Kaya, a soil, vegetation, land use and erosion risk inventory of the northern part of the Sanmatenga province, Burkina Faso was carried out. This resulted in the production of a physiographic map at a scale of 1:100,000 and a derived erosion risk map. The mapped area covers 5136 km^2.
The area is characterised by low, and highly variable, rainfall (average 550 mm/year). The geology consists of two major units, the Antébirimien and the younger Birimien, both from the Precambrium. Furthermore aeolic depositions from the Late Pleistocene are present. Terrain, soil and vegetation data are collected mainly in the Antébirimien area.
Satellite data of the Landsat Thematic Mapper (TM), recorded in the wet and the dry season, were available. Aerial photographs were interpreted creating a preliminary legend. Hard copies of composite images (band 4 3 2, September 20, 1988) and (band 4 7 3, May 7, 1988) were the bases for mapping. These copies were created using the insight gained during the aerial photograph interpretation.
Using a Global Positioning System (GPS), the field position was located on the co-ordinate raster (UTM) overlying the satellite image. The observation sites in the field were selected from the images. Observations were done following cross-sections in the landscape. After insight was gained in landscape processes and its features, random sampling was used to extrapolate and to verify the soil, vegetation/land use and terrain data.
Field observations were used to create a legend. Its hierarchy consists of four levels. Its highest level is that of geology, followed by a major land form type, a minor land form type and a land element. This resulted in 13 physiographic map units.
The extrapolation of soil, vegetation/land use and terrain data was possible using the spectral differences, and the morphological features, visible on the satellite images. Vegetation densities mainly depend on water availability and therefore strongly correlate with the different types of land forms. In this respect the vegetation density was a very important criteria in mapping the area with the aid of satellite images.
The map was created by using the ArcInfo (7.0) Geographic Information System (GIS). An interpretation of the satellite images was scanned, corrected, vectored and imported into the GIS. Next further correction and labelling of the created polygons took place.
The result is a map of physiographic units with, for each unit the soil, vegetation, land use and erosion risk data. In order to describe variability, the soil and vegetation data are grouped into associations.
The soil associations consist of a group of soil types. These are created by grouping soil observations within a physiographic unit, based on such characteristics as soil depth, texture, colour, mottling, nodules and surface features. The vegetation associations are formed by using a series of programs (INTAKE, TWINSPAN, CLUTER, CLUTAB) that cluster the data into vegetation associations, independent of the legend. Using a matrix table the vegetation associations are linked to each land form unit. Erosion risk indices range from no (1) to a very high erosion risk (5). The indices are the result of an "expert knowledge" evaluation of the terrain, soil and vegetation/land use data. They present the actual risk of soils to water erosion, with regard to their agricultural potential.

The reliability of the presented data is depending on its future application, the scale on which it is used and the methods which have been used to generalise and present the data. However it can be concluded that using satellite images (remote sensing) is an excellent tool in mapping soil, vegetation/land use and erosion hazard at the scale and in the area in which it has been used. GIS tools are very useful in presenting, editing and storing the data in a way that they can easily be used in further applications. However creating a vector map in ArcInfo is relatively time consuming.

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1 INTRODUCTION

1.1 General

Burkina Faso became well known in the Netherlands at the beginning of the seventies. In these years a severe drought drove the Sahel countries (the countries between the Sahara and the more humid West Africa countries) to famine (Ettema and Gielen, 1992). Together with consequences of overpopulation, like overgrazing and intensive agriculture, this climatic drought has lead to serious degradation of the natural environment. This degradation includes a reduction of the vegetation cover and a subsequent loss of soil fertility. As a result, land use is changing rapidly, labour productivity is falling, migration increasing and food security diminishing so far, that the rural population risks becoming marginalized (Begeman *et al.*, 1995).

In order to tackle some of the complex problems, an interdisciplinary research program was started by the Wageningen Agricultural University (WAU) in 1992. This program is named "Aménagement et Gestion de l'Espace Sylvo-Pastoral au Sahel (SPS)". It is carried out by WAU, in Burkina Faso represented by the Antenne Sahélienne, in co-operation with the University of Ouagadougou, Burkina Faso. The objective of the program is to determine the production level, the management type and the role of village communities in 'sustainable' management of the natural recourses in the Sahel, and in particular in Burkina Faso.

The government of the Netherlands has incorporated Burkina Faso in the official aid program led by the Directoraat Generaal Internationale Samenwerking (DGIS) of the ministry of Foreign Affairs, since 1974. The co-operation program with Burkina Faso is directed to sustainable development of agriculture on behalf of food supply, to a wise conservation of the natural resources and to drink water supply. DGIS has several institutions spread all over the country which are called PEDI (Programmation et Execution de Developpement Integré). One of these institutions is placed in Kaya, the capital of the province Sanmatenga, about hundred kilometres north of Ouagadougou (see Annex 1, map of Burkina Faso).

1.2 Objectives

In September 1994, a team of eight students of the WAU started the "Sanmatenga project". This project is part of the cluster "physique" of the above mentioned SPS research program. The objective of the project is to produce a soil map, an erosion map, a vegetation map a land use map and a land evaluation map at a scale of 1:100,000 with the aid of aerial photographs and multi temporal Landsat TM satellite images for the province Sanmatenga, Burkina Faso. The mapping is done as a part of a co-operation between PEDI-Kaya and the Antenne Sahélienne.
Piet van Asten and Dirk Wijnalda carried out the soil and erosion mapping research, Jacqueline van de Pol the vegetation and land use mapping research, Gisbert van Ginkel the land evaluation mapping research, Linda de Boer the detailed erosion research, Marcel

Steenis did the compilations of the satellite images, and Douwe Dijkstra and Sebastiaan Raaphorst the research on the exact positions of villages and roads and a detailed research on a sample stream area in the province.
This report describes the research done for mapping the soil, erosion, vegetation and land use of the northern half of the province.

1.3 Contents of this report

In Chapter 2 a description is given of the mapped research area. This description includes position, geology, hydrography, climate, vegetation and land use.
In Chapter 3 the materials used during the research period are discussed including the computer programs.
In Chapter 4 all methods that led to the construction of the soil, erosion, vegetation and land use map are described. These methods are split up in methods before the field period (interpretation of available literature and aerial photographs), methods during the field period (sampling methods) and methods after the field period (data processing and map drawing).
In Chapter 5 the results are given, the soil descriptions and the vegetation types, and data concerning the map units.
In Chapter 6 the legend accompanying the final map is discussed. The highest level of the legend is geology, followed by major land form, minor land form, land element and finally the composite attributes of soil associations, vegetation associations, land use and a erosion risk.
In Chapter 7 the methods, results and map are discussed on their reliability.
In Chapter 8 Some conclusions and remarks are given concerning the suitability of satellite images and GIS-technics for the use physiographic mapping. Additional tips and remarks are given for possible follow-up projects.
The Annexes are given in the supplement accompanying this report.

2 DESCRIPTION OF STUDY AREA

2.1 Location

The study area is part of the province Sanmatenga, Burkina Faso (see Annex 1).
For the mapping project the province was split up in two parts. The border between the two areas is marked by a transition in landscape, due to a difference in geological history. This report is the result of mapping the northern of the two parts. In the collaboration between PEDI-Kaya and the Antenne Sahélienne the mapping of the southern part is to be accomplished in 1996.
The total surface of the mapped area is about 5136 km^2. It stretches north-south from Universe Transverse Mercator (UTM) co-ordinates 1544 to 1448 and east-west from UTM co-ordinates 753 to 674.

2.2 Geology/ geomorphology

Burkina Faso is part of the African shield. This shield was formed in the Precambrium and consists of rocks older then 600 million years (Kroonenberg, 1985).
In Burkina Faso, one can find formations of the Precambrium A, Precambrium C (the Birimien) and Precambrium D (the Antébirimien). In Sanmatenga this is restricted to the formations of the Birimien and the Antébirimien.
The Birimien has a history from 2300 MA up to 1500 MA years ago. Periods of tectonic activity accompanied by some volcanic activity resulted in the formation of mountain chains, which consist mainly of metamorphic and some volcanic rocks. The altitude of these chains is about 500 meters high. One can find greenschists, schists, quartz, manganese-quartz, graphite, basalt and some pyroclasts (volcanic sediments)
The Antébirimien covers almost the whole northern part of the province; the area which was mapped. The formations of the Antébirimien are said to be formed about 2660 ± 135 MA years ago (Hottin and Ouedraogo, 1975). The formations of the Antébirimien consist mainly of igneous rocks. Weathering and erosion transformed these formations to the present peneplain with altitudes of 250 to 300 m above sea level.
At the end of the Eocene (37 MA) the landscape consisted of a slightly undulating peneplain, submitted to strong weathering and leaching. During the Neogene (25-2 MA), especially its last 3 million years (the Pliocene) with its various rainy periods, pedogenetical processes created slopes with plinthite that, during drier periods, hardened into extremely hard ironstone crusts. As a result of relief inversion (erosion) the ironstone crusts (often abusively referred to as laterite) are nowadays often present in the form of plateau's. This plinthite formation and hardening is still active nowadays.
During the glacial periods of the Pleistocene arid and humid climatic conditions succeeded each other. In the early Weichselien transversal dune patterns developed (Sombroek & Zonneveld, 1971). They are now present as fixed dunes.

Steenis did the compilations of the satellite images, and Douwe Dijkstra and Sebastiaan Raaphorst the research on the exact positions of villages and roads and a detailed research on a sample stream area in the province.
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During the glacial periods of the Pleistocene arid and humid climatic conditions succeeded each other. In the early Weichselien transversal dune patterns developed (Sombroek & Zonneveld, 1971). They are now present as fixed dunes.

2.3 Hydrography

Also from a hydrographical point of view, a distinction can be made between the northern and the southern part of the province Sanmatenga. Almost all the valleys in the southern half of the province drain in the Nakambé (the former White Volta). The northern area however is part of the Niger basin (Hottin and Ouedraogo, 1975). Water, which flows only in the wet period, is partly collected in artificial lakes. Most of these lakes do not dry out during the dry season.

2.4 Climate

The research area (the northern part of the province Sanmatenga) falls in the subsahelien climatic zone, the area in the upper north east even falls in the Sahel climatic zone (Guinko, 1984).
Because climatic data of villages in the northern part are scarce, the data of Kaya (the capital of the province, forty kilometres south of the borders of the research area) are given (see Table 2.1). Temperatures in Kaya are highest just before the wet season (March, April and May) and immediately after the wet season (October). The coldest periods are in the middle of the wet season (July, August and September) and in the middle of the dry season (November until February) (Guinko, 1984).

Table 2.1 Kaya average monthly precipitation (in mm) calculated from years 1968-'85, maximum and minimum temperatures (in °C) calculated from years 1962-'80. (CILLS, 1992)

month	Jan.	Feb.	March	April	May	June
prec. '68-'85	0.0	0.8	6.4	6.9	37.3	95.6
max. '62-'80	32.9	35.7	38.0	39.0	38.3	35.2
min. '62-'80	16.9	19.7	22.9	25.4	25.4	23.2
month	July	Aug.	Sept.	Oct.	Nov.	Dec.
prec. '68-'85	160	205	102	13.0	0.0	0.0
max. '62-'80	32.2	30.7	31.8	35.9	35.6	33.0
min '62-'80	22.1	21.3	21.7	22.6	19.8	17.5

Annual average rainfall in Kaya dropped from 762 mm in the period 1951-1967 to 638.3 mm in the period 1968-1985. Annual rainfall decreases in Sanmatenga from 650 mm at the southern borders of the province to only 430 mm in the most northern parts (CILLS, 1992).

2.5 Vegetation

The survey area is located in the transition zone between the Sahelien steppe vegetation and the Soudanian savanne vegetation (see Annex 1). Therefore its vegetation is called a Sahelo-Soudanian vegetation (Guinko, 1984).
The structure of the vegetation varies with the land form units. It differs from herbal steppes on the soilless parts of hills and plateau's (for more detailed information is referred to Chapter 6 and especially to Chapter 6.4), via steppes with herbs, shrubs and small thorny trees in differentiating abundance (depending on the degree of erosion), to park steppe vegetation with high deciduous trees, and finally to woodlands along the valleys.

2.6 Land use

The northern part of the province Sanmatenga is inhabited by Mossi as well as Peuhl. In former times the Mossi practised agro-sylvopastoral systems and the Peuhl pastoral systems. Some Peuhl also practised agriculture. Because the soils were used extensively, both systems were complementary. The cattle grazed in the natural vegetation and the fallow lands, and after the harvests they ate the remnants of the harvests on the agricultural fields (Van der Hoek *et al.*, 1993).
Since the pressure on land is increasing (see Paragraph 1.1), these two systems are more and more becoming competitors. The competition is centred around the best soils of both systems, the lower slopes and the valleys. These are used for agriculture during the wet season and for pasture during the dry season. Problems can arise when harvests are late and herds of the Peuhl have already arrived.

3 MATERIALS

3.1 Materials used for interpretation

A topographical map (1960) of the whole province of Sanmatenga was available on a scale of 1:200,000. Besides villages, also roads, water streams, most of the department borders and some information on tree densities were given.
A geological map (Hottin & Ouedraogo, 1975) of Burkina Faso was also available. The scale of this map is 1: 1,000,000.

Aerial panchromatic (black and white) photographs (stereoscopic) of the whole area of Sanmatenga were available. The scale of the photographs was 1:50,000. All Pictures, a total of 150 photo's, were taken in the visible light area. The photo's were made in January 1980, October 1981, May 1982 and February 1983 and were supplied by the 'Institute Geographique de Burkina' (IGB).

Three multi spectral data sets of the Landsat thematic mapper satellite (to be explained below) were available. The data were from May 7, 1988, September 20, 1988 and January 5, 1991. The data sets covered almost the whole province, only the upper northern parts were missing. The completing (northern) part of the September image was supplied by PEDI in Gorom gorom. For the mapping project only the data of May 7 and September 20, 1988 were used.

The Landsat thematic mapper (TM) satellite records reflected sun radiation of the earth surface. It has a swath width of 185 km, which means that recordings are made form an area of 185 to 185 kilometres. The recordings of Landsat TM are made in seven spectral bands. Three bands are recording in the visible light part of the spectrum (VIS), one in the near-infrared part (NIR), two in the middle-infrared part (MIR) and one in the thermal-infrared part (TIR) (see Table 3.1). The TM-sensor, which records the reflected radiation, has a ground resolution of 30m * 30m. This means that the reflection data of an area of 30m * 30m are stored in one pixel, all pixels together contain the data of the recorded area of 185km * 185km. The recorded reflection of each spectral band has a value between 0 and 255. These values pronounce the degree of reflection (more reflection means a higher value) and are called Digital Numbers (DN) (Epema *et al.*, 1994). Based on spectral data of the satellite EOSAT, the supplier of the recorded data, a geometrical correction was applied on the spectral data of all three dates and the imagery was re-sampled to a spatial resolution of 25m * 25m. Only data from bands 1, 2, 3, 4, 5 and 7 are used. The TIR band (band 6) has a resolution of 120m * 120m and was therefore not used during the time of research (Steenis, 1995). The type of geometric projection used was UTM. The "standard systematic correction" of the pixels has a maximum error of 250 metres.

Table 3.1: Landsat TM bands and wavelength (Buiten and Clevers, 1990).

band	wavelength (μm)	na-me
1	0.45 - 0.52	VIS
2	0.52 - 0.60	VIS
3	0.63 - 0.69	VIS
4	0.76 - 0.90	NIR
5	1.55 - 1.75	MIR
6	10.4 - 12.5	TIR
7	2.08 - 2.35	MIR

3.2 Computer programs

The following computer programs were used for the project.

- Erdas Imagine, version 8.1, was used to correct the co-ordinates of the spectral data and two create images of which printouts could be made to use during field work and interpretation. Erdas Imagine is a program that incorporates functions of image processing as well as raster Geographic Information System (GIS). It was run on the workstation (running under UNIX).

- dBASE, version 4, was used to create files containing all sampled data on the soil, the vegetation and the land evaluation. dBASE gives good possibilities for entering the data, changing the sequences of the data and matching the data to the final map. dBASE runs under MS DOS.

- Arc-info, version 7.0, Especially the Edit-tools (a menu interface under Arctools) and the modules Arcplot and Tables were used to store, edit and present the maps. Arc-info is running under the UNIX system.

- NEDIT, a edit program works under the UNIX system was used to create and edit AML-files.

- Joe's-editor was, similar to NEDIT, used to create and edit AML-files, it also works under UNIX.

- INTAKE, TWINSPAN, CLUTER, SHAKE, CLUTAB and UED were the programs used for processing the vegetation data. The function of each program is explained in Paragraph 4.3. (all MS-DOS programs)

- Word Perfect, version 5.1, and Microsoft Word for Windows, version 6.0, were used to process literature and to write this report. They are both editing programs (MS-DOS).

- Microsoft Excel for Windows, version 5.0, was used to edit the tables produced in dBASE (MS-DOS).

- Paintbrush is a simple grid-based drawing program , standard to Microsoft Windows, used for editing the scanned coverage (TIF-file)

- Paint Shop Pro (Shareware version 2.01) was used to convert different graphic file formats. The program runs under Microsoft windows 3.1

4 METHODS

4.1 Research before field period

4.1.1 Aerial photograph interpretation

The mosaic of all available aerial panchromatic photographs, a total of 150, was laid out on a table, after which the province's boundaries were drawn on it. This was done by comparing landscape features (valleys, escarpments) on the photographs with those of the topographic map of Sanmatenga. As described in Paragraph 2.1.1, the province Sanmatenga was split up in two parts for this mapping project: a southern and a northern part. The border between these two areas is marked by a transition in landscape: an undulating southern part (hills) and an almost flat northern part.

Figure 4.1: Mosaic of aerial photographs used for the interpretation before the field period.

A preliminary legend, which was constructed during the photo interpretation, was based on distinguishable geomorfological features on the aerial photographs. On the photographs it was not only possible to distinguish geomorfological features like, hills, plateau's, slopes, valleys and eroded areas, but also lakes, roads, houses, villages and fenced fields (agricultural fields or cattle krales). In the field this legend was corrected and adjusted to the mapping scale of 1 : 100,000.

4.1.2 Creation of Landsat TM images

The multi spectral data sets of May 7, 1988 and September 20, 1988 contained too much digital information for the laptops that were used during the field period. Also for other practical reasons, like the absence of electricity at most residences during the field period, the use of printouts was preferred. These printouts were created in Wageningen before the field period in Burkina Faso.
The coloured printouts are composed of three colours. The colours are red, green and blue, that is why they are also called RGB-images. The three colours represent the reflection values of three spectral bands; the brighter a colour the higher the reflection in the represented band. The RGB-images were created in Erdas imagine 8.1 (see Paragraph 3.2). The requirement for these RGB images was that they should distinguish at least as many and similar features as could be distinguished on the aerial photographs.
A band combination of bands 4, 7 and 3 was chosen for the image of May 7, 1988. This is at the end of the dry period. Because vegetation coverage is at a minimum at that time, the RGB-image of May could give a good idea about mineral differences at the earth's surface. Band 7 is important for discrimination of geologic rock formations and soil boundaries, as well as soil moisture content (Epema *et al.*, 1994). Therefore an image was processed using band 7. Band 4 and band 3 were taken to give a good impression of vegetation densities. Band 3 is useful for discriminating between many plant species. It is also useful to determine soil surface differences and geological boundaries and cultural features. Band 4 is especially responsive to the amount of vegetation biomass present in a scene. It is useful for crop identification and emphasises soil/ crop and land/ water contrasts (Epema *et al.*, 1994).
The differences in reflection of several features in each spectral band are clearly visible in Figure 4.2.

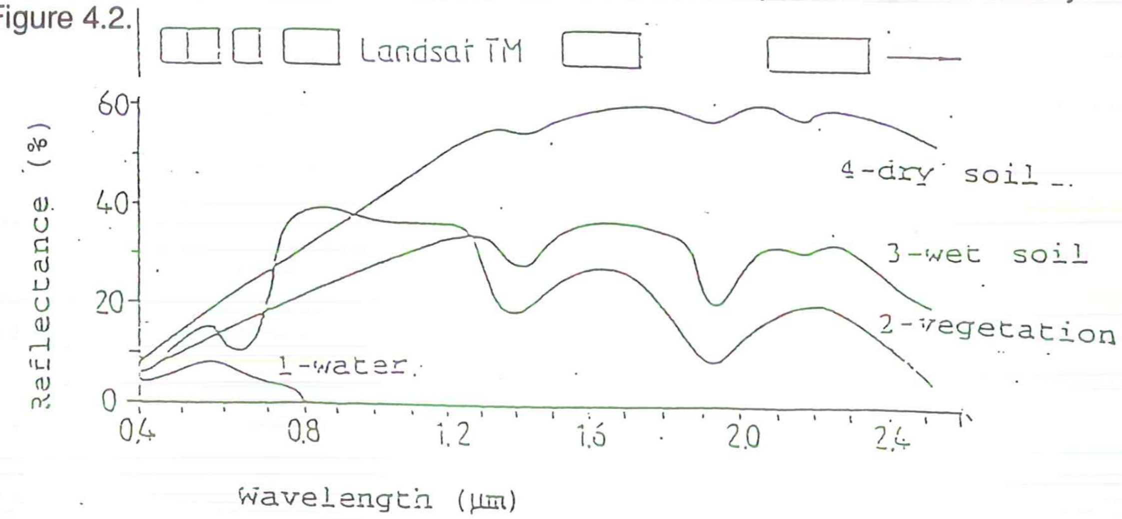


Figure 4.2: Spectral curves of different surface features (source Epema et al., 1994)

A second image was composed of bands 4, 3 and 2 from September 20, 1988. September is the end of the wet period. The amount of phytomass is then at its peak. Band 3 and 4 are used for the same reasons as mentioned above. Band 2 responds to the green reflectance of healthy vegetation. It is also useful for cultural feature identification (Epema *et al.*, 1994).

A third image was composed using a new created band. This band was processed by the formula known as vegetation index (VI):

$$\frac{(DN_{band4} - DN_{band3})}{(DN_{band4} + DN_{band3})} * 127 + 128 = \text{value between 0-255}$$

This is in the same range as the reflection of all bands is represented (see Paragraph 3.1). The final composition of the third image was RGB: VI, 5, 7, all spectral data from September 20, 1988. The purpose of the vegetation index was to show clear differences in vegetation densities and plant species composition. Band 5 is sensitive to the amount of water in plants, which is useful in crop drought studies and in plant health analyses.
More information on the use of satellite data can be found in Van de Pol (1995) and Steenis (1995).

4.2 Field methods

4.2.1 Creating a legend

In Paragraph 4.1.1 it was explained that, with the aide of aerial photographs, a preliminary legend was created.
In the field, this legend was adjusted and corrected stepwise to the proper terminology and to the scale on which it was to be used. In a first field trip two soil scientists from BUNASOLS explained the methodology and legend they used for mapping the neighbouring province of Bam. Although the Bam mapping scale was 1 : 50,000, their legend looked very useful at a scale of 1 : 100,000 in an almost similar area.
Further adaptations had to be made to create a legend suitable to fit with the main source of information: the satellite images. The images determined what could be mapped and what not. Differences between physiographic units not only had to be visible in the field, but also on the images.
Field observations were necessary, not only to collect soil- and vegetation data, but also to check if the existing legend made any sense and if further desaggregation would be possible to minimise variability of soil and vegetation within each unit.
Building the legend, there has always been an urge to separate units with different land use (and/or agricultural potential). The vegetation density -clearly visible on the satellite images- and the presence of a certain type of land use, were important characteristics in this. In Figure 4.3 at the next page, a flow chart is given, in which the process of creating a legend is illustrated.

4.2.2 Selection of observation sites

Field work started with one week of field orientation, during which the land form units were introduced by specialists from the "Bureau National du Sol" (Bunasols).
Experience with the recognition of the vegetation types and plant species was gained by working together with a student (A. Bambara) from the University of Ouagadougou during the first week of the field period.
Because the dirt roads hampered quick travelling, villages were selected in different parts of the province to act as a base for field work. Mopeds made it possible to do field work in a radius of 20-30 (sometimes even 50) kilometres around these villages.

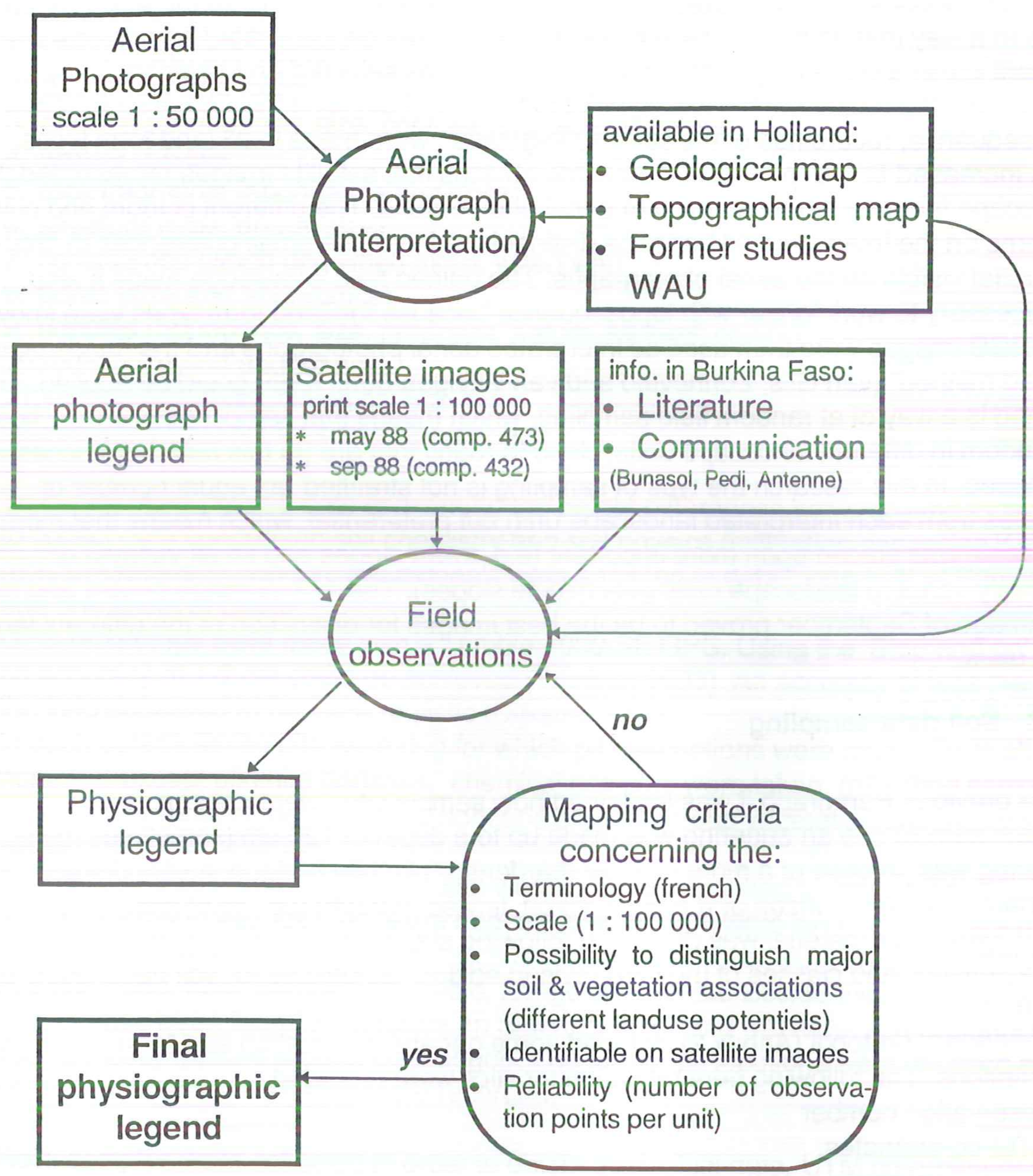


Figure 4.3: flowchart of creating the physiographic legend

The total survey area was available on seven A3 plastified print-outs of each RGB image described in Paragraph 4.2.2. These print-outs had a scale of 1:100,000 (mapping scale). On the images, a raster of UTM co-ordinates was printed. During the field work a GPS (Global Positioning System) was used that gave the sampling position in UTM co-ordinates. In this way it was possible to determine the sampling position on the image. The GPS used was a Trimble Pathfinder GPS. Its accuracy is (depending on the positions of the satellites) 100m - 300m on the horizontal level (Trimble, 1993). This is acceptable at a scale of 1:100,000 and a pixel size of 25m * 25m. Considering the maximum differences in relief to have a maximum of 250m and the deviation on the vertical axis (height) of the GPS (600m), height measurements have not been taken.

At the start of the field period both the photo interpretation and the satellite images were used for choosing sampling sites. They were chosen before going into the field. This was done in a way that as many different land forms (colours on the image) as possible were present within a close range. After such a location was selected an imaginary line was drawn from the highest to the lowest point in the field. Following this line, also called toposequence, recordings of the soil and vegetation were made in all land form types. With increased field experience, it became obvious that satellite images represented the landscape features more clearly than aerial photographs. The different colours and colour patterns on the images could better be distinguished than the small differences in grey-tone and relief visible on the aerial photographs. The gained field knowledge made it also unnecessary to work longer with toposequence because the land form types were known. The RGB images were then used as interpreted aerial photographs and the "landscape guided method" (van Gils, Zonneveld and van Wijngaarden, 1985) could be applied. This method is a way of at random field sampling, which means that sampling plots are chosen at random in different landscape units, close to roads that are (in this research) accessible by moped. In this research the type of sampling is not stratified (an equal number of samples from each interpreted landscape unit) but preferential, which means that more emphasis was placed upon more important (e.g. lower slopes and small valleys) or relatively variable landscape units (like middle slopes). The 4, 7, 3 image of May and the 4, 3, 2 image of September proved to be the best images for distinction of the different land form units.

4.2.3 Soil data sampling

In the previous Paragraph it was explained how sample sites were chosen.
At each sample site an augering was made up to a depth of 120 cm (sometimes more). The augering was, in case of a more shallow (hardened) plinthite horizon, a very dry and compact illuviation horizon or a rocky horizon, limited in depth (i.e. <120 cm).
The augered soil material was described following standard protocols, containing characteristics and classes of the third revised edition 'Guidelines for soil description' (FAO, 1990).
The standard protocol (Annex 2) included some general information and terrain and soil descriptions. The following general characteristics were recorded:
1. observation number
2. UTM-co-ordinates.

The following terrain data was recorded:
1. topography
2. land form
3. land element
4. slope gradient and form
5. parent material
6. micro topography
7. vegetation/land use
8. rock outcrops
9. surface coarse fragments (abundance and size)
10. erosion/deposition types and their affected area and degree
11. surface sealing (thickness and consistency)
12. surface cracks

13. drainage class, internal drainage, external drainage and flooding.

The following soil characteristics were recorded:
1. horizon (symbol and depth)
2. colour (dry and moist)
3. mottling (abundance, size, contrast and Munsell colour)
4. texture classes
5. rock fragments (abundance and size)
6. structure (type, grade, size)
7. consistence (when dry, when moist, when wet)
8. pores (size and abundance)
9. nodules (abundance, size, hardness, nature, Munsell colour)
10. roots (size and abundance)
11. various (artefacts, biological activity)
12. boundary (distinctness and topography).

To obtain more precise date concerning the height differences between land form units and to collect data concerning soil chemistry and soil physics (infiltration capacities K_{sat} and moisture retention curves), two catena's were sampled in detail: one east of Barsalogho and one south of Dablo.
GPS-recordings were made with a Trimble 4000 SE GPS. Using the 'Stop and go' method an accuracy of 1-2 cm could be achieved (Trimble, 1993). An accuracy of less then 5 cm in the field appeared to be more realistic (Dijkstra, 1995)
In each catena seven pits were dug for which pit descriptions were made. From all horizons, except plinthite horizons, chemical samples were taken. (pF)-Ring samples were collected for most of the upper two horizons and numerous vegetation descriptions were made.
The collected soil- and vegetation data were to be extrapolated to other areas. To check if the extrapolation was justified, extra augerings at random were executed. Where the extrapolation was not correct or insufficient new pits had to be dug. Overall a total of 24 pits has been dug, near Barsalogho, Dablo, Zongo and Pensa. Beside these pits, a number of 13 pits have been found in literature (in Siderius, 1982 and MDR/Service National des Sols, 1984), mostly located around Barsalogho. The former pit locations were revisited and UTM co-ordinates and terrain data were recorded.

Rock samples were collected in order to obtain geological data. UTM co-ordinates of the sample sites were taken. In case the lithological name was unknown to us, the sample was brought to the 'Institute des Mines et du Geologique' were it was to be identified by experts. Furthermore the geological map of Burkina Faso was used (Hottin and Ouedraogo, 1975).

4.2.4 Vegetation- and land use data sampling

Two methods were applied for collecting the vegetation- and land use data. The first is a detailed sampling method. This method was applied to all observation sites where soil descriptions were made via auger holes and at several locations, including the pit locations in the catena's at Barsalogho and Dablo. The second method is called the "rapid road sampling method". This method was performed to collect vegetation- and land use data that could be used for an evaluation of the vegetation types and landscape units in the final map.

The detailed sampling method

For the vegetation descriptions a field protocol was designed, based on examples of vegetation descriptions of the International Institute for Aerospace Survey and Earth Sciences (ITC) in Enschede, the Netherlands, and descriptions of the soil surface and its coverage used for remote sensing research at the Department of Soil Science and Geology from the WAU, adjusted to the local circumstances in Burkina Faso (see Annex 3). The adjustment was based on the first week of field experience, recommendations of M. Slingerland (the supervisor of the biological cluster at the Antenne Sahélienne in Ouagadougou) and on other available forms for description of the vegetation and land use in Burkina Faso. Vegetation descriptions were made between October 1994 and January 1995.
On the protocol the following items were recorded:

- General information such as the landscape element, the type of land use, the track- and plot number, the size of the observation plot (usually 25m*25m), the GPS co-ordinates and the colours of this sampling site on the 4, 7, 3 RGB May image and the 4, 3, 2 RGB September image.
- Data on the structure of the vegetation. For this purpose the vegetation was divided in four different layers: 1. tree layer, woody species taller than 5m
  2. high shrub layer, woody species between 2m and 5m height
  3. low shrub layer, woody species between 0.5m and 2m
  4. herb layer, woody species smaller than 0.5 m, grasses and herbs.

  In the herb layer four subgroups were distinguished:
  1. perennial grasses
  2. annual grasses
  3. perennial herbs and climbers
  4. annual herbs and climbers.

  Of all layers coverage and average height were estimated and the dominant species were noted. The coverage of the soil surface by the total vegetation was also recorded. The coverages were recorded in classes to facilitate the storing of the data and to enlarge the possibilities for using the coverage data in the vegetation map in Arc-info.
- Data on the species composition of the vegetation types. For each structure layer the coverage's/ abundance's of all species present were estimated This was done according to an adjusted scale of Braun-Blanquet with fourteen classes. This fourteen point scale is a general scale for vegetation surveys (Van Gils *et al.*, 1985). The used codes were as follows:

1. coverage less than 5%, 1-2 specimens
2. coverage less than 5%, 2-4 specimens
3. coverage less than 5%, 4-7 specimens
4. coverage less than 5%, more than 7 specimens
5. coverage between 5- 10%
6. coverage between 10- 20%
7. coverage between 20- 30%

8. coverage between 30- 40%
9. coverage between 40- 50%
10. coverage between 50- 60%
11. coverage between 60- 70%
12. coverage between 70- 80%
13. coverage between 80- 90%
14. coverage between 90-100%.

The phenological stage of the species was indicated using these codes:
1. vegetative
2. flowering
3. carrying fruits or seeds
4. dead
5. harvested (not phenological but relevant for arable observation sites).

At last of each species information on its use was noted. To be able to store this information in dBASE (after the field period) the use of species was numbered as shown below:
1. mixed cropped (in case of arable sample site)
2. mono cropped (in case of arable sample site)
3. grazed or browsed (of woody and herb species)
4. cut (only relevant for woody species)
5. trampled (only relevant for herb species)
6. burned
7. other use
8. no use at all

The sizes of sampling sites and the heights of shrubs and herbs were measured with measuring tapes. The heights of trees were measured with a measuring tape in combination with a bank-indicator. The coverage's by the different layers and species were estimated with the help of sample coverage graphs (see Annex 4).
Maydell (1992) was used to identify the shrubs and trees at the sampling sites. Hutchinson (1954-1972), Berhaut (1971-1988) and Van der Zon (1992) were used to verify the scientific names of the grasses and herbs.
All grass and herb species were stored in a herbarium. M. Savadago from the Antenne Sahélienne in Ouagadougou and O. Sannon form the INERA in Dori, were so kind to assist with the identification of species. The plants that still could not be identified were brought to the University of Ouagadougou for identification at the Department of Taxonomy. In case plants were already too dry for identification, they were referred to as "dead grass" or "dead herb". Sometimes only their genus name was found. When trees had been cut near the ground and thus had become unrecognisable, they were referred to as "unknown trees".

115 relevés were made, most of them at the same sample site as the augering for soil descriptions. However some relevés are however from sites with no augering. For example on top of the plateau's where no augering could take place because of the hardened plinthite crust.

The rapid road sampling method

The rapid road sampling method is an adjusted version of the road sampling method (Oslo, 1985). For this quick mapping method observation sites are used along roads which cross all different landscape units. The road sampling method was done by car. Three roads were selected that traversed the northern part of the province Sanmatenga. The first was the road to Dablo, the second the northern road to Pensa and the third the southern road to Pensa. In the road sampling method the vegetation is described at one kilometre intervals. However, because of a combination of length and poor condition of the roads to Pensa, it would take too much time (to be back before dark) to stop every kilometre. So it was decided to have intervals of three kilometres, being the lowest possible distance between observations still yielding a representative number of samples. At each observation site a description of the vegetation, including the land use and soil surface characteristics, on a strip of land 10-25 metres from the road was described. These descriptions were not done on special protocols like the ones of the detailed sampling method. All vegetation-, land use- and surface features were recorded in tables. Above the tables the date and the driving route were noted. The features described were the following:

1. GPS co-ordinates
2. colour of site on the 4, 7, 3 image of May 7, 1988
3. colour of site on the 4, 3, 2 image of September 20, 1988
4. landscape unit
5. type of land use: 1. semi-natural vegetation/ grazing
   2. agriculture
   3. fenced horticulture
   4. drinking place (for the cattle)
   5. brick making place (next to pools)
   6. living/ houses
   7. orchard (these were also fenced)
6. tree coverage: 1. 0-25% 2. 25-50% 3. 50-75% 4. 75-100%
   names of the dominant (most abundant) trees
7. shrub coverage: 1. 0-25% 2. 25-50% 3. 50-75% 4. 75-100%
   names of dominant shrubs
8. coverage of herb layer: 1. 0-25% 2. 25-50% 3. 50-75% 4. 75-100%
   names of dominant grasses and herbs.
9. crusts clearly present (>10%): 1. yes 2. no
10. gravel clearly present (>10%): 1. yes 2. no
11. gullies clearly present (>10%): 1. yes (give width and depth) 2. no
12. rows of stones (*) present: 1. yes 2. no
13. complementary remarks about the colour of the soil and the greatness of the gravelstones or remarks like "many tree stumps".

(*) These rows of stones are to reduce erosion. They are constructed by villagers with aid of PEDI-Kaya (see Paragraph 1.1), on crusted soils, along contour lines.

4.3 Data processing

4.3.1 Process of map drawing

Working with the satellite images in the field had lead to a good insight in the relation between image colours and/or colour patterns and physiographic units. Using this knowledge it was possible to draw lines, which divided the different landscape units on the image, which was printed out at scale 1:100,000 (in eight A3-format hard copies). The actual drawing was done on a overlay using tracing-paper and black waterproof fineliners. The basis used to draw the map was the satellite image of September 20, 1988, bands 4, 3, 2. This image was chosen since the main discriminating property was the vegetation density; vegetation densities are highest at the end of the wet period (i.e. September). Since its band 7 showed clear reflection differences for different minerals the may image was often consulted when making distinctions between different bare surfaces. How the correlation between spectral information and the physiographic map units was used for drawing the physiographic interpretation on an overlay is explained in Figure 4.4 at the next page.

The eight tracing-paper sheets were taped together creating a large sheet in the size of an A0-format (87 * 118 cm). In order to use UTM coordinates and to be able to display simultaneously coverage and satellite image, reference points of the satellite image were copied to the tracing-paper. This overlay was scanned by Reprocart BV in Rotterdam, the Netherlands. The scanned file was stored in a Tagged Image File Format (TIF-file).
Since the quality of the scan was very low at some places, a primary correction was made to the raster TIF-file with the Microsoft program Paintbrush under Microsoft Windows 3.1. This primary correction was necessary since the raster TIF-file had to be vectored (rewritten) to vector-file. Vectorisation is only possible if clear lines can be identified from the raster file.
The vectorisation was necessary so that the coverage file could be read by the Arc-Info 7.0 GIS program. In order to work in the computer with UTM co-ordinates, it was necessary to put the right co-ordinate system onto the overlay. This was done with the aid of reference points, which were copied onto the tracing-paper from the satellite image; this was done before it was scanned.
Arc-Info (GIS) allows you then to display simultaneously coverage and satellite image. In this way it was easily possible to further edit and label polygons. Minor errors (few millimetre on map scale) in polygons, such as small loose ends and small gaps, disconnecting two arcs, can be corrected automatically by the ArcInfo program using the command "clean" -set dangle length and fuzzy tolerance-.
Bigger errors, like missing arcs or wrong drawn polygons, can be corrected too using Arc-edit or the edit-tools in Arc-tools. The latter is a, more user-friendly, menu co-ordinated interface within ArcInfo.
After correcting the polygons with the aide of a satellite image at the background, the polygons have to be labelled. These labels (items/attributes) are stored in a Polygon Attribute Table (PAT-files). Every polygon coverage has such a PAT-file, which automatically contains a unique identifier for each polygon. Using the "additem" command it is possible to create a new item in the PAT-file. The item added was in this case called

"LANDUNIT". For each polygon the mapunit code (A, B1, B2, C1, etc...) were used for the item "LANDUNIT".

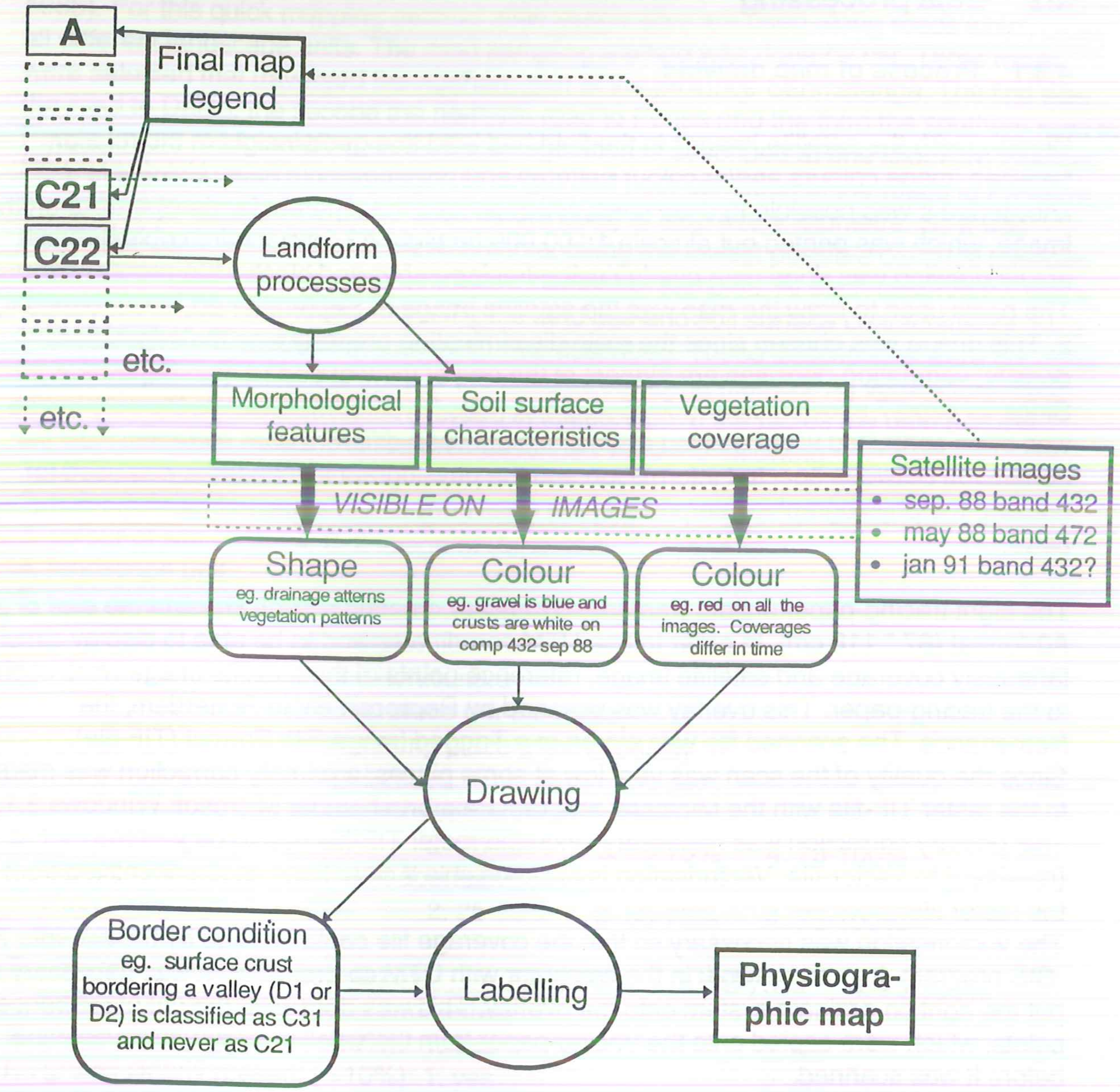


Figure 4.2: flowchart explaining which characteristics determine where and why borders are drawn

After labelling the whole coverage, a colour item, named LUCODE and an erosion risk (explained in Paragraph 6.5) index item, named EROSION, were added to the file. This was done using the command "joinitem", in which a self created table with "LANDUNIT" and the other two items are linked via the key attribute "LANDUNIT" to the PAT-file. The joined table (PAT-file) of the SANM-coverage could contain for example the following:

SANM-ID	AREA	PERIMETER	LANDUNIT	LUCODE	EROSION
2056	231820.9	1964.60	B1	2	1
2057	3334067.8	15770.29	C32	8	3
2058	1325671.5	14764.23	D1	9	2

The values of the LUCODE-item can be linked to a shadeset-file. This is a file containing a colour palette, which can be edited depending on taste and use (separate shadesets were created for the physiographic as well as the erosion map). After this a hardcopy was printed out at the "Kartografische dienst" on the "DLO Winand Staring Centre" in Wageningen, the Netherlands.

Next to editing and storing data, ArcInfo also allows to do queries. As explained, the PAT-file of the coverage automatically contains an ID-item (which is polygon specific), the area and the perimeter of the polygon. Also these items the items LUCODE and its joined erosion index codes have been added. Storing data in this way allows you to calculate the sum, the mean value, the max value, the min value, the frequency and the standard deviation of an area or perimeter per map unit . These values are given in Paragraph 5.2

4.3.2 Soil data

In dBASE two files were created in which the terrain data and the profile data were stored. In order to minimise space and to simplify sorting the data the files contain FAO-codes. Both files contain the UTM co-ordinates and the field observation number.

The soil data is represented on the physiographic map by soil associations; the association is a composite attribute from a lower level than the physiographic unit. For each physiographic unit a range of soil types is elaborated. The soil types are given in Paragraph 5.2.
The total of 133 soil observations was first sorted on physiographic unit at field level (N.B. the physiographic unit at map level could be different due to inclusions of polygons smaller than 0.25 cm^2). The subsequent phase is to form a group of soil types which best describes the soil variability within a physiographic unit. The formation of soil types is done by sorting the soil observations on characteristics as, soil depth, soil texture, mottling, nodules, soil colour and surface characteristics. The weight of the characteristic in forming soil types differs per physiographic unit. This means that the generalisation of soil information is done on the bases of expert knowledge and not on the bases of a fix classification.
The amount of soil types created per physiographic unit depends on the variability of the soils within the unit when compared to the total area of that unit. This resulted in soil associations varying from one to six soil types per physiographic unit.
The soil type name consists of the mapping code of the physiographic unit plus an alphabetic code depending on the amount of soil types within this physiographic unit.
Each soil type is described by a range of characteristics. Each soil type refers to one or more representative profiles. These are field observations, in most cases accompanied by chemical data.
For each soil type, a relative surface cover is given. This cover percentage is calculated by dividing the number of observations belonging to the soil type by the total number of observations of that physiographic unit. In case the relative cover percentage seemed not realistic, it was edited by the surveyor.

4.3.3 Vegetation data

Storage of data in dBASE

With data of the relevés and of the 'rapid road sampling' tables three files were created in dBASE. One with data on the vegetation structure, a second with the rapid road sampling records and a third with the names of the found species.
This last file contains not only the scientific names of all species but also (if available) the names in French, Peuhl and Moree. The French names were abstracted from Maydell (1992), Hutchinson (1954-1972) and Berhaut (1971-1988). The names in Peuhl and Moree were collected by B. Diallo, an interpreter from the Antenne Sahélienne in Ouagadougou. During the fieldwork in Dablo old Mossi farmers, old Peuhl herdsmen, an old medicine woman and farmers children were asked the names of the species that were collected for the herbarium mentioned in Paragraph 4.3.3. He asked the names several times to several people to be sure they were the right ones. The collected names were compared to the Peuhl and Moree names in Maydell (1992), Hutchinson *et al.* (1954-1972), Berhaut (1971-1988) and Kintz and Toutain (1981). Many of these names were the same or slightly different from the names in the literature.
Other information stored in this file concerns the occurrence of the species; woody species (BS), perennial herb (MK), annual herb (EK), perennial grass (MG) or annual grass (EG). Herbs that were biennials or of which it was not exactly known if they were annuals or perennials (contradictory references) got the code TK. Not (exactly) known trees, herbs and grasses respectively got the codes OB, OK and OG.
Further, information on the leguminosity of the species was given. If they are leguminous plants (1), or not (0).

INTAKE

The vegetation data on the species composition were processed with the aid of several computer programs. These computer programs are described here briefly, for more detailed information see Anonymous (1994).
First a condensed format file was needed which contained all samples, and all species with their abundancies in these samples. This file was created with the program INTAKE. With this file it was possible to run a program to cluster and order the samples (TWINSPAN). After clustering some other programs (CLUTER and CLUTAB) were used to create a synoptic table. This was done to be able to define the different vegetation types.

INTAKE, designed by R. Pot, is an auxiliary program to enter relevés in a PreeFree format file and to create a Cornell condensed format file (Anonymous, 1994). The entering of relevés is done by indicating the present species one by one on a list with scientific names. Considering the fact that no such lists were available for Sahelien species, the scientific names of the species list created in dBASE were used. The "Sanmatenga species list" was for this purpose adjusted to the recording method of woody species. This means that all woody species were mentioned three times. For example *Acacia albida* was mentioned as ACAC ALBI (occurrence as tree), ACAC ALB2 (occurrence as high shrub) and ACAC ALB3 (occurrence as low shrub). Because of this adjustment, in this Paragraph species will be called 'species' when woody species are involved.

In order to use TWINSPAN the abundance/ coverage values of the fourteen point scale had to be converted to a nine point scale as follows:

1 and 2	=> 1
3	=> 2
4	=> 3
5	=> 4
6	=> 5
7	=> 6
8 and 9	=> 7
10 and 11	=> 8
12, 13, 14	=> 9

When the PreeFree format file was converted in the Cornell Condensed format file, the 'species' that were not indicated (such as certain woody species that were not found as shrubs) were omitted and the 'species' left were recounted and numbered. The final Cornell Condensed format file contained two hundred and forty seven 'species' and one hundred and fifteen samples.

TWINSPAN

TWINSPAN (TWo-way INdicator SPecies ANalysis) is a computer program in FORTRAN for arranging multivariate data in an ordered two-way table by classification of the individuals (read samples) and attributes (read species) (Hill, 1979).
The ordening steps taken by TWINSPAN can be summarised as Figure 4.5 below (for more information see Hill, 1979).

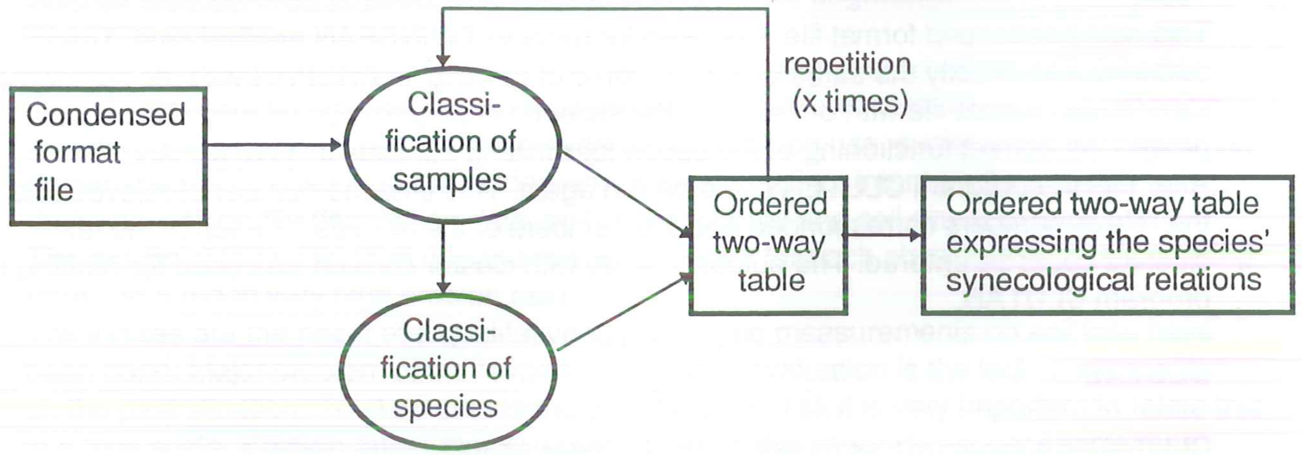


Figure 4.5: the ordering steps taken by TWINSPAN

As input file the Cornell Condensed format file was used. The first time the program was run, all default options were chosen which means among others no species or samples were omitted, no special weights were given to certain species or samples and chosen was for six cut levels (six times each formed cluster was again split in two).
Before running TWINSPAN it was not considered that the collection of, for example all unknown grass species in one group called "unknown grass", would make these grasses look like one regularly occurring species. As soon as this was realised the 'species' "unknown grass", "unknown herb" and "unknown tree" were omitted. However, the omitting option for undesired species in TWINSPAN turned out not to function because the

unknown species still occurred in the outcome (the two-way ordered table). To solve this problem the species were removed from the Cornell Condensed format file with an editing program called Useful EDitor (UED). Another option to overcome this problem was to give the unknown species names like "unknown grass 1", "unknown grass 2" etc. But as these unknown species were not really important for the final map, it was decided to use the first mentioned solution.
After analysis of the ordered two-way tables, it became also clear that some relevés were not made at homogeneous sampling sites. The heterogeneous samples made the TWINSPAN table indistinct and had to be omitted also. This option in TWINSPAN did work, sixteen samples were omitted which means that in the table ninety nine samples were left. The program UED was used to edit the TWINSPAN table.

CLUTER

CLUTER is a program that has the purpose of putting a cluster division on file. Such a file is needed for the program CLUTAB (explained below). For information on the use of CLUTER see Anonymous (1994).

When this program was used problems occurred as soon as the sample numbers were entered. The reason for this was that for running CLUTER first the number of samples has to be given, which was ninety nine. When later the sample numbers were entered, some of them had higher values than ninety nine because TWINSPAN had not renumbered the samples when the sixteen samples were omitted. CLUTER did not accept these sample numbers, they were seen as mistakes. To overcome this problem a new condensed format file was made with the program SHAKE (designed by O. van Tongeren, see Anonymous, 1994).
This new condensed format file was used for running TWINSPAN another time. The outcome was exactly the same as the outcome of running TWINSPAN with the old Cornell Condensed format file with omission of the sixteen heterogeneous relevés. This again proved the correct functioning of the option for omitting samples in TWINSPAN.
After this the program CLUTER could be run again. This time the number of relevés and the relevé numbers corresponded and the numbers of the relevés for each of the ten clusters could be entered. The outcome, a file with cluster division was used for running the program CLUTAB.

CLUTAB

CLUTAB is a program that makes synoptic tables (Anonymous, 1994).
To run CLUTAB two things are needed:
1. a condensed format file with vegetation data
2. a file with the cluster division of the samples.

To run the program it is necessary that the number of records and species in both files are equal. Here the condensed format file that was created in SHAKE and the file with the cluster division created in CLUTER were used. CLUTAB was asked to create a synoptic table with the proportional frequencies of all vegetation types (clusters).
This synoptic table was edited in such a way that the species were placed in five blocks. In the first two blocks all differentiating woody 'species' and all differentiating herb and grass species were placed. A species was called differentiating when its proportional frequency in

one vegetation type was 30% (or more) higher than the proportional frequency in at least one other vegetation type. Woody 'species' were only differentiating when the tree occurrence was differentiating. If a woody 'species' was differentiating, its shrub occurrences were also placed in the block with differentiating species. In the next two blocks all constant woody species and all constant herb and grass species were placed. If one woody 'species' was constant the other occurrences of this species were again placed in this block. A species was called constant when it had a proportional frequency of 50% (or more) in one or more vegetation types. In the fifth block all remaining species were placed.

Naming of the vegetation types

After analysis of the data eight main groups with ten associations (or vegetation types) could be distinguished. These distinctions were based on differentiating species (syntaxonomic property) and appearance on the same or closely correlated positions in the landscape (synecological property). For each vegetation type two representing differentiating species were searched. Vegetation types in the same main group got the same first name. When a cluster had no differentiating species, the best characterising species for that cluster were used. At this point field knowledge was of great importance.

4.3.4 Erosion risk evaluation

At the third level of the legend, beside soil- and vegetation descriptions, erosion risk (or erosion hazard) indices are given for each physiographic unit. The indices represent the actual risk of the soils to water erosion. The risk index is given in respect to their physiographic position, their ground cover and land use. Other forms of land degradation, such as wind erosion, physical degradation and chemical degradation of soils, are not taken into account.
For each physiographic unit data collected on the following characteristics was used to come to an erosion risk evaluation: slope gradient, slope form, relative position on slope (runoff/run-on), parent material, vegetation cover and land use, surface coarse fragments, erosion/deposition features and its degrees, surface sealing, internal and external drainage, soil profile description data, soil chemical data and soil physical data.
The results of the evaluation are an erosion risk index for each physiographic unit, ranging from 1 to 5 (no to very high erosion risk).
The indices are the result of a qualitative approach; no measurements on soil loss have been done. Major problem of the "expert knowledge" evaluation is the lack of information on the past situation. To state something about erosion risk it is very important to relate this to a time scale. Erosion rates -measurements!- are in this respect very important when evaluating erosion risk. The context in which this evaluation is done is explained by the definition of land degradation made by Poels (1994): "Land degradation is a process that lowers the capacity of the land to supply useful products and/or services. In this case erosion risk is therefore mainly related to loss of agricultural potential on a time scale of five to fifty years.
The erosion risk is explained for each physiographic unit in Chapter 6.3 to 6.7.

5 RESULTS

5.1 Physiographic and erosion map

On the hard copies of the physiographic map thirteen different colours can be distinguished. These colours represent the different physiographic units (plus artificial lakes). For each physiographic unit information is given concerning: dominant soil properties and soil surface characteristics (both according to the third edition of the FAO-guidelines), vegetation structure, vegetation associations and erosion risk. The dominant soil properties and surface characteristics are a further generalisation of the soil associations as described in Paragraph 6.3 (see also Annex 5). The complete legend and its attributes are extensively described in Chapter 6.

Table 5.1: total (km²) and relative (%) area per physiographic unit and their polygon frequency

Phys. mapunit	area (km²)	% of total	freq.
A	5.85	0.1	28
B1	141.41	2.8	610
B2	360.62	7.0	1079
C1	11.83	0.2	7
C21	78.97	1.5	237
C22	1779.39	34.6	1000
C31	137.37	2.7	432
C32	2129.21	41.5	578
D1	171.83	3.3	130
D2	113.98	2.2	15
D3	100.59	2.0	129
E	80.82	1.6	17
W	23.70	0.5	12
SUM	5135.57	100.0	4274

Table 5.2: total (km²) and relative (%) area per erosion risk unit and their polygon frequency.

Erosion mapunit	Area (km²)	% of total	freq.
1	616.0	12.0	1704
2	178.2	5.4	287
3	2210.0	43.0	595
4	1791.2	34.9	1007
5	216.3	4.2	669
w	23.7	0.5	12
SUM	5135.6	100.0	4274

Beside the legend, a table is presented on the map in which the relative cover percentages are given for each mapunit. Since fluctuations in water surfaces can be relatively high -the boundary of unit W drawn is that of September 1988- map unit W (artificial lake) was excluded from the coverage calculations.
For each map unit the total area, their relative percentage cover and the number of polygons are given in Table 5.1 above. The same calculations are made for the erosion risk map; results are presented in Table 5.2.
Conclusion and remarks concerning the relative area percentages of both the physiographic and the erosion risk units are given in Paragraph 7.1.

5.2 Soil types

To give information about the distribution of soil properties within land form units, soil associations have been made. Of each map unit the dominant soil types and their coverage are given. Fao-classification names are only mentioned in the representative profiles.
The description of the soil associations starts with a range of surface characteristics. Surface characteristics are generally the same for the whole unit. Secondly the ranges of all known soil properties are given for the different soil-associations. Colour descriptions given refer to the dry colours of the Munsull Color Chart.
For each soil type one or a few representative profiles are given, in case of pit descriptions accompanied by chemical data. These descriptions can be found in Annex 5.
Soil observations were mostly restricted to soils in the Antébirimien (exceptions are unit A and C1). Soil associations are therefore given for land forms of the Antébirimien. This information can therefore not be extrapolated to the Birimien part without losing a great deal of reliability. Soil information (which is to be) collected in the southern half of the province, the Birimien, is better used when stating something about general soil properties of Birimien soils.

Hills (A)

Soil type Aa
Representative profiles: 26.2, 33.1
Gently sloping to sloping; often abundant medium gravel to bolders; thin, slightly hard to hard surface sealing; moderately to somewhat excessively drained; mostly very shallow, strong brown, loamy sands; few iron manganese mottles and very few iron manganese nodules; always rocky.

Plateau (B1)

Soil type B1a
Representative profile: 2.4
Gently sloping; many to dominant surface gravel; often exposure of hard hardened plinthite; slight sheet erosion; medium, slightly hard surface sealing; excessively drained; very shallow (depth limited by hardened plinthite); yellowish brown or brown sandy (clay) loams; iron-manganese nodules abundantly present; mottles absent.

Eroded and/or less developed indurated cap (B2)

Soil type B2a
Representative profile: 32.3
Nearly flat; abundant surface gravel; moderate sheet erosion; none to thin hard surface sealing; somewhat excessively drained; (very) shallow (depth limited by hardened plinthite), pink, reddish yellow or light yellow brown sandy (clay) loams; many or abundant iron manganese nodules and no mottles; very few roots and few fine pores.

Upper slope (C1)

Soil type C1a
Representative profile: 19.4
Nearly flat to gently sloping; common boulders; moderate sheet and rill erosion; thin hard surface sealing; well drained; shallow (depth limited by rocks), strong brown, sandy (clay) loams; very few fine iron-manganese mottles; no nodules.

Crusted middle slope (C21)

Shared properties:
Nearly flat; surface crust with none to common gravel; no rock outcrops; moderate sheet erosion, sometimes also some gully erosion; medium to thick hard crust, sometimes extremely hard, alternated by areas with a small (<20cm) sand cover; (moderately) well drained.

Soil type C21a
Representative profile: 22.1
Shallow to moderately deep, pale brown to brownish yellow, reddish yellow, strong brown or yellowish red loamy sand to sandy clay loams; always iron manganese nodules present, from very few in the upper horizon to abundant in the lower horizons; iron-manganese mottling is also increasing with depth from none to many.

Soil type C21b
Representative profiles: 12.1, 12.2, 12.7
Deep, very pale brown to yellowish brown or reddish brown sandy loam to sandy clays; clay percentage often increasing with depth; often abundant iron manganese nodules deeper in the profile, sometimes very few in the upper part; always iron-manganese mottling up to many in the deeper horizons; few fine pores and very few fine roots.

Not-crusted middle slope (C22)

Shared properties:
Nearly flat; surface often covered with, up to many, gravel; sometimes rock outcrops; slight to severe sheet erosion, sometimes gully erosion; wind deposition can occur; thin and sometimes thick slightly hard to very hard surface sealing; moderately well to somewhat excessively drained.

Soil type C22a
Representative profile: 12.8, 33.2
Deep, very pale brown or pink to dark yellowish brown sand to sandy clays; texture is getting distinctly heavier with depth; none to common iron-manganese mottling increasing with depth; iron-manganese nodules, sometimes abundant in the deepest horizon otherwise none to few; few fine roots and many fine pores.

Soil type C22b
Representative profile: 27.1, 13.5
Shallow, very pale brown to dark yellowish brown or strong brown sands (top layer) to sandy clays; rocks can be present, quartzite (AntΘbirimien) and/or schist (Birimien); none to common iron manganese nodules throughout the whole profil; none to few iron manganese mottles.

Soil type C22c
Representative profile: 30.4
Moderately deep, (strong) brown to brownish yellow or reddish yellow sand to sandy clays, clay percentage distincly increasing with depth; none to many iron manganese mottles increasing with depth; sometimes rocks.

Eroded lower slope (C31)

Soil type C31a
Representative profile: 13.4
Nearly flat; surface crust with none to few gravel; no rock outcrops; moderate, sometimes severe sheet erosion; medium thick hard to very hard crust; well drained; deep, light gray to yellow or reddish yellow sandy (clay) loams; often iron manganese mottles, numbers increasing with depth; sometimes iron manganese nodules; no roots present; many very fine pores; soil often very compact.

Soil type C32a
(see below)

Soil type D1c
(see below)

Not eroded lower slope (C32)

Shared properties:
Flat to nearly flat; soils C32d, C32e and C32f have no gravel at the surface, soils C32b and C32c none to few gravel and soil C32a none to many gravel; soils C32c and C32e have deposition; other soils have slight to moderate sheet or rill erosion or water/wind deposition; none to medium, thick, slightly hard to sometimes very hard surface sealing; they are somewhat excessively to moderately well drained.

Soil type C32a
Representative profile: 12.3, 13.3, 34.2
Deep, dark brown to (reddish) yellow or yellowish red loamy sand to sandy clays; clay percentage increasing with depth; none to many iron manganese nodules in the deeper horizons; none to abundant iron-manganese mottles increasing with depth.

Soil type C32b
Representative profile: 12.4, 33.5
(Very) shallow soils, depth limited by iron-manganese gravel or hardened plinthite; brownish yellow to brown or yellowish red sandy loam to sandy clays, clay percentage

increasing with depth; none to common iron-manganese mottles; none to common iron-manganese nodules, increasing with depth; few to common roots and many fine pores.

Soil type C32c
Representative profile: 31.6
Moderately deep soils, depth limited by iron-manganese gravel or hardened plinthite; pale brown to dark yellowish brown loamy sand to sandy clays; number of nodules increasing with depth from none to many; often common iron-manganese mottles.

Soil type C32d
Representative profile: 33.3
Deep, dark yellowish brown to (reddish) yellow loamy sands to sandy clays, percentage clay increasing with depth; iron manganese nodules throughout the profile from few to many; many pores and common roots.

Soil type C32e
Representative profile: 2.6
Deep, pale brown to yellowish brown or strong brown loamy sands to sandy clays; no nodules; up to abundant iron-manganese mottles deeper in the profile.

Soil type C32f
Representative profile: 13.1, 34.4
Deep, light yellowish brown to dark yellowish brown or yellowish red sands to sandy clay loams; upper horizon often loamy sand; none to many iron manganese nodules; none to few mottles only present in the deeper horizons.

Small valley (D1)

Flat/level; surface, sometimes very few gravel; no rock outcrops; water deposition; thin hard surface sealing on soil type D1a and D1c; medium very hard surface sealing on soil type D1b; moderately well to poorly drained.

Soil type D1a
Representative profile: 17.2
Moderately deep soil (depth limited by hardened plinthite and/or quartz layers); brownish yellow to dark yellowish brown or strong brown loamy sands to sandy clays; often a few rocks (quartz) of medium size; few to many iron manganese nodules, number increasing with depth; none to common mottles, number increasing with depth.

Soil type D1b
Representative profile: 28.4
Deep, gray to dark yellowish brown sandy clay loams to sandy clays; few to abundant iron and manganese mottles; no nodules.

Soil type D1c
Representative profile: 13.2
Deep, light gray to dark yellowish brown mostly sandy loams or sandy clay loams, sometimes sand or clay layers; in the deeper layers (very) few mottles present and up to abundant nodules in the deeper parts; often many fine and larger pores.

Large valley (D2)

Flat/level; surface gravel is rare; no rock outcrops; water deposition; strongly variable surface sealing ranging from thin to very thick and from slightly hard to very hard surface sealing; moderately well to poorly drained.

Soil type D2a
Representative profile: 33.4
Very deep, gray to yellowish brown sandy clay loams to silty clays, often increasing clay percentage with depth; sometimes iron-manganese nodules in the deep layers; always iron-manganese mottles, sometimes none in the upper horizon, often abundant in the deeper horizons; many very fine pores, few larger; few roots.

Soil type D2b
Representative profile 13.7, 34,3
Very deep, light gray to dark yellowish brown or reddish yellow loamy sands to sandy clay loams, often increasing clay percentage with depth; often some nodules down in the profil and oten a lot of mottles; few little pores and few fine roots.

Soil type D2c
Representative profile 13.6, 34.5
Very deep, light gray to (strong) brown or reddish yellow loamy sands to silty clays; much variation between the horizons within the profile; always iron-manganese mottling from none in the upper horizon to abundant under in the profil; often a few nodules in some horizons; many fine and a few larger pores; many fine roots.

Plain (D3)

No surface gravel; no rock outcrops; mostly water deposition; none to medium (slightly) hard surface sealing; somewhat poorly (imperfectly) drained.

Soil type D3a
Representative profile:12.5, 16.2
Moderate deep soil, depth limited by hardened plinthite; pale brown to strong brown or dark, yellowish brown sandy loams to sandy clays; common iron-manganese mottling increasing with depth; iron manganese nodules only sometimes absent in the top layer, number increasing with depth to many.

Soil type D3b
Representative profile:12.6
Deep to very deep, pale brown to light yellowish brown loamy sands to sandy clay loams; increasing clay percentage with depth; deeper in the profile (very) few iron-manganese nodules and rocks present; iron-manganese mottling increasing with depth to many.

Aeolian complex (E)

(Nearly) flat; slight sheet erosion features on top of dunes; thin to medium (slightly) hard surface sealing on top of dunes; in depressions thick and up to extremely hard; somewhat excessively drained on top of old dunes to poorly in depressions.

Soil type Ea
Representative profile:16.3
Position: top of the dune
Very deep, yellowish brown, very pale brown or reddish yellow loamy sands to sandy loams, below 140cm sandy clays; iron nodules common deeper than 80cm; few iron-manganese mottles below 80cm.

Soil type Eb
Representative profile: 16.4
Position: lower parts
Deep, pale brown to yellowish brown loamy sands to sandy clay loams; percentage clay increasing with depth; no nodules; few iron manganese mottles in the deepest horizon; few rocks.

5.3 Vegetation descriptions

A table with the structure data of all relevés is given in Annex 6, sorted on vegetation type. The dBASE file with this information is connected to the map file in Arc-info via the UTM co-ordinates.
The table with the data of the rapid road sampling method can be found in Annex 7, it is sorted on landscape unit. This dBASE file is also connected to the file with the physiographic map via the UTM co-ordinates.
The list with the scientific, French, Moree and Peuhl names, information on the occurrence of the species and whether they are leguminous plants or not, is given in Annex 8. The first sorting property of this list is the occurrence of the species (BS, EK etc.), the second sorting property is the alphabetical order of the scientific names. Five scientific names could not be traced back in the literature and are therefore given with a question mark, these are *Aspilia antelma, Monechma aliaris, Abutilon trenosum, Tephrosia niora* and *Tapinanthus ophioides.*

The final condensed format file created with SHAKE can be found in Annex 9. This file contains ninety nine homogeneous samples and two hundred forty four 'species'.
The adjusted TWINSPAN table can be found in Annex 10, in this table the species are ordered by vegetation type.

The synoptic table with separated blocks for differentiating woody or grass and herb species, constant woody or grass and herb species and for the remaining species can be found in Annex 11.
The description of the vegetation types is as follows: when a main group contains more than one vegetation type, first the shared differentiating species are given. After the name of the vegetation type the following properties are given:
1. structural properties
2. syntaxonomic properties (differentiating and constant species)
3. synecological properties.

The meaning of the structure types mentioned in the vegetation descriptions is given in the "key to the vegetation structure" (Annex 12).
A summarising table with structure characteristics of all vegetation types is given after the description of the vegetation types.

Main group 1

Association of *Cassia nigricans* and *Blepharis linariifolia* (3 relevés)
Vegetation structure: grassland. The coverage by the herb layer is fairly high (60-80%). The occurrence of shrubs is sparce (0-20%).
Syntaxonomic properties:
- Differentiating species: *Cassia nigricans* and *Blepharis linariifolia. Andropogon pseudapricus* is differentiating for this association together with the associations in main groups 2, 3 and 6.
- Constant species: *Acacia senegal, Aristida adscensionis, Schoenefeldia gracilis, Borreria radiata* and *Leptadenia hastata.*

Synecological properties:
This vegetation type is found on the hills in the Birimien (see ideal topsequence in Chapter 6. It is a herbacous vegetation with mainly grasses. These grasses are mainly annual, but near the transit to the savanne vegetation the share of perennial grasses increases.

Main group 2
Shared differentiating species: *Fymbristylis exilis, Tripogon minimus* together with main group 3, *Andropogon pseudapricus* together with the associations in main groups 1, 3 and 6.

Association A, association of *Fimbristylis exilis* and *Gardenia sokotensis* (12 relevés)
Vegetation structure: sparcely vegetated land. The shrub layer has a coverage of 0-20% and trees are practically absent. The coverage by the herbaceous layer is 20-40%. The total coverage by the vegetation is low (20-40%) because the inundated hardened plinthite crust has no surface soil layer.
Syntaxonomic properties:
- Differentiating species: *Gardenia sokotensis.*
- Constant species: *Combretum micranthum,Ctenium elegans, Pandiaka involucrata, Guiera senegalensis, Polycarpaea linearifolia, Aristida adscensionis, Schoenefeldia gracilis, Pennisetum pedicellatum* and *Leptadenia hastata.*

Synecological properties:
This vegetation type is found on the steep slopes and rimbs of the plateaus and on the laterite residues. The shrub layer consists out of deciduous species. The herbaceous layer has a higher coverage of grasses than of herbs.

Association B, association of *Fimbristylis exilis* and *Loudetia togoensis* (6 relevés)
Vegetation structure: sparcely vegetated- to grassland. The shrub layer has a coverage of 0-20%. The herb layer has an average coverage of 20-40%. The total coverage by the vegetation is 40-60%.
Syntaxonomic properties:

- Differentiating species: *Loudetia togoensis*, only for this association but also with the association in main group 3.
- Constant species: *Combretum micranthum, Guiera senegalensis, Dactyloctenium aegyptium, Zornia glochidiata, Boscia senegalensis, Aristida adscensionis, Schoenefeldia gracilis* and *Pennisetum pedicellatum.*

Synecological properties:
This vegetation type is found on the flat slopes of the plateau's at some distance form the rim. Here a shallow soil has developed which causes a higher vegetation coverage. The shrub layer consists of deciduous species. The herb layer consists mainly of annual grasses.

Main group 3

Association of *Pterocarpus lucens* and *Acacia macrostachya* (7 relevés)
Vegetation structure: bushed woodland. Trees and shrub are present with coverages of 0-20%. The vegetation coverage is 60-80%.
Syntaxonomic properties:

- Differentiating species: *Pterocarpus lucens.Tripogon minimus* is differentiating for this association together with the associations in main group 2. *Loudetia togoensis* is differentiating for this association together with association B in main group 2. And *Andropogon pseudapricus* is differentiating for this association together with the associations in main group 1, 2 and 6.
- Constant species: *Acacia macrostachya, Combretum micranthum, Guiera senegalensis, Zornia glochidiata, Boscia senegalensis, Anogeissus leiocarpus, Waltheria indica, Sida alba, Cassia obtusifolia, Aristida adscensionis, Schoenefeldia gracilis, Borreria radiata* and *Pennisetum pedicellatum.*

Synecological properties:
This bushed woodland vegetation type is found on the wet spots of the aeolian deposits and the wet spots of the middle slopes where normally the *Fimbristylis exilis* and *Loudetia togoensis* association is found. The soils here are deeper and the water availability is higher which causes a higher abundancy of trees. Most woody species are deciduous species, and the herb layer is dominated by annual grasses.

Main group 4

Association of *Cenchrus biflorus* and *Brachiaria distichophylla* (17 relevés)
Vegetation structure: sparcely vegetated land. The presence of trees is rare but shrubs are present although with very low coverages. The coverage by the herb layer is 20-40%.

Syntaxonomic properties:

- Differentiating species: *Cenchrus biflorus.*
- Constant species: *Eragrostis tremula, Aristida adscensionis, Schoenefeldia gracilis* and *Leptadenia hastata.*

Synecological properties:
This association is found on all middle slopes. The vegetation grows on the sandy soils between the crusted soils. It consists mainly out of annual grasses. The most common shrub is *Boscia senegalensis*. The trees are, if present, thorny and small (up to 7 metres), *Balanites aegyptiaca* or *Acacia senegal.* Sometimes this vegetation type is found on small gravel hills (hardened plinthite residues).

Main group 5

Association of *Pupalia lappacea* and *Balanites aegyptiaca* (10 relevés)
Vegetation structure: sparcely vegetated land. Trees and shrubs are common (coverages of 0-20%) but the trees remain small. The coverage by the herb layer is 20-40%.
Syntaxonomic properties:

- Differentiating species: *Pupalia lappacea.*
- Constant species: *Balanites aegyptiaca, Zornia glochidiata, Boscia senegalensis, Eragrostis tennela, Piliostigma reticulatum, Cassia obtusifolia, Corchorus tridens, Aristida adscensionis, Schoenefeldia gracilis, Pennisetum pedicellatum* and *Leptadenia hastata.*

Synecological properties:
This vegetation type is found on the more or less degraded lower slopes and on middle slopes. Between the annual grasses many herbs can be found that are present on arable land.

Main group 6

Association of *Andropogon gayanus* and *Anogeissus leiocarpus* (14 relevés)
Vegetation structure: bushed woodland to woodland. Trees and shrubs are present with coverages between 0-20% up until 40-60%. With 60-80%, the vegetation coverage is high.
Syntaxonomic properties:

- Differentiating species: *Andropogon pseudapricus* is differentiating for this association together with the associations in main groups 1,2 and 3.
- Constant species: *Guiera senegalensis, Waltheria indica, Andropogon gayanus, Piliostigma reticulatum, Sida alba, Schoenefeldia gracilis, Borreria radiata* and *Pennisetum pedicellatum.*

Synecological properties:
This vegetation type is found in small valleys and wet plains. It can also be found on the humid transitions of lower slopes to the valleys. The woody species are deciduous species and perennial grasses are common.

Main group 7

Association of *Leucas martinicensis* and *Corchorus olitorius* (24 relevés)
Vegetation structure: park steppe. This is a herb vegetation with a regular occurrence of large trees. These trees have a low coverage. Because of regular cutting, the shurbs, that

are treated as weeds, remain small. During the rainy season the herbal coverage is high (60-80%), but during the dry season as the crops are harvested the herbal coverage is low (20-40%).
Syntaxonomic properties:
- Differentiating species: *Leucas martinicensis, Corchorus olitorius, Sorghum bicolor* and *Hibiscus sabdariffa* (these last two species are crop species). *Hyptis spicigera* is differentiating for this association together with association A in main group 8.
- Constant species: *Alysicarpus ovalifolius, Ipomoea eriocarpa, Eragrostis tremula, Andropogon gayanus, Piliostigma reticulatum, Sida alba, Corchorus tridens, Schoenefeldia gracilis* and *Pennisetum pedicellatum.*

Synecological properties:
This is a park steppe vegetation type. In these park landscapes most of the woody species are removed in exchange for agricultural crops. The trees that are left are large ones that are useful to the inhabitants (for example *Tamarindus indica*). This vegetation type is found on arable lands on the lower slopes.

Main group 8

Shared differentiating species: *Deternanthera nodiflora* and *Mitragyna inermis. Schoenefeldia gracilis* is negatively differentiating.

Association A, association of *Mitragyna inermis* and *Bractea lata* (4 relevés)
Vegetation structure: woodland. The trees of have an average coverage of 20-40%, but coverages of 60-80% were also found. The height of the trees is about 16 metres. Total vegetation coverage depends on the presence of water. During inundation it is 20-40% but as soon as the water is gone and the herb layer is developed the coverage is 60-80%.
Syntaxonomic properties:
- Differentiating species: *Mangifera indica, Citrus sinensis* (these two species are fruit trees), *Ipomoea spp., Brachiaria lata, Fimbristylis littoralis* and *Ludwigia abyssinica. Hyptis spicigera* is differentiating for this association together with the association in main group 7.
- Constant species: *Cassia obtusifolia, Leptadenia hastata, Cassia mimosoides, Eragrostis tenella, Corchorus tridens, Aspilia antelma* and *Cymbopogon schoenanthus.*

Synecological properties:
This vegetation type is found along the banks of very large valleys that can be found north of Pensa (see Picture 2.1 In Chapter 2). Besides these orchards also vegetable gardens can be found, especially close to villages. Both orchards and gardens are fenced. The trees are deciduous. The herbal cover exists of both perennial- and annual species, more herbs than grasses.

Association B, association of *Mitragyna inermis* and *Deternanthera nodiflora* (2 relevés)
Vegetation structure: woodland. The large trees have a coverage of 20-40% while shrubs are absent. The presence of grass and herb species is very low and they only start emerging after the water has dried up.
Syntaxonomic properties:
- Differentiating species: *Deternanthera nodiflora* and *Mitragyna inermis* are differentiating for this association together with association A in this main group.

- Constant species: *Leptadenia hastata* and *Cymbopogon schoenanthus.*

Synecological properties:
This vegetation type is found in the valleys on the banks of the very large streambeds that are inundated for a large part of the year. The number of species is very low and perennial. *Mitragyna inermis* is the only tree species present here.

In Table 5.1 a summary table with structure data of all vegetation types is given. Because the rounded average values (used for classifying the different structure types) strongly generalised the structure data, original values of the average coverage classes are given. By showing the original values the differences in coverage of the vegetation types become more clear to the reader.
It is clearly shown that trees have the highest coverage and are the largest in valley vegetation types. The smallest trees (if present, see coverage class) are found in vegetation types growing on shallow soils (hills and plateaus), and on eroded soils with crusts.

Table 5.1: Summary table with structure data per vegetation type. The codes in the first collumn represent the vegetation types. TC, HC, LC, HEC, VC: average coverage classes of the tree-, high shrub-, low shrub-, and herb layer and of the vegetation as a whole. TH, HH, LH: average heights of the tree-, high shrub- and low shrub layer (in cm). The coverage classes are as follows: 1= 0%, 2= 0-20%, 3= 20-40%, 4= 40-60%, 5= 60-80%, 6= 80-100%.

	TC	TH	HC	HH	LC	LH	HEC	VC
1	1.3	700	2.0	283	2.0	140	5.3	5.3
2A	1.2	700	1.8	415	2.5	151	2.9	3.4
2B	1.4	700	2.0	430	2.0	131	3.4	3.7
3	2.2	883	2.5	450	2.0	132	3.8	4.7
4	1.5	615	1.5	417	1.8	112	2.8	2.9
5	1.7	764	1.8	431	2.1	138	3.2	3.6
6	2.5	958	2.1	408	2.3	158	4.4	5.1
7	1.8	972	1.7	376	2.0	109	3.4	3.7
8A	3.4	1260	1.8	350	1.6	120	4.0	5.0
8B	3.0	1200	1.0	-	1.0	-	1.5	3.0

6 LEGEND

6.1 Introduction

The legend divides the landscape into units by aggregation and classification. This system of aggregation and classification is explained in Paragraph 6.1.1.
In Paragraph 6.1.2. it is explained how the presented information of Paragraphs 6.2 to 6.7 has to be interpreted.

6.1.1 Aggregation and Classification

Vegetation, soils, land use and erosion risk are strongly correlated to geomorphological features. This is a universal fenomenum. Therefore distinguishing different geology and land form units (at different levels), in order to give information on distribution of soils, vegetation, land use and erosion risk, makes sense.
It is for this reason that legend distinguishes four aggregation levels. Its highest level is geology and the second level is that of the major land forms (geomorphology). These major land forms are mostly further divided (desaggregated) into minor land forms at a third level. In some cases desaggregation took even place at a fourth level into land elements. The physiographic map unit is the resultant of this desaggregation.
At each level classification took place and at the lowest level composite attributes are given, from what could be regarded as a fifth level. These composite attributes are soil associations, vegetation associations, land use and erosion risk indices. (Des)aggregation of and classification on each level is explained in the Figure 6.1

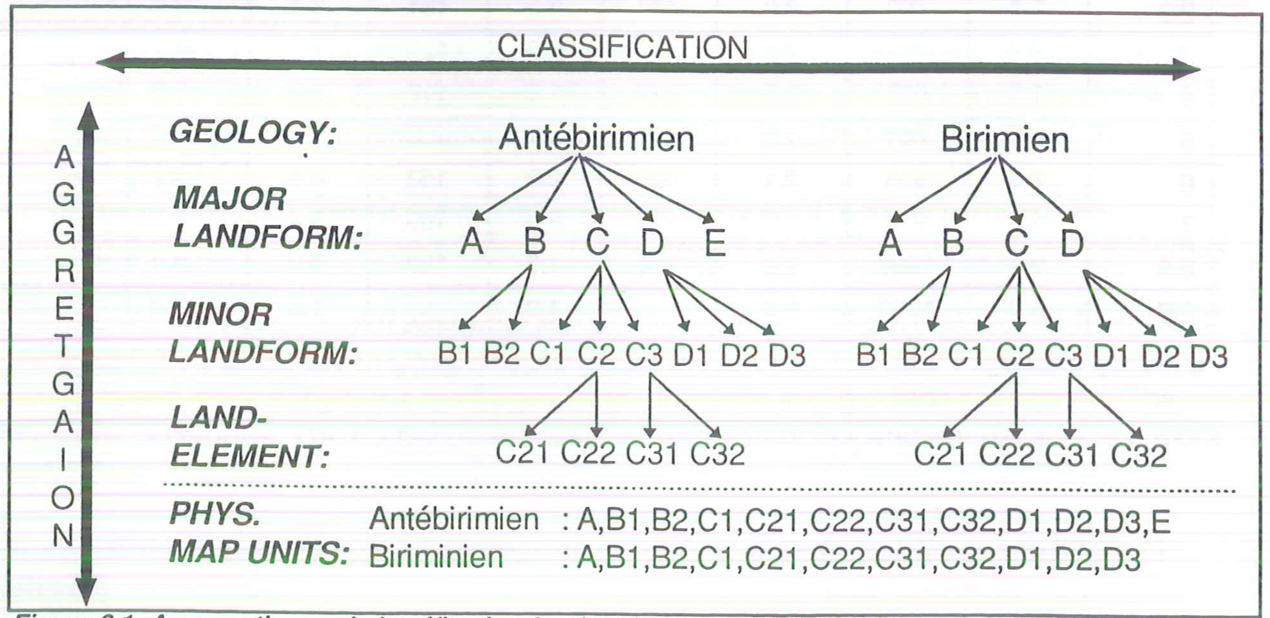


Figure 6.1: Aggregation and classification for the physiographic legend.

Geology is classified into two major units. The units are characterised by differences in parent material and somewhat steeper slopes, yet the same distinctions in land form can be

made. A third geological unit could be distinguished, these are the aeolic sands from the Pleistocene found in the Antébirimien area.
The major land forms dived the land into its most elemental units; Hills (A), Indurated caps (B), Slopes (C), Bottomlands (D) and Aeolian complexes (E) are distinguished. The major land form classes are presented by capital letters in the mapunit codes. The minor land forms by an integer value following the capital. A second integer represents the different land elements. Only two of the three slope groups have desaggregation at this level. Surface characteristics play a major role in this desaggregation step. The soil associations, vegetation associations and erosion risk indices are the (composite) attributes which form the heart of this research: providing basic information for land evaluation, land use planning and management.

6.1.2 Explanation to the descriptions of geology, land forms, soils, vegetation, land use, and erosion risk

In Paragraph 6.2 the geology of the area is described.
In Paragraph 6.3 to 6.7 a description is given for the major land form units. In subsequent Paragraphs (e.g. 6.5.2) further descriptions are given for the minor land forms. If necessary, these are followed by Paragraphs (e.g. 6.5.2.1) describing the land elements.
Every physiographic unit is then followed by a soil, a vegetation, a land use and an erosion risk description.
Since observation sites were mainly located in the Antébirimien, the soil, vegetation, land use and erosion risk information described in the following Chapters, is only applicable to the physiographic units of the Antébirimien! (Exception to this rule are the soil, vegetation, land use and erosion risk descriptions for physiographic unit A and C1)

Land forms

In the descriptions of the land forms, each english name for a land form unit is followed by the french term, written in *"Italic style*". Topography, position and slope are described as in the "Guidelines for soil profile descriptions" (FAO, 1990). Few indications are given concernig soil and vegetation, in order to illustrate land forming processes which play a role. A small idealized toposequence is showed in Figure 6.2 on the next page. Units E and D3 are however missing in order to keep the Picture small.

Soils

Variability of soil properties within a land form unit is expressed by a set of soil types -a soil association- in which soils are grouped by generalisation. The variability is very often correlated to the type of parent material and to the relative position of a soil within a land form unit. In this chapter variability will be compared to these properties and the resulting soil associations are given. The soil types are explained in Paragraph 5.2. The relative nutrient status of the soils of (almost) each physiographic unit are discussed in "Nutrient status of two water catchments in Burkina Faso" (de Boer, 1995).
In case a soil depth is given, it represents the depth where the gravel horizon is too dense, or where a solid ironstone layer is found so that augering is impossible (rootable depth).

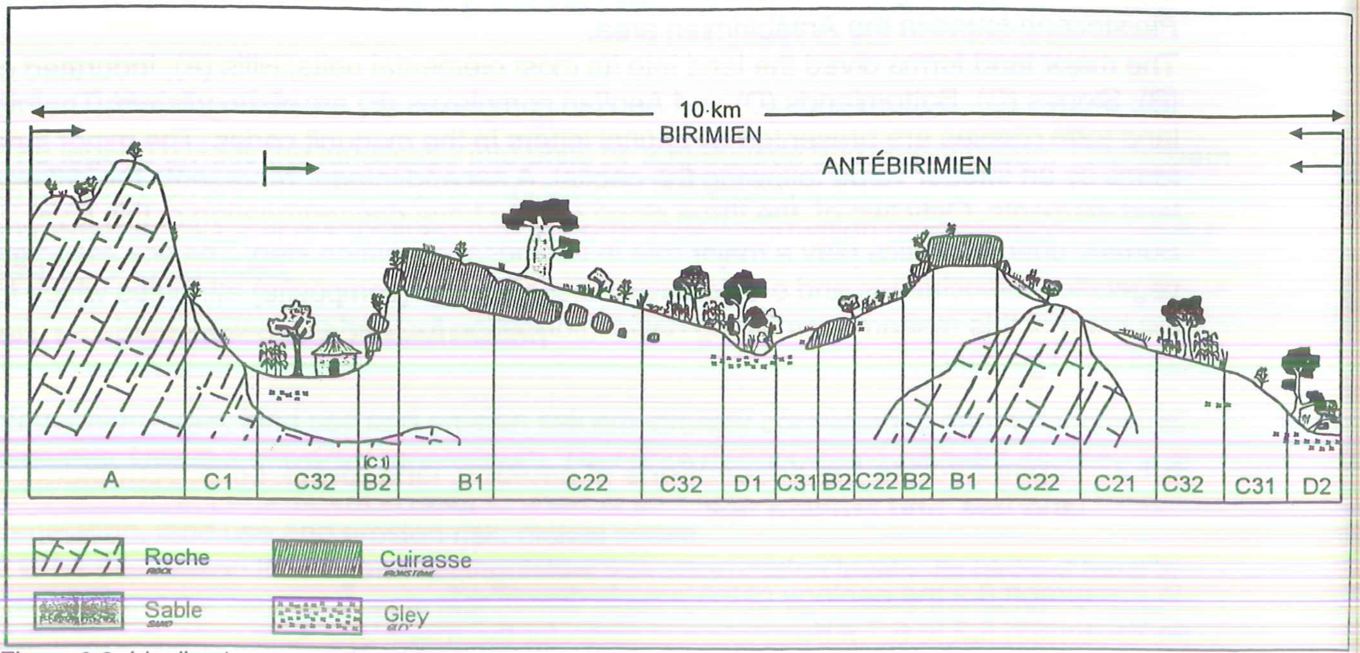


Figure 6.2: Idealized cross-section (toposequence) of the mapped area.

Vegetation

For each mapping unit first the structure of the vegetation is described. This structure information is obtained from the dBASE file with structure data of all vegetation observations (see Annex 6). Besides the structure, the vegetation types occuring each mapping unit are given. The abundance of each vegetation type in a mapping unit is evaluated in Paragraph 6.8.

Land use

The land use is described as it was observed during the field period. Some physiographic units have such bad growing conditions that these are practically not used. Others have several land use types.

Erosion risk

The erosion risk indices represent the actual risk of the soils to water erosion. The risk index is given in respect to their physiographic position, their groundcover and land use. Other forms of land degradation, such as wind erosion, physical degradation and chemical degradation of soils, are not taken into account. The erosion risk indices ranch from 1 to 5 corresponding to no, low, moderate, high and a very high erosion risk. It should also be noticed that indices are relative and should not be used as an absolute value outside the mapped region.
Deposition of eroded materials is not explicitly mentioned, but when evaluating the erosion risk of an area it is automatically taken into account. Areas where deposition rate is generally higher than erosion rate are, of course, very "low risk" areas, despite possible high local erosion rates. Also the fact that areas might not benefit from a deposition surplus is not taken into account here, but it must be well realised that water erosion in one area can have positive or negative (!) effects in a lower area.

6.2 Geology

As been stated before the major geological distinction to be made is that between the Antébirimien and the Birimien. A third epoque however involved the formation of the fixed dunes: the Pleistocene. In this order, the different units will be explained.
Because exposure of bare rock in the mapped area was only limited to few sites, it was not possible to give a good idea about the spatial distribiution of different kind of rocks. Therefore lithological names have not been mentioned in the classification name of the second level of the legend.

6.2.1 Antébirimien

The formation of the Antébirimien is of ingeous origin. It is the oldest formation of which traces can be found in Burkina (Hottin & Ouedraogo, 1975). The rocks found are granites, granodiorites and diorates. The rock is fairly to strongly resistent to erosion and therefore can still be found as small round-shaped outcrops. The outcrops are too small to be distinguished on the map. Mostly these rock outcrops are found in unit C2, Middle slope.
During the first stages of weathering especially the dark minarels are released. Its most resistent mineral is quartz (Pannekoek et al., 1975). This is why soils in this unit almost always contain a relative large amount of quartz-sand. The weathering product of granite is not rich in nutrients. This, combined with strong and pronounced eluviation of minerals causes the low nutrient level of the soils.
Contents of released Iron- and alluminium are not very high, but their accumelation can result in the formation of plinthite, and later irreversable hardened plinthite, also known as ironstone. It is even possible to find a laterite cap directly overlying granitic-saproli-te/granitic rock.

6.2.2 Birimien

The epoque succeeding the Antébirimien is the Birimien. The rocks are formed during a tectonically more active period. Therefore one can find metamorphic and vulcanic rocks, such as greenschist, graphite, quartz-manganize, quartz, metamorphized volcanic sediments (mentioned as redschist in 'Elkenbracht et al., 1995), pyroclasts, andesite and basaltic rock. They are still visible in the landscape as isolated hills or little mountain chains with a height up to 250m above the rest of the landscape. The different rock types are found next to each other at relative short distances. In the south eastern part of the province, also igneous rocks (granitic) from the Birimien can be found. Because this formation is not present in the mapped area it will not be discussed further.
The different rock types can be divided into two groups. One group is of volcanic origin, even when metamorphized. The second group is of (metamorphized) igneous origin, such as the greenschist facies. An exception is the graphite, found next to the so called redschist facies, which is of organic origin.

The first and most prominent group (the volcanic) contains the most fertile soils (see chemical data, Annex 5). Rocks are not very resistent to erosion. This is especially true for

the low-metamorphized volcanic sediments (redschist). Weathering results among others in the release of active clay minerals. This increases the CEC (see Annex 5, Profile 3.1). High aluminium and iron contents are realesed upon weathering. The accumulation of the sesquioxides often leads to the presence of ironstone caps on top of the rock, or in its direct environment (Elkenbracht et al., 1995). Pyroclastic sediments are seldom found (south west of Lac Dem). Old volcanic hills of basaltic/ andasitic rock are moderately to strongly resistent to erosion. Weathering leads to the formation of dark reddish soils.
Graphite, manganese-quartz and quartz are seldom found and only in small bands. The quartz rock is sometimes polluted with gold. This gold is being exploited at a small scale.

The second group contains the methamorphized igneous rock. These greenschist are often found near the metamorphic tuff (redschist). Chlorite gives the typical green colour (Pannekoek et al., 1975). The higher metamorphized greenschist is more resistant to weathering. Soils on greenschist hills therefore tend to be shallower and more stony. Typically, ironstone caps have not been found on the greenschist rock, although iron and aluminium contents are allmost as high as in 'redschists' (Elkenbracht et al., 1995).

6.2.3 Pleistocene

The pleistocene is known for its glacial periods. Glaciers did not occur in Burkina Faso, but the climatic changes were also drastic during these periods. Humid and desert conditions were succeeding one after another.
The desert like conditions favoured wind (aeolic) erosion and deposition. The old dune-complexes, which still can be found in the province of Sanmatenga, are probably one of the oldest still visible. By comparing the dune patterns and its soil properies with the 'Sangiwa coversand deposits' (Sombroek and Zonneveld, 1971) in Niger and Nigeria, it was concluded that the formation of these dunes was probably around 100,000 B.P.. In the European time table this period is known as the 'Early Weichselien".
The dunes are only a few meters higher than the surroundings. The dune tops form a rather regular grid with some orientation N-S or NNE, SSW, thus forming the pattern of transversal parabolic dunes. The varying orientation of the dune complexes could be the result of small differences in wind direction during their formation.
For an aeolic deposit, the grain-size sorting is poor. Both, different sand fractions, silt and clay are found. Due to this property the soils of the denudated or nearly denudated parts are very liable to surface sealing (Sombroek & Zonneveld, 1971). The formation of a compact surface layer is a major limitation for agricultural use. After tillage the soils would immediatly re-seal. This might be the reason that these dune complexes are still found under a semi-natural vegetation cover.
Next to the old-dune complexes, younger aeolic sands are found. They are mostly deposited around hills and plateaus, where wind velocities are decreasing. They are found throughout the area, but more abundant in the northern region (near Dafya, Dablo and in the north-east region around Pensa). The sands found show clear resemblances with the Zurmi- and Sokoto cover sand deposits found by 'Sombroek and Zonneveld" (1971), but with a less pronounced relief and pattern. The deposition of these sands is estimated to have taken place between 20,000 and 15,000 B.P. (Weichselien). The sands are better sorted than those of the old-dune complexes and have lower silt- and clay contents. Their colours are reddish-yellow to yellowish-red. The coversand areas are often cultivated with peanuts, peas, millet and sometimes sorghum. There is (almost) no surface sealing and

infiltration rates are high. The semi-natural vegetation consists of some shrubs and grasses (especially *Schoenefeldia gracilis*). These coversands are found throughout the province and don't form a separate land form unit. Soil information, collected in coversand areas, is incorporated in the description of soil associations.

6.3 Hills (A)

Colline

Hills form the crests in the terrain, their topography is hilly. Hills occur mostly in the metamorphic (schist, greenschist, graphite, quartz) or vulcanic rock parts (pyroclasts, basalt) of the Birimien. Sometimes however bare igneous rocks (granitic) are exposed in the Antébirimien. In the mapped area the latter rock outcrops were too small to classify as "hill" and they were to small to be mapped on a scale of 1 : 100,000. On other maps in Burkina "hills" are often called "residual relief".
In some cases one can find ironstone directly on top of the rocks. This is especially the case with schist. When this indurated cap is large enough, it can be classified as Unit B.

Soil

Soils are only very limited in depth or even absent. The surface is often covered with large boulders, or parent rock is exposed at the surface. Exceptions are found on minor depressions were soil material accumulates. Soil colour and texture strongly depend on parent material, but are usually dark (reddish) brown and sandy clay loam.
This means that the hue is much lower than in most of the other soil types found. This could be the result of different parent material (soil augerings were done in the Birimien instead of the Antébirimien) and may be, the result of a difference in weathering stage of the material. The high slope gradient causes most soils to be somewhat excessively drained.
Soiltype *Aa*, as described in Paragraph 5.2.1, covers 60-80% of the total surface; in other cases their is no soil.

Vegetation

The vegetation coverage is high (60-80%) throughout the whole year. The cover consists mainly of annual grasses in the north of the province (north of Pensa). In the southwest of the area (near Zongo) the cover consists mainly of perennial and annual grasses. Next to grasses also some shrubs are found both in the north and in the south. The vegetation type that is found here is the *Cassia nigricans* and *Blepharis linariiolia* association (type 1). Vegetation depends strongly upon the parentmaterial. In general however, vegetation densities seem to be higher near rock outcrops of the Birimien when compared to those of Antébirimiem.

Land use

The natural grass cover and the small shrubs are extensively grazed. The dead woody species, also in the following physiographic units, are collected for fuelwood. The living woody species are not collected, this is forbidden by the authorities. Shallowness and stoniness of the soils are serious limitations to arable cropping.

Erosion risk

In order to quantify the erosion problem "Smith and Wischmeier" introduced in 1962 the Universal Soil Loss Equation (USLE). Slope length and gradient are, according to their equation, two important factors determining the total amount of eroded material. Although

slope gradients easily reach values of ten percent or higher, erosion seems not to be severe; no clear erosion features were found (see Annex 3).
The major reason for this is the limited availability of easily erodible material; soils, if present, are very limited in depth -Leptosols (FAO)- and most soil material fills up cracks or is positioned in minor depressions and is therefore situated in a very stable position.
The high vegetation coverage (see Paragraph 6.4.1) protects the topsoil from slaking as a result of the direct impact of raindrops. The surface coarse fragments prevent water from running down too fast.
Since only soil chemical data from one pit is available no general conclusions can be drawn regarding the chemical status of the soil in relation to structure stability and susceptibility of the soil to erosion. Profile 33.1 (Annex 5) indicates however that CEC and nutrient content is somewhat higher than within other units, resulting in a somewhat better structure stability.
Pieri (1989) developed a linear equation for the degradation risk (DR) of soils as a function of organic matter (M.O.) percentage and clay+silt percentage (A+L):

$$M.O. / (A + L) * 100 = DR \qquad (eq. 6.1)$$

No risk was given for DR-values higher then 9, little risk for values between 9 and 7, high risk for values between 7 and 5 and if values reached lower than 5, than this would indicate that soils are physically degraded. Although it can be doubted if Pieri's formula is valid for this area, the DR-value of 2.2 in the topsoil of profile 33.1 might indicate that low organic matter contents are a reason for low structure stability.
Considering the fact that no erosion features have been observed, that erodible material is only limited available, but on slopes which are rather steep, the erosion risk index given to this unit is "2", representing a low risk to erosion.

6.4 Indurated caps (B)

Cuirasse

Indurated caps form the crests and higher parts of the terrain. The caps consist of ironstone (often referred to as laterite) which are being formed when plinthite hardens irreversible. The formation of plinthite takes place when there's an accumulation of sesquioxides (See also de Boer, 1995a).
One can find ironstone in the Birimien as well as in the Antébirimien. The ironstone forms caps which can be several meters thick. The ironstone forms a shield against erosion of underlying material. Two forms (stadia) of indurated caps are being distinguished on the "minor land form level".

6.4.1 Plateau (B1)

plateau

The ironstone plateau's are so resistant to erosion that thousands of years of erosion made the thickest and oldest caps rise above the landscape; relief inversion took place. The original low positioned areas are nowadays situated up to 50 meters (mostly 10-20m) higher than the surrounding terrain. Their form is mostly flat with steep edges (escarpments), or gently sloping on one side and steep on the other side. At the escarpment side of the plateau soil material (mostly white; kaolinite) is being exposed

enhancing plant (mainly) schrub growth. In this material quartz bands can stil be found at their original position.
The relatively high position and the limited internal drainage, cause a high external drainage (runoff). This is at the expense of moisture conditions.

Soil

On top of the plateaus ironstone is exposed. 40-60% of the surface is covered with very shallow (<30 cm) well drained soils. This soil is often very gravelly, especially at its surface where some sheet erosion results in an erosion pavement of ironstone gravel. The soildepth increases in minor depressions and downslope on the gently sloping side of the cap. When soildepth increases 30 cm, the number of scrubs increases rapidly and the land form type changes into "C22". Soil chemical analyses by de Boer (1995) show that the nutrient status of the soil is relatively high. This is probably due to the origin of the material, which is light aeolic material (Harmattan dust). Tiessen *et al.* wrote in 19990 a report on this subject.
When soil is present on to of the plateau, it is mostly of soiltype *B1a*.

Vegetation

The vegetation coverage of the plateaus is moderate (40-60%). The vegetation consists mostly of annual grasses, but small shrubs and perennial and annual herbs are also present (see Picture 6.1). Sometimes high shrubs or/and small trees can be found. On the plateaus and their steep slopes almost no soils are present, the woody species grow in uneven and cracked rocks or take roots superficially in the herb layer (Guinko, 1984). The vegetation type that is found here is the *Fimbristylis exilis* and *Gardenia sokotensis* association (type 2a). The *Pupalia lappacea* and *Balanites aegyptiaca* association (type 5) was found only once (relevé 173) but is not representative for this land form unit.

Picture 6.1: Vegetation growth on a plateau, clearly visible are the green shrubs of Combretum micranthum

Land use
In this unit shrubs are cut for fuelwood and fodder. The plateau's are extensively grazed by goats and sheep because these animals can climb the plateaus.

Erosion risk
Soils are not present or very limited in depth (see Annex 3) in places were soil material - windblown or by runoff- accumulates. In the latter, under a moderate vegetation cover, some sheet erosion can occur. Since land use and vegetation are almost absent, hardly any effect on the agricultural potential will result from further erosion, therefore the erosion risk index given to this unit is "1", representing a no risk to erosion.

6.4.2 Eroded or less developed indurated cap (B2)

cuirasse érodée et/ou moins développée

Small laterite hills (*buttes*), laterite pavements, and gravel surfaces which rise above the landscape for only several meters or less are all part of this unit. The small laterite hills are in fact minor plateaus which have less pronounced caps and cover a smaller surface area. The gravel surfaces are formed by the weathering of ironstone caps and/or as a result of severe soil erosion. In this latter case, the former B-horizon, with a dense matrix of plinthite concretions, is exposed at the surface, irreversibly hardening the plinthite gravel (Driessen & Dudal, 1989) .

Soil
Soils in this unit are mostly similar to those found on the plateaus. The soildepth is however somewhat deeper (<50 cm).
In case of a less developed cap, the original strongly weathered parent material (alluvial, or weathered granite), is more of influence than more present aeolic depositions. This can result in a somewhat coarser textured and nutrient poor soil. The high ironstone gravel in the soil hampers rootability and augering.
Soiltype *B2a* covers in this case 40-60 % of the total surface. Leaving 40-60% of the surface to where no soil, or a very dense gravelly soil was found.

Vegetation
Besides the *Fimbristylis exilis* and *Gardenia sokotensis* association which is also found on the plateaus, the *Cenchrus biflorus* and *Brachiaria distichophylla* association (type 4) and the *Pupalia lappacea* and *Balanites aegyptiaca* association (type 5) can be present here. Both vegetation types were found on gravelly places were a shallow soil had already developed, this could be seen by the presence of soil in between the small gravel stones.

Land use
The eroded caps or gravel hills are accidentally used for extensive grazing. Sometimes they function as sacred place of the death, but it is not sure if people are buried there also. It is also seen that these places were used for dyeing of clothes. This dyeing was done in pits that were dug in the hard soil material.

Erosion risk
The hardened plinthite layer is a mixture of partly consolidated gravel with some soil material. High runoff as a result of the bare surface induces occasionally sheet erosion. Yet, as with the former physiographic unit, erosion of overlying soil material has lead to the formation of hardened plinthite caps. The hardened plinthite cap is the final stage of the erosion process rather than that thyself get deteriorated by it. Because erodible soil material is more present within this unit than on the plateaus, the erosion risk index given will be 2, representing a low risk to erosion.

6.5 Slope (C)

Glacis

The glacis forms the sloping part between the higher units (A and B) and the bottomlands (unit D). Processes like runoff, run-on, erosion and depositon are more determined by relative slope position than by slope gradient; slope percentages seldomly exceed 2% (exceptions on the "upper slope"). At the level of minor land forms a distinction was made between an "Upper slope", a "Middle slope" and a "Lower slope".

6.5.1 Upper slope (C1)

Pente supérieure

Upper Slopes are found directly below units "A" or "B". Their slope gradient of 2-5% causes a high runoff, especially during heavy rains storms, on the allmost bare soils. It is believed that (nowadays) erosion is stronger than deposition. Runon is limited due to their relative high position in the catchment area. However, deposition of coarser fragments from units A and B is however possible. Clay, silt, sand and gravel are washed downslope. Water runs off rapidly and is hardly retained, causing water-availabillity to be low.
In many cases an area can be named both Upper slope as well as Eroded or less developed laterite-caps. In that case it will be mapped as unit "B2".
In the Antébirimien part of the mapped area, the unit C1 is always to little to be distinguished on a 1 : 100,000 scale. It always is being merged into other units. In the Birimien part some "Upper slopes" were distinguised on the map.

Soil
Receiving freshly weathered material from unit A, the well drained "Upper slope" soils are best compared to those of the Hills. The dry Munsell soil colours are mostly strong brown. The decreasing slope gradient, when going downhill, causes a differentiation in transported particle size; surface coarse fragments decrease in number and size going downhill. Light soil material, such as sand, silt, clay and organic matter, erodes, leaving an erosion pavement of surface coarse fragments. Parent rock or a rocky horizon strongly limits the effective soil depth (<50 cm).
A general soildescription is given for the soils found within this unit, *C1a*.

Vegetation
The vegetation coverage of the soil in this unit is very low, not exceeding 40%. The vegetation is concentrated on the sandy places, leaving the crusty places are bare.

The vegetation consists mostly out of annual grasses. Some small thorny trees and shrubs are found with a very low abundance. The vegetation type found here is the *Cenchrus biflorus* and *Brachiaria distichophylla* association (type 4).

Land use
This land form unit is only grazed by passing herds and flocks.

Erosion risk
The bare surface will be susceptible to surface sealing. Surface course fragments are commonly present. Even boulders larger than 20 cm were found and sheet and rill erosion features were observed. All together this gives the impression that erosion problems on the "Upper slope" are pretty serious. This is true from a soil science point of view. The "upper slope" is, however, not being used for agricultural purposes because of serious limitations in rooting depth (shallow soils; 30-50 cm) and because stones hamper cultivation. In this respect erosion can not do much damage. However it must be clear that erosion rates (in ton/ha/year) will be relatively high.
Soil and water conservation measures would prevent water running down to fast, causing erosion on the middle slope. On the other hand, run-off water now infiltrates in agricultural important lower areas.
Erosion is taken place but because of the absence of land use, except for some extensive grazing, and the low agricultural potential, the erosion risk given is 'only' high; index number "4".

Picture 6.2: soil profile 12.2, aeolic deposition at vegetation patches has is overlying the original A-horizon at unit C21.

6.5.2 Middle slope (C2)
Pente moyenne

Middle slopes can be found directly under the Upper slope. In this unit both erosion of light material (runoff) as well as the deposition of coarse material (run-on) plays an important role. Dispersed clay particles and other fine material (organic matter) are likely to be transported in suspension with running water. Hence the slope gradient does not have to be high. The "middle slope" has

been split up at the level of land elements, according to surface characteristics.

6.5.2.1 Crusted middle slope (C21)
Pente moyenne croûtée

The unit is characterised by a nearly flat crusted surface, often alternating with patches of vegetation. Because of the few obstacles on the surface and very low infiltration rates, water runs-off readily. When the crust is removed (permanently?!), or covered with a thin sand layer (5-20 cm), as is the case with the patches, water can infiltrate and arable cropping is possible. Especially grasses like Schoenefeldia Graciles are important for deposition of local aeolian sands on the surface crust. An example of a sand cover is given in Picture 6.2 at the previous page. The crust is mostly formed after the A-horizon (organic matter) is eroded away. The vegetated patches catch saltating sand particles and are therefore in a fragile equilibrium of erosion (by water) and deposition (by wind).

Picture 6.3: Vegetation growth on crusted middle slope, among others Guiera senegalensis (shrub), Schoenefeldia gracilis and Cenchrus biflorus

Soil
The soils of the Crusted middle slope are well drained, having a slow internal drainage, but with moderately rapid run-off. This is because of a surface crust or, in case of local aeolic deposition, by a thin sand deposit (<20 cm) overlying the former crust. Soil texture is mostly sandy clay loam, but it is often found more sandy at the top of the profile. The CEC is very low (5-10 cmol(+)/ kg soil), indicating the presence of low-activity clays (kaolinite). Base saturation is generally higher than 50%. The former A-horizon, containing organic matter, is mostly eroded away. Locally, in case of pronounced erosion, the former Bcs (B-horizon with a dense matrix of iron-manganese concretions)

is exposed at the surface. If not so, the soils are generally limited in depth by a Bcs-horizon. Actual hydromorphic features (mottling) are mostly only present in the in the deeper (>60 cm) horizons.
The soil is characterised by a dense soil matrix, having a low infiltration capacity, although termite activity is commonly present.
Soiltype *C21a* covers about 35% of the surface and soiltype *C21b* covers about 65%.

Vegetation

Picture 6.3 (previous page) shows the vegetation growth on a crusted middle slope. The vegetation of this unit is the same as the vegetation of the upper slope. On the transition to Non-crusted middle slopes the vegetation coverage can exceed 40%. This higher vegetation coverage percentage is not caused by more trees but by a higher coverage of the grass layer. On these transitions the *Fimbristylis exilis* and *Loudetia togoensis* association (type 2B) may be present.

Land use
The eroded slope only grazed by passing herds and flocks.

Erosion risk
The dominant bare surface soil is directly exposed to the destructive impact of raindrops, resulting in crust formation which can be extremely hard and compact due to its textural characteristic (sandy clay loam).

The most common soil within this unit is the Lixisol -FAO classification-, which is known for its susceptibility to erosion (Driessen & Dudal, 1989).
Many studies have been done on surface crusting of soils, resulting in more questions and controversial findings. Some general statements however can be done on surface crusts and there effect on erosion.
Stroosnijder and Hoogmoed (1984) showed that the formation of a crust causes infiltration rates to drop

Picutre 6.4: sheet erosion on a crusted soil

dramatically. Values in literature state that the hydraulic conductivity of the seal-crust can be a few to 2000 fold smaller than that of the original soil.

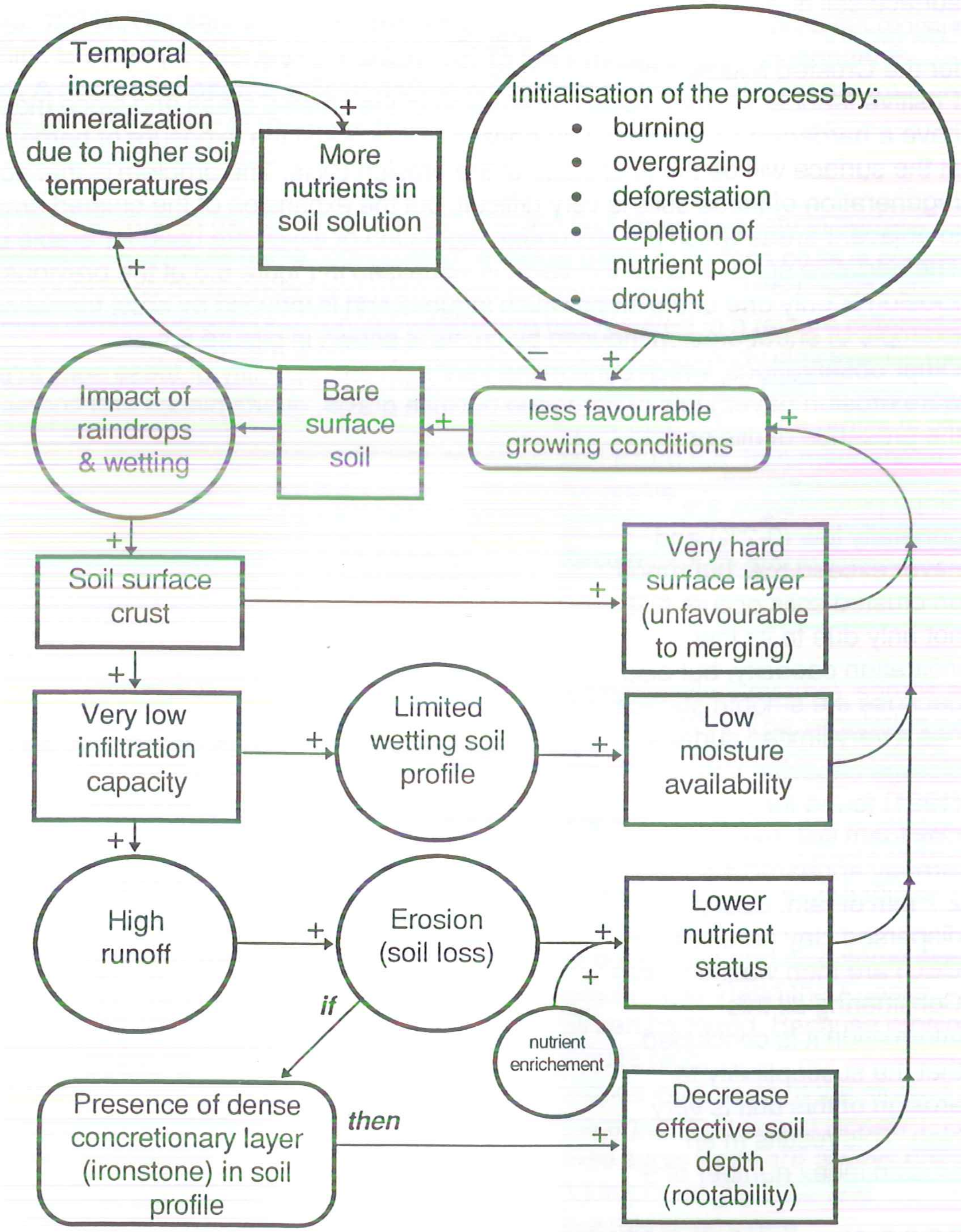
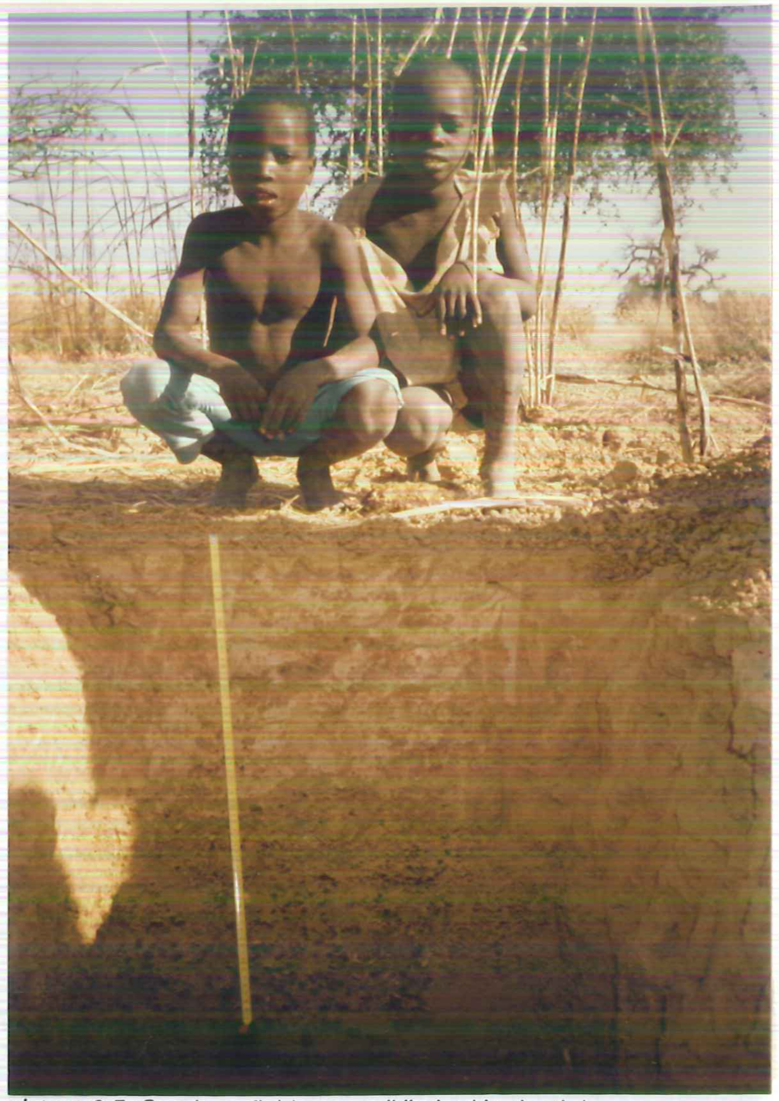


fig. 6.3: A negative spiral leading to degradation by erosion and crust formation (structure loss)

Tammes (1993) found in the area around Silmiougou (Sanmatenga) that seasonal runoff - as a percentage of rainfall- could reach about 65-70% for this unit, increasing to higher than 85% for an individual rainstorm of 89 mm. It must be clear that the high runoff values enhance sheet, rill and gully erosion. However splash erosion, caused by the impact of raindrops, was found reduced on crusted soils (Bradford et al., 1986).

Driessen and Dudal (1989) stated that Lixisols have a higher pH and lower AEC -and CEC- (see also Annex 5) than most other weathered tropical soils. Consequently, the structure stability is lower than, for instance, in Acrisols and Ferralsols and slaking and caking of the surface soil is a serious problem.
Low organic matter content makes that degradation risk values after Pieri (1989) calculated for the Crusted Middle slope are between 2 and 3 (eq. 4.1)
Positive feedback deteriorates the situation of the crusted areas and since most of the soils have a hardened plinthite (gravel) horizon in its subsoil the exposure of hardened plinthite at the surface will be the final stage of the erosion cycle. The problem is that not only the regeneration of these soils is very difficult, but the expansion of the crusted area is a threat to adjacent areas which are still under vegetation or which are used for arable cropping. The negative spiral of crust formation is visualised in Figure 6.3 at the previous page.
Erosion is only one of the steps which induces and is induced by crust formation. An example of sheet erosion induced by crusts is shown in picture 6.4.
Other observations, which confirm the very high susceptibility of these soils to erosion, were erosion pavements of hardened plinthite gravel, quartz pieces and coarse sand and the presence of rills and occasionally gullies.
Slope percentages are generally low (0-2%) and never exceed 5%, but runoff on crusted soils occurs fast; not only due to its low infiltration capacity, but also because the smooth surface has a very limited surface storage capacity. Valentin (1991) found for a crusted clay loam soil that runoff already appeared after only 2,7 mm of rain. Easily dispersed clay particles (low CEC) are then washed away. Considering all this information it is concluded that the susceptibility to erosion of this unit is very high. This results in an erosion index number of 5.


picture 6.5 :Sorghum field on a soil limited in depth by a concretionary layer (soil profile 13.5)

6.5.2.2 Non-crusted middle slope (C22)
Pente Moyenne non-croûtée

The crusted areas are alternated by areas with denser vegetation areas. These non-crusted areas are less affected by erosion, due to better infiltration rates and the occurance of obstacles such as vegetation, mulch and gravel. Due to the vegetation, wind velocity drops, which locally results in the deposition of wind-blown material. This is an important nutrient input (Janssen, 1994). The sandy cover increases infiltration and therefore improves moisture availability. Erosion (at past and at present) led to the exposion of concretionary B-horizons. A reason for often finding ironstone gravel at the surface; 40% of the total area has some to many gravel at the surface.

Soil
Soils on the not-crusted middle slope are well drained and show a variety in surface characteristics. Despite its name "not-crusted" a thin to medium surface crust is commonly found, although less pronounced and hard when compared to the crusted middle slope.
Local aeolic deposition and pronounced weathering has resulted in a texture differentiation, generally from sandy loam at the top of the profile (A-horizon) to sandy clay loam in the middle of the profile (B-horizon). As with the Crusted middle slope the CEC is very low (5-10 cmol(+)/kg soil) and base saturation is generally higher than 50%. The profile is often limited in depth by a concretionary horizon, as visible on Picture 6.5. Iron manganese mottles are often present particularly at the bottom of the profile.
Organic matter content is low, between 0.5 and 1.5 %.
Soiltype *C22a* covers 40% of the surface, soiltype *C22b* covers 30% and soiltype *C22c* covers 30% of the surface.

Vegetation
In this land form unit trees are absent or relatively small (maximally 9 metres), shrubs are very common and have a coverage of 0-20%, sometimes up to 40%. The vegetation types found here are numerous, depending on deepness of the soil, water supply and degree of erosion.
From a distance of about ten metres of the rim of the plateaus, where the soil is shallow, the *Fimbristylis exilis* and *Loudetia togoensis* association is found. In one sample (relevé 123) the *Fimbristylis exilis* and *Gardenia sokotensis* association was found, but this is considered an exception.
At a larger distance from the rim, were a deeper soil has developed and also some erosion is visible, the *Cenchrus biflorus* and *Brachiaria distichophylla* (type 4)and the *Pupalia lappacea* and *Balanites aegyptiaca* (type 5) associations can be found. Because erosion is still limited the vegetation coverage is 40-60%, which is quite high.
On the very humid spots, found on not-crusted middle slopes in all parts of the studied area (but that too small to be mapped on this scale), the *Pterocarpus lucens* and *Acacia macrostachya* association (type 3) can be found. On these spots trees are always present and reach a height up to 12 metres. Occasionally the *Andropogon gayanus* and *Anogeissus leiocarpus* association (type 6) may occur but this is very rare.
On the transition to the lower slope the *Leucas martinicensis* and *Corchorus olitorius* association (type 7) is present.
What is striking for all vegetation types in this land form unit is the fact that the grass species *Pennisetum pedicellatum* is always growing in combination with shrubs.

Land use
Most of this land form unit is used by the inhabitants (mainly Peuhl but also Mossi) for extensive grazing by their herds. Huts and kraals of Peuhl were found in open areas near the humid spots. On these places also stumps of trees were found.
Local redistribution of water can allow some agriculture. Also on the transition to the lower slope some agricultural fields were found.

Erosion risk
The dominant Lixisols have a low organic matter content; average organic matter content is below one percent, causing structure a low stability. This results in the formation of crusts, although less thick and hard when compared to the Crusted middle slope. Coarse surface fragments -mostly hardened plinthite gravel- are commonly present, indicating sheet erosion. Gullies are only incidentally found, indicating that runoff is not being very concentrated, but flows of rather homogeneous. This is probably caused by the denser and more homogeneous vegetation cover, hampering runoff and protecting the underlying soil surface from degrading too far by raindrop impacts; resulting in somewhat better infiltration capacities when compared to the Crusted middle slope.
The sum of all the characteristics and processes which play a role on the Non-crusted middle slope results in an erosion risk index of 4, meaning a high susceptibility to erosion. Degradation of these soils results in an expansion of the total surface "crusted middle slopes" and "eroded/less developed indurated caps"; soils on the middle slope are often limited in depth by a concretionary (hardened plinthite) layer.

6.5.3 Lower slope (C3)
Pente inférieure

The Lower slope can be found under the Middle slope and bordering the Bottomland. Runoff from the middle slope slows down due to a somewhat gentler slope and a denser groundcover. This causes the run-on to partly infiltrate, depositing light soil material and organic matter from the higher parts. Next to runon, horizontal unsaturated waterflow could play a role due to the concave shape of the slope (Zaslavsky & Sinai, 1977). This, and the vertical transportation of clay minerals enhances the formation of an illuviation horizon. The equilibrium between depostion and erosion shifts constantly, depending on local conditions. Erosion can therefore be a serious problem at places. On that bases a further subdivision is made.

6.5.3.1 Eroded lower slope (C31)
Pente inférieure érodée

The dynamics of the Eroded lower slope are best compared to those of the Crusted middle slope, although the minor land form name "lower slope" is not preceded by the term "crusted" as is the case with the crusted middle slope. This is because of the fact that hardened plinthite gravel is often exposed at the surface as a result of the removal of the layer overlying a hardened plinthite horizon. One can therefore better speak in terms of an erosion surface rather than a crusted surface. Soils are however often crusted, limiting infiltration capacity, which causes surface run-off and low moistureconditions.

This runoff is enhanced by the somewhat convex slope form, inreasing runoff velocities. The soils are often located between a Middle slope or a Non-eroded lower slope and the Bottomland. (Fossil?) hydromorfic features are therefore often found in these soils. Vegetetation patches as described in unit "C21" are not as common. Moreoften the eroded surfaces are intersected by small valleys (draining into a nearby larger valley) forming stripes of land simular to unit "C32".

Soil
The well drained soils of the Eroded lower slope can very well be compared to those found at the Crusted middle slope. Medium thick and very hard surface crusts are the main soil surface characteristic
Soils are however somewhat deeper (>100 cm.. Mottles are always present and their number increases with depth. Nodules can be found at the bottom of the profile (>80 cm) but a dense concretionary layer, as often found at the Crusted middle slope soils, is not common. Texture is sandy clay loam.

Picture 6.6: Passing herd on an eroded lower slope (C31).

The soil described above covers about 70% of the surface; soiltype *C31a*.
The eroded areas are however intersected by lower areas, where vegetation and soil are similar to the Not-eroded lower slope and the Small valley. These intersections could not be separately mapped. Therefore 20% of the Eroded lower slope surface is covered by soiltype *C32a* (Paragraph 5.2.3) and 10% by soiltype *D1c* (Paragraph 5.2.4).

Vegetation
On the eroded lower slope the *Pupalia lappacea* and *Balanites aegyptiaca* association (type 5) is present. This vegetation type is characterised by the presence of small thorny trees with low coverage (0-20%). Shrubs are present but small (1 metre high) and with the

same low coverage. Because of the severe erosion the herb layer is scarce and concentrated on the sandy places similar as on the crusted middle slope.

Land use

This land form unit is only grazed by passing herds and flocks, as visible on Picture 6.6 (previous page).

Erosion risk

The active role of erosion processes is reflected in the numerous erosion features (mainly sheet erosion).

As drawn in the idealised topo-sequence (Figure 6.2), the slope gradient slightly increases within this unit; the slope form is slightly convex. This feature is hardly noticeable in the field. However, on aerial photographs, the increasing slope gradient towards the drain is clearly visible. The convex slope form accelerates runoff, enlarging its transport capacity and therefore enhancing erosion.

Soils have very low organic matter contents in the bare surface soils. This makes them susceptible to physical degradation.

Taken all this information into account one can conclude that the susceptibility to erosion for the majority of the surface is very high. This equals an erosion index number of 5.

Picture 6.7: soil profile 12.3, a relatively well structured well drained deep soil on the Non-erosded Lower Slope.

6.5.3.2 Non-eroded lower slope (C32)

Pente inférieure non-érodée

The low slope gradient and position cause run-on and a relative high infiltration. This leads to good moisture conditions. There is some erosion but depostion is often dominant. Flooding does not or seldomly occur in this unit. So conditions for arable cropping are the best in this unit. However, agricultural suitability and natural vegetation depend much on local soil conditions. Soil conditions change regionally and locally within a lower slope.

The transition from middle to lower slope is often marked by the appearance of trees which can grow due to better moisture conditions (deeper soils, better infiltration).

Soil

The not-eroded lower slope shows the widest range in soil properties. Some overall properties are: having an effective soildepth is almost always larger than one meter and a pore- and root density higher than on the middle slope. Organic matter contents are around 1% and base saturation is always higher than 50% (usually around 80%). Most soils are probably (strongly) weathered alluvial soils.

The soils bordering the middle slope are well drained. Local aeolic depositions cause the Soil texture of the upper horizon is sandy loam and deeper in the profile sandy clay loam. A thin to medium hard surface crust is present. Mottling and some nodules can only be found in and below the B-horizon.

The soils bordering the Bottomland are (moderately) well drained. Soil texture is somewhat heavier; sandy clay loam and in the subsoil (120 cm) often sandy clay. Iron-manganese mottles are always present, increasing with depth. Nodules are often found and their number sometimes even limits the effective soil depth. A thin to medium (very) hard surface crust is often present. These soils, especially where large areas are found bordering a large valley, are most intensively used soils for arable cropping. An example of a relatively well drained, well structured and deep soil is soil profile 13.3, visible on Picture 6.7.

The soil types *C32a* covers about 50% of the surface and soil types *C32b, C32c, C32d, C32e* each cover about 10% of the surface.

Soiltype *C32f* covers also covers about 10% of the surface, but originates from a different parent material: aeolic sand. These deposits are better sorted estimated to be somewhat younger as the aeolic depositions of the Aeolian complex (see Paragraph 6.1.3). It is commonly found in the northern region of the province, north-east of Pensa, and around Plateaus.

Organic matter content, CEC and base saturation do not significantly differ from those found for the not-crusted middle slope.

Vegetation

Sixty percent of this land form unit is used for agriculture. The vegetation found on these arable lands is a called "park steppe". This is a human formed structure type which means that most woody species are removed and only the useful trees are left. In the mapped area the most found useful tree was *Tamarindus indica*, other more or less useful trees were *Buterospermum parkii, Bombax costatum, Sclerocarrya birrea, Lannea microcarpa* and *Acacia albida*. These trees can reach heights up to 16 metres. Near old settlements also *Adansonia digitata* was found. A useful shrub that regularly occurs is *Ziziphus mauritanius*. *Piliostigma reticulatum* was found very often as a small shrub, it gave the impression of a hard to combat weed. The vegetation type found here is the *Leucas martinicensis* and *Corchorus olitorius* association (type 7).

On the less fertile and little eroded parts, that are not used for agriculture, the *Pupalia lappacea* and *Balanites aegyptiaca* association (type 5) is found. The trees here are small (up to 9 metres) and shrubs are scarce. The coverage by the herb layer is high; 40-60% and even up to 80%. It consists mainly of annual species.

On the transition to the Bottomland the *Andropogon gayanus* and *Anogeissus leiocarpus* association (type 6) is present. Trees are moderately high, shrubs are present and both are deciduous species. The coverage by the herb layer is high again and consists of perennial and annual grasses and herbs.

The *Fimbristylis exilis* and *Loudetia togoensis* (type 2B) and *Pterocarpus lucens* and *Acacia macrostachya* (type 3) associations may also occur here; type 2B on the transition to the middle slope and type 3 on moist spots.

Land use
As described above, sixty percent of this land form unit is used for agriculture by the Mossi. Most arable land has a mixed cropping system of *Sorghum bicolor* and *Pennisetum typhoides* and several bean species. On soils with a relatively high amount of clay (mostly the lower and more moist soils) mainly *Sorghum bicolor* is found. On soils with a relatively high amount of sand (mostly the higher sandier and somewhat dryer soils) mainly *Pennisetum typhoides* is found. The mixed cropping system is a kind of risk spreading to be sure of food in wet years (good sorghum harvest) as well as in dry years (still a reasonable millet harvest). With a distance of a few metres or along the paths of these fields rows of *Hibiscus sabdariffa* are planted (see Picture 6.8), and sometimes *Sesamum indicum*. The agricultural fields are separated by strips of *Andropogon gayanus*. On the transitions to the less fertile and little eroded parts (with the association of *Pupalia lappacea* and *Balanites aegyptiaca*) small fields with *Voandzeia subterrana* are found. When these fields are harvested the dominating emerging grass is *Eragrostis tremula*. This in contrast to normally dominating grasses like *Schoenefeldia gracilis*. On the transitions to the Bottomlands small fields with *Arachis hypogea* were found. Both *Voandzeia subterrana* and *Arachis hypogea* are mono cropped. When all agricultural fields are harvested the Peuhl arrive with their herds. The herds graze the remnants of the harvest and the emerging weeds (Van der Hoek *et al.*, 1993).

Picture 6.8: Arable land with Pennisetum typhoides and Sorghum bicolor and rows of Hibiscus sabdariffa. Between the plants Striga hermonthera is visible (pink flowers), a parasite of Pennisetum typhoides and Sorghum bicolor. This parasite emerges after some years of cultivation when the soil is becoming depleted (Guinko, 1984).

Villages are present in this land form unit, close to the agricultural fields. Near the houses trees like *Azadirachta indica* are planted. Some maize and legumes are also grown. The fruits, nuts and leaves of the trees close to the houses and on the fields, are used for consumption, medicines, insecticide etc. Their wood is used for construction and fuel (Maydell, 1992).
The part that is not occupied by agriculture or settlement, is used for extensive grazing.

Erosion risk
Though the term "not-eroded lower slope" suggest a low erosion risk, the opposite is often found true. When compared however to the "eroded lower slope" it is found that erosion has not (yet?) deteriorated the soils of the "not-eroded lower slope" as is the case with the "eroded lower slope".
Slope form and related processes might play a major role in this. Though slope gradient never exceeds two percent, the concave slope form -recognisable on the aerial photographs- causes run-on to slow down, leading to deposition of eroded material (mostly fine sand to clay). Vegetation cover and higher soil biological activity, resulting in a better soil pore matrix thus higher infiltration rate, also plays a major role in preventing water and soil material from further transport downslope. In areas with semi-natural vegetation coverages are higher than on the "non-crusted middle slope". The arable areas have high vegetation coverages in the middle and the end of the wet season. However the most vulnerable period is at the beginning of the wet season when the soil is still bare.
Organic matter contents found for the "not eroded lower slope" are also so low that, when applying "Pieri's" equation, soils are expected to rapidly deteriorate physically when exposed to the direct impact of raindrops. The formation of a surface crust favours in that case erosion. Surface crusts found on agricultural fields were mostly (moderately) thin and hard (but then field observations have only been done in the dry period!) After which surface crusts formed in the beginning of the wet season are often broken by human and animal activity and/or removed due to tillage practices. Slight to moderate sheet and rill erosion features were occasionally found.
That erosion on the "not eroded lower slope" is found to be a problem by farmers is suggested by the stone rows (diguettes) which are often found at plot borders, perpendicular to surface flow.
Regarding the different erosion risk properties of arable and non-arable land one should make two different ratings. From this point of view it is clear that management plays a major role when evaluating erosion risks.
The non arable not eroded lower slope is not faced with pronounced erosion; the equilibrium between erosion and deposition varies locally but is generally around zero. Therefore erosion risk is only low. In arable zones erosion can be strong in the beginning of the wet time. Therefore erosion risk is rated moderately to high. In this case management can stimulate soil erosion as well as soil conservation. This should be well taken into account when using land for agricultural purposes.
Since mapping units don't distinct arable from non-arable land, the general erosion risk index given is 3, representing a <u>moderate</u> risk to erosion.

6.6 Bottomland (D)

Bas-fond

The lowest parts of the landscape are frequently inundated during the wet season (heavy rainstorms). A distinction has been made between three different Bottomlands on the bases of relative position, morphology and size.

6.6.1 Small valley (D1)

Petit bas-fond

The unit is only a narrow (100 - 500 metres wide) stripe of land around a drain (gully). Water coming from the slopes accumulates in the valleys and runs moderately fast through the gullies. This causes the land to be inundated for only short periods. Depostion of eroded materials makes the soil fairly fertile. The type of depositon depends on the flow velocities of the water. Semi-natural vegetation is abundant.
Moisture conditions for arable cropping are optimal in years with low rainfall (personnal communication) . Nowadays small valleys are therefore more and more used for arable cropping in order to tackle the problem of highly variable rainfall. Dams (of earth) are build in the small valleys to store water for agriculture.

Soil
The soils of the small valley are (very) deep, though few cases were found with an ironstone layer present. As a rule of thumb, it can be stated that the small valley soils always have hydromorphic properties.
However, the drainage and texture classes strongly depend however on the relative position of the soil within the unit. Moderately well drained soils are found on the somewhat higher parts (bordering the Lower slope). Their texture class is sandy clay loam throughout the profile, or with a sandy loam A-horizon. These soils are characterised by soiltype *D1a*, which covers about 40% of the surface, and soiltype *D1b*, which covers about 20% of the surface.
Near the drain (gully) and further downstream water accumulation is larger and soils are ponded for a longer time; soils are imperfectly to poorly drained. Texture here is often sandy clay, but local higher flow velocities of the water cause sand to be deposited. Soils found here often show an alternation of fine and coarse textured horizons. These soils are characterised by soiltype *D1c*, covering about 40% of the surface.
The CEC of the Small valley soils is somewhat higher compared to the soils on the middle and lower slope; between 10-15 cmol (+)/kg soil. Base saturation is higher than higher then 50% (in general even >80%) and organic matter content is low (<1.5%).

Vegetation
The vegetation in the small valleys can be called woodland. Trees are always present with average coverages of 20-40% and heights up to 18 metres. Shrubs are also present but with lower coverages. The trees and shrubs are deciduous species. The coverage by the herb layer is high; 40-60%, and up to 80%. Annual grasses and herbs are still dominant, but perennial grasses and climbers are very common. The total average vegetation

coverage here is 60-80%, and sometimes even 100%. The vegetation type found here is the *Andropogon gayanus* and *Anogeissus leiocarpus* association (type 6).

Land use
This land form unit is mainly used by herds for extensive grazing and resting during the warmest parts of the days. During and just after the rainy season, as long as the valleys contain water, they are at several places used as drinking places for cattle, as shown on

Picture 6.9: Small valley at the and of the rainy season, water has not yet dried up and parts of the river bank are eroded because of drinking herds and flocks.

Picture 6.9. Some of these woodlands have very high tree abundance's, these are sacred forests, and not used for grazing or agriculture. No recordings were made in these forests. In 20% of the recordings agriculture was practised and sorghum was grown, here the *Leucas martinicensis* and *Corchorus olitorius* association (type 7) was found. Sometimes dams were buildand rice was grown.

Erosion risk
Water and eroded soil material runs on from higher parts in the catchment area. In combination with a minimum slope gradient and a high vegetation coverage this results in deposition of eroded materials. Evaluating erosion risks for Bottomlands seems therefore unrealistic.
However, erosion can cause local problems. Especially in small valleys and plains where the drainage channels are mostly gullies. During and just after rainstorms, discharge and stream velocity through these gullies can be high. Capacity to transport soil material is then relatively high and a change in the position of the streambed is than accompanied by local erosion.

Secondly, at the start of rainstorms -before overflow of gullies occurs-, sheet erosion can occur on bare surface soil due to the direct impact of raindrops.
Thus, though waterlogging seems most dangerous to cropping, local erosion on rice and sorghum plots could cause problems. Erosion on Bottomlands does however not decline the agricultural potential on long terms. Therefore the erosion risk should be interpreted in this case as the risk of erosion to lower harvest on short term.
Since agriculture is almost absent in the "large valleys" (D2) and deposition is the dominant process, no actual erosion risk, index number 1, is present. For the "small valleys" (D1) and the "plains" (D3) only a low risk is, index number 2, present since arable cropping is commonly practised.

6.6.2 Large valley (D2)

Grand bas-fond

The Small valleys drain in the Large valleys. Untill far in the dry seasons soils in this unit are moist and some parts are inundated during the whole year. Texture differences in the alluvial soils can occur as a result of different water velocities. In the case of water stagnation even the very light suspended particles are being deposited. Flooding makes arable cropping to a hazardous business. The Large valleys are often recognisable from great distance because of its large amounts of tall trees, but the parts which are inudated during a long period of the rainy seasen show little or no grass- and herb-vegetation.

Soil

Similar to the Small valley, the soils of the Large valley differ on relative height position. The soils bordering the lower slopes are moderately well drained, the soil texture is sandy clay loam. These soils are characterised by soiltype *D2b*, covering about 35% of the surface.
The lower parts of the Large valley are inundated for longer times; drainage class is imperfectly to poorly drained. Soils here always show gleyic properties (grey reduction colours). Soiltexture is generally sandy clay loam to silty clay. Soiltype *D2a*, is an example of such a soil covering about 40% of the surface. However, local sand deposits can alternate the heavy textured layers due to local higher stream velocities. These soils are represented by soiltype *D2c*, covering about 25% of the surface.
The high clay percentage of soiltype *D2a* causes the soils to swell and shrink little upon wetting and drying (slight vertic properties).
Flat/level. Surface gravel is rare. No rock outcrops. Water deposition. Strongly variable surface sealing ranging from thin to very thick and from slightly hard to very hard surface sealing. Moderately well to poorly drained.
Organic matter content, CEC and base saturation are in the same range as given for the Small valley. Nutrient status is somewhat higher when compared to other units (de Boer, 1995).

Vegetation

Here a woodland and sometimes even forest is found. The woody layer is dominated by high trees; shrubs are usually absent. The coverage by the herb layer is (after the water of the rainy season has dried up) moderate; 20-40%, and is dominated by annual herbs, but annual grasses and perennial herbs and grasses are also present. Here the *Mitragyna inermis* and *Bractea lata* association (type 8A) (without the orchard species *Mangifera*

indica and *Citrus cinensis*!) is present. When the valleys are extremely large, the *Mitragyna inermis* and *Deternanthera nodiflora* association (type 8B) is present along that part of the

Picture 6.10: Vegetable garden on a large river bank.

river bank that is inundated for a large part of the year.

Land use

The large valleys are mostly used as drinking places for cattle, but also for fishing and washing. Sometimes agriculture is practised and rice is grown. South-east of the reservoir (artificial lake) in the large valley near Dablo even a large irrigation system is developed for rice growing.
Close to villages near very large valleys (for example Pensa), the somewhat higher banks (that are not inundated for a large part of the year) are planted with fruit trees. Besides these orchards also vegetable gardens and sometimes tobacco plots are present here (transition to unit "C32"), as shown in Picture 6.10. Both orchards and vegetable gardens are fenced against grazing by passing cattle. Here the *Mitragyna inermis* and *Bractea lata* association (type 8A) is present again.

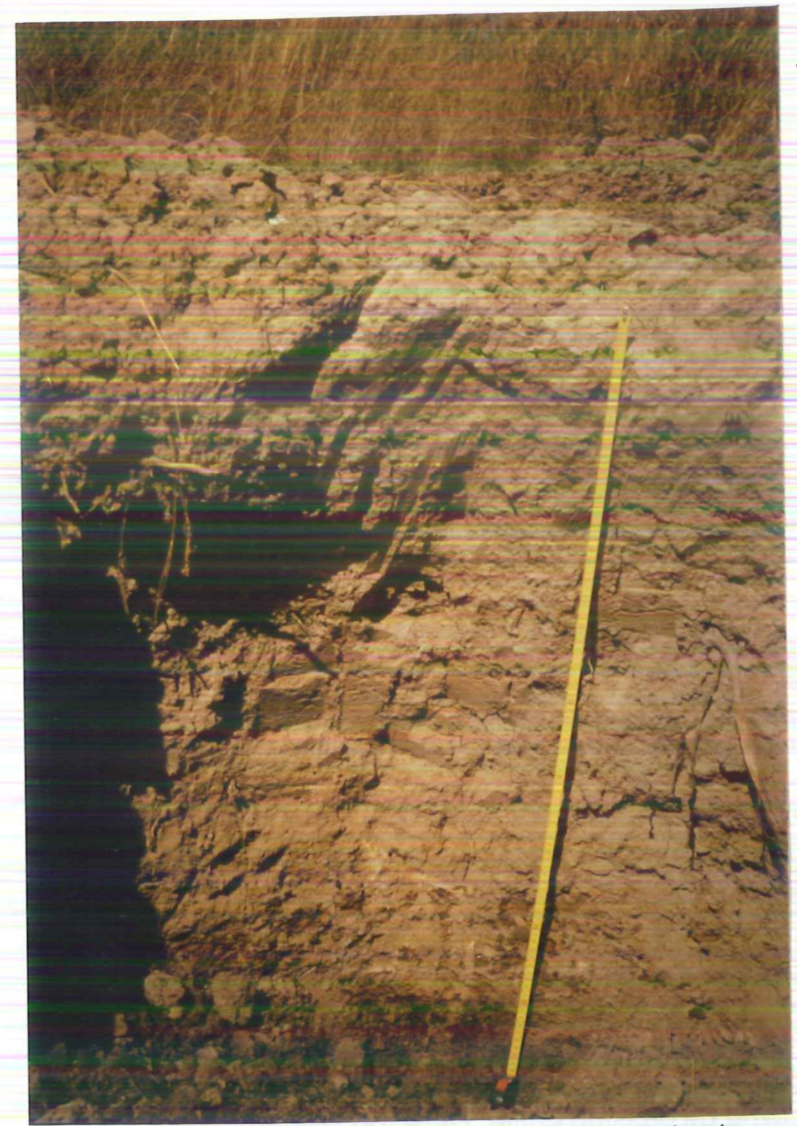
Erosion risk

The erosion index is 1, meaning no erosion risks. See for explanation, Chapter 6.6.1, Paragraph Erosion risk.

6.6.3 Plain (D3)

plaine

This unit is a flat area, where water accumulates from surrounding areas before discharging into a valley. As a result of limited infiltration rates in the subsoil the area is inudated for a certain period during the wet season. In some cases these conditions are also found on somewhat higher positioned parts in the terrain. The subsoil consists mostly of plinthite which is formed under alternating oxidized and reduced conditions. But als a dense illuviation horizon can do the trick (low K_{sat}). Vegetation is often similar to unit "D1". The appearance of the baobab is often (not always!) an indication for a soil with limited rooting depth. This unit is not widely used for agriculture, probadly because of limitations in rooting depth and waterlogging problems.



Picture 6.11: A grey reduction colour as a result of watterlogging, caused by the plinthite horizon at 90cm (soil profile 12.5, unit D3))

Soil

The soils of the plains are moderately well to imperfectly drained, more so because of a low internal drainage than as a result of run-on. The low internal drainage is caused by a dense illuviation horizon or a plinthite horizon (limited effective depth). The soils are ponded only a few days per year, but are water saturated for a long period. Gleyic properties are therefore common. The grey matrix colour of the soil at Picture 6.11 is an example of the waterlogging caused by a shallow plinthite horizon. Texture ranges from sandy loam at the top of the profile up to sandy clay in the illuviation horizon. The most heavy textured soils can be found in minor depressions. Soiltype *D3a* represents the soils limited by a plinthite horizon, covering about 40% of the surface. Soiltype *D3b* represents the soils with an illuviation horizon, covering about 60% of the surface. Despite the high clay percentages, the CEC is low (<10 cmol(+)/kg soil). Organic matter contents found were very low (<1%). Base saturation was very high (>90%).

Vegetation

Plains have a very high vegetation coverage which is between 60 and 100%. Trees and shrubs are both present. They are deciduous species that can reach heights of 14 metres. Annual grasses are dominant in the herb layer, but annual herbs and perennial grasses and herbs are present as well. The vegetation type found here is the *Andropogon gayanus* and *Anogeissus leiocarpus* association (type 6). At places were a lot of water accumulates also the *Mitragyna inermis* and *Bractea lata* association (type 8A) can be present.

Land use

Plains are used as drinking and resting places for cattle. Some higher places in the plains are used for agriculture.

Erosion risk

Erosion risk index is 2, meaning a low erosion risk. See text in Paragraph 6.6.1.

6.7 Aeolian complex (E)

Complexe éolien

This is a complex of old sand dunes which are formed during a dryer period (Late-pleistocene) with still a slight relief. Differences in soil and vegetation between the high and low parts are clearly visible. In the lower parts where water accumulates, the semi-natural vegetation is more like in unit C32. In the higher, dryer parts one finds grasses or bare soil (sometimes with a thin crust). Coarse textured soil are found on the crests, and heavier textured soils in the depressions (locally to periodical waterlogging).
Anisotropy leads to (almost) horizontal unsaturated waterflows, even with slope gradients of 1 percent (Eppink & Stroosnijder). Zslavski & Sinai stated that this can lead to the development of a loamy or clayey B-horizon on dune sand parent material. This could be especially true in these poorly sorted aeolian deposits. The heavier texture soil could then be the result of horizontal clay illuviation. The areas are not used for agriculture. Probably because the parent material on top of the dunes (aeolian sand) is nutrient poor and soils in the lower parts are very succeptable to crust-formation; sand, silt and low-activity clays cause the surface to seal after wetting. (Sombroek & Zonneveld, 1971).

Picture 6.12 : Crest of old dune complex with some surface sealing.

Soil

The name complex indicates a wide variation between soil types. Generally a subdivision can be made between the high and low positioned soils.
One can find thin to medium (slightly) hard surface sealing on top of dunes and in depressions thick and up to extremely hard surface sealing. Drainage is somewhat excessively on top of old dunes to poorly in depressions
The soils on the higher parts have a strong graduation in texture. The top of the profile (<30 cm) is loamy sand, but deeper (>140 cm) the texture changes into sandy clay. Assuming that the soils have formed on aeolic depositions (dunes), the change in clay percentage must be the result of a pronounced illuviation process. Some mottles and nodules were found deeper in the profile (>80 cm). Soiltype *Ea* represents these soils, covering about 45% of the surface.
Clay illuviation has also taken place in the soils of the lower parts. The soil texture in the top of the profile is sandy loam and sandy clay loam deeper in the profile (>30 cm). The soil matrix is very dense. Mottles can be found at some depth (>50 cm).. The surface of these soils is often marked by surface crust. These soils are represented by soiltype *Eb*, covering about 45% of the surface.
A third group of soils is found in minor depressions (see picture 6.13). The soils can very well be compared to soiltype *D3a*, the formation of a plinthite horizon has lead to a poor internal drainage. This causes periodic waterlogging. The soils cover about 5 % of the surface.

Vegetation

The vegetation types of the aeolian complex differ with their positions. On the old dune tops the coverage by trees and shrubs is low, trees are small or even absent. The coverage by the herb layer is 40-60% and concentrated on the not crusted parts of the soil (similarly to the vegetation on crusted middle slopes and on eroded lower slopes, see Picture 6.12). Annual grasses are dominant and annual herbs and perennial grasses and herbs are present but with very low coverages. Here the *Fimbristylis exilis* and *Loudetia togoenis* association (type 2B) can be found.
In old depressions the coverage by trees and shrubs is much higher (see minor depression on Picture 6.13). Trees reach heights up to 11 metres and can have coverages of 40-60%, and species are
deciduous (*Ficus platyphylla*) as well as thorny (*Acacia macrostachya*). The coverage by the herb layer is low (< 40%). It consists mainly out of annual grasses, annual herbs are present too but not always up to perennial species. The vegetation types found here are the *Pterocarpus lucens* and *Acacia macrostachya* association (type 3) and the *Andropogon Gayanus* and *Anogeissus leiocarpus* association (type 6).

Land use

This land form unit is used for extensive grazing. Huts and kraals of Peuhl are present here. The agricultural use of the aeolian complex is marginal.

Erosion risk

Since soil formation has taken place for over thousands of years, soil(surface) differs distinctly between higher and the lower parts of the complex.

Picture 6.13: Vegetation at a minor depression of the Aeolian Complex

The higher parts are still very sandy and well drained. Crusts are formed on bare surface spots, but they are soft and relatively porous; the soil was still found moist in December '94 (good infiltration capacity). Vegetation coverage are moderate and erosion seems not to be a great risk in decreasing the already low agricultural potential of the poor and sandy soil. Erosion risk is therefore estimated moderate, index number '3'.
The lower parts have further developed soils. Texture on the lower parts is sandy clay loam, making it very susceptible to surface crusting. In combination with a poor internal drainage this can easily lead to erosion in case the land is used for arable cropping. Arable cropping was however not found and therefore erosion seems not to be a severe problem. Erosion risk given is therefore moderately, index number "3".

6.8 Physiographic units versus vegetation types

Below a matrix is given in which the presence of the different vegetation types in the land form units is shown (Table 6.1). It should be emphasised that these percentages are results of the relevés. In reality the correlation between the land form units and the vegetation types is much higher. This counts mainly for the not-crusted middle slopes with vegetation types 2b and 3, and for the small valleys with vegetation type 6. On the middle slopes the presence of vegetation type 2B is around 40% and of vegetation type 3 around 30%. The presence of the other vegetation types in this land form unit is much lower, but the ratio's between these types remain the same.
The vegetation in the small valley consists for 90% out of vegetation type 6. The low presence in the matrix is caused by the fact that many of the relevés made in this land form

unit were not homogeneous. Because this also happened in other land form units, the sum of the percentages of vegetation types in some land form units is not always 100%.
The last things that are not represented well in this matrix are the presence of vegetation type 2A on plateau's, this should be 99%, and the absence of vegetation type 7 in the plains, this should be a presence of 10%.

Table 6.1: Contigency matrix of the presence of vegetation types in land form units (in %), constructed with the relevé data.

	1	2A	2B	3	4	5	6	7	8A	8B
HILL	100									
PLATEAU		71				14				
ERODED IND. CAP		70			20	10				
UPPER SLOPE					100					
MIDDLE SLOPE CR.			20		70					
MIDDLE SLOPE N-CR.		4	9	13	26	17	4	13		
LOWER SLOPE ER.						100				
LOWER SLOPE N-ER.			3	6		9	14	54		
SMALL VALLEY							30	10		
LARGE VALLEY									67	33
PLAIN							75		25	
AEOLIAN COMPLEX			50	25			25			

7 MAP AND DATA RELIABILITY

In this Chapter the methods used to make the maps and the quality (reliability) of the maps will be discussed. Next will be dealt with the methods used for sampling, classification and presentation of the soil and vegetation data.

7.1 The physiographic & erosion map

Variability (related to scale) and reliability, the latter important to determine the usefulness of the maps, of the presented information will be discussed in this Chapter. In Chapter 7.1.1 the variability versus scale will be discussed and in chapter 7.1.2 the reliability in respect to the methods used for map drawing will be discussed.
As explained in Chapter 4.3.1, the erosion map is deduced from the physiographic map. In this sense, all the remarks, concerning variability and reliability of the (physiographic) map, also apply to the erosion map.
In Chapter 7.1.3 the present map will be compared to preliminary results of a similar study done in the province of Bam.

7.1.1 Variability versus scale (aggregation level)

Variability of map information is directly linked to the scale on which the map is drawn. This map was drawn as on a scale of 1 : 100,000, usually known as a reconnaissance level. Literally this means that it is a scale on which one can recognise things. In reality this means that the map is suitable for identification of minor land forms and sometimes land elements. Soil and vegetation data are grouped (classified) into associations for each physiographic unit (also mapping unit). This means that soils are not directly visible on the map, but that a range of soil properties is given for each unit; the same applies for vegetation.
Variability within a map polygon is caused by natural variability within the mapunit and by pollution of incorporated small areas of other units. These incorporated (<0,25 cm²) areas are too small to be distinguished on scale of 1 : 100,000. During field observations the original physiographic name of the site was noted on the observation description. However, on the map, this site was sometimes classified as another physiographic unit, because it was too small to be separately mapped; the physiographic name on the map became the name of the surrounding polygon into which it merged. Making the soil and vegetation associations, only use was being made of field observations, without taking inclusions of other units into account. (Exception is the C31 soil association in which inclusions of certain units are so regular that soil data of these units was incorporated.) Conclusion: the differences in field level (1 : 1) and map level (1 : 100,000) causes variability in reality to be higher than mentioned in the soil and vegetation associations.
This variability in soil properties and vegetation should always be taken into account when using the map. Dominant soil properties as given on the map itself give the idea that soils can be regarded as rather homogeneous. This, of course, is not true. Precaution should therefore be taken when using the soil properties in erosion models, hydrological models or quantitative land evaluation models (QLE).

In Table 5.2.1 is shown units C22 and C32 make up 75% of the mapped area. This leads to the conclusion that these areas are either rather homogeneous or should have been subdivided into more separate units. In the latter case, a distinction could have been made between a non-crusted middle slope with or without an ironstone gravel cover at its surface. The non-eroded lower slope could have been divided into arable and semi-natural vegetated land and/or clayey and sandy soils and/or more or less eroded areas. Since variability in vegetation and soil data seems to be the highest in units C22 and C32, further subdivision probably would have been useful (remark: no statistical analyses have been done to support this).
When comparing the C32-polygons to the total number of polygons, it is striking to see that this number is rather small compared to its relative surface. This leads to the conclusion that the mean area of a C32 polygon is relatively big. This could make further subdivision for this unit very useful without fragmenting the overall Picture to much.
When observing Table 5.2, it is striking to see that most areas have a moderate erosion risk. This is due to the relative scale of the erosion risk indices; the erosion risk is compared to that of its environment.

7.1.2 Reliability in respect to the methods used for map drawing

Another explanation for the relatively large C32 and C22 areas could be their overestimation. Vegetation density was one of the main characteristics on which distinction between different mapping units was made (red colour on September 1988, 4, 3, 2 image). Observations were mainly done in the northern and middle part of the survey area. During field observations the relation between satellite images (colours of the hard copies) and ground truth in this area was established. However, the southern part of the mapped area receives a higher annual precipitation (see Paragraph 2.1). This results in higher vegetation densities that than are identified as non-eroded lower slopes (C32). Studying the map this could apply to the south-eastern corner of the map.
Ironstone gravel or caps were found to be blue on the September 1988, 4, 3, 2 satellite image. In the north-eastern part of the province, in the Birimien, bare strong brown (reddish brown) sandy clay loam soils were found near hills. The colour on the September image of these bare soils strongly resembles those of the ironstone surfaces. Some of these misinterpretations could be corrected after field observations revealed the differences. Still there might be some areas left that are mapped as unit B2 (eroded and/or less developed ironstone caps) instead of unit C1.
Next to colour and morphology also neighbouring areas were used for identification. E.g.: it is assumed that a crusted area (white or very light pink on image September 1988, 4, 3, 2) near a valley (very red with black or dark blue dots on image 4, 3, 2) has the features of an eroded lower slope and not of a crusted middle slope. However, this does not have to be the case. Misinterpretations are therefore possible and are a direct result of the lacking three-dimensional view of satellite images. In case of doubt aerial photographs were used to verify the interpretation.
A different kind of problem was properly geo-referencing the drawn coverage after it had been scanned. As explained co-ordinates were added to the coverage to do so. However, when comparing to the original satellite images some areas were found to have shifted. These deviations differ both in order and direction over the map, but seldom exceed one or two millimeters on the map (100m - 200m). Small errors, in taping together the eight A3

images to construct a composite A0 scan of the full area, have led to these deviations of some of the polygon's UTM-co-ordinates.

7.1.3 A similar study: similar results?

Recently Bunasols was in the process of making a soil map of the province Bam (west of Sanmatenga). During the Séminar BUNASOLS/AB-DLO/INERA from 14-16 march 1995, Nébié et al. presented preliminary results from this study. As in Sanmatenga, the province of Bam is divided into two parts: the northern Antébirimien part and the southern Birimien part. Although the scale used by Bunasols is only 1: 50,000, the physiographic legend is very similar, due to the fact that the Sanmatenga legend is partly deduced from the Bam legend. Their unit "Relief Résiduel" corresponds with the units "Hills", "Plateau" and "Eroded and/or Less Developed Indurated Caps" (mapping units A & B). The slope is also divided into a high, middle and lower slope (Pente supérieure, -moyenne and -inférieure; mapunit C) and their unit "Plaine Alluviale" corresponds with the "Bottomland" (mapping unit D).
Comparing the relative surfaces in the Antébirimien of the major land forms in the Bam province to the overall relative surfaces of the Sanmatenga map, evidently the preliminary results of their study are very similar to the relative surfaces found in Sanmatenga.
In the Bam study unit A & B cover about 9 %. In Sanmatenga this is 10 %. For unit C this is 79 % versus 81 % and for unit D 12 % versus 8 %.
Some of the differences can be explained by the fact that the preliminary results of the Bam province covered only an area of 456.5 ha (513 557 ha was mapped in Sanmatenga). Considering the natural variation, it is also very likely that the Bam landscape is slightly different from the Sanmatenga landscape.
However, there is one striking difference between the two studies. This concerns the minor land forms, higher-, middle- and lower slope, which have a relative surface percentage of respectively 37 %, 26 % and 16 % in the Bam study and 0.2 %, 36 % and 44 %. These differences can partly be explained by the fact that land form units, which consist of small surface areas, are less mapped at a larger scale. The fact that vegetation density was one of the key properties, on which different land forms were distinguished, can have resulted in an overestimation of vegetated areas such as the non-crusted middle slope and the non-eroded lower slope. This is a direct result of working with satellite images, on which vegetation densities are easily recognised and therefore used for mapping.
However, it is more than likely that these differences also result from different interpretations of the terms higher-, middle- and lower slope. These differences in interpretation may have resulted from a field trip done at the early start of the Sanmatenga study in which two Bunasols field experts explained the Bam legend. The field trip was done near Kaya, mainly in the Birimien part of the province. In this geological unit, higher slopes are more pronounced (steeper slope, bare, abundant surface coarse fragments) than in the Antébirimien. This resulted in an underestimation of the upper slope in the Antébirimien in Sanmatenga, because the land form properties like surface coarse fragments and slopes > 2 % only occurred near plateau's and buttes. These areas were too small to map at a 1 : 100,000 scale (instead of 1: 50,000 as in the Bam study), or they were regarded as mapping unit B2. It is also very likely that mapping unit C21, used in the Sanmatenga study, would correspond to an upper slope (Pente supérieure) in the Bam study. But even then the differences in relative surface percentages are striking.

7.2 Soil data

The reliability of the presented soil data depends on the number of observations, the methods used for collecting the data and the way in which the data are processed afterwards to come to a meaningful generalisation (classification) of the data.

As mentioned in Paragraph 4.3.1, the sampling method was preferential and not stratified; more emphasis was placed upon more important or relatively variable land form units. The more variable units were determined by studying satellite images, aerial photographs and the, already finished, field observations. The most important land form units were those which were intensively used for agricultural purposes and/or suffered from severe erosion. This sampling method makes it more difficult to make a statement about the probability that a certain soil property will occur at a certain place. It is directly linked to the method used for making soil associations.
The observation forms were first grouped per mapping unit after which an association was constructed. The percentages given to each soil type in the association were calculated from their relative number of the observations. To this rule few exceptions were made, e.g. when calculated percentages seemed not realistic due to small numbers of total observations of the soil association). This method suggests random sampling, which was not completely the case. Field observations were taken semi-preferential, by choosing observation areas on the satellite images. Within a observation area, the sampling was random.
However, semi-preferential sampling was found not to be the only problem when generalising soil data. A second one was the relatively low number of observation points compared to the number of mapping units and the number of soil types created to form soil associations; a total number of 132 pits, generalised into 27 soil types. This means an average of slightly less then five observations to describe a soil type. However in some cases only two observations were available (as with mapunit C1).
This is very marginal and once again precaution should be taken when interpreting the soil information. A relative high number of profile descriptions have been taken in the Slope and Bottomland mapping units.
A third remark is to be made on the spatial distribution of soil types within one unit. The descriptions in this report do hardly mention anything about the relation between position within one mapping unit and its soil type. However to a great extent this relation determines the land use possibilities, e.g. at the borders of small valleys soils are often more used for arable cropping than in the centres.
As stated before, the "Birimien" covers a small minority of the total area and observations were mainly made in the Antébirimien (exceptions are mapping units A and C1). With other words the soil, vegetation, land use and erosion risk information can not be extrapolated without losing reliability.

7.3 Vegetation

7.3.1 Field period

One reliability factor is the time of data collection. The relevés were made in the period of October until January. This was at the end of the wet season and the beginning of the dry season. This means that in most land form units some species, that only grow at the start of the rainy season, had already disappeared, which makes the relevés incomplete. In the valleys however some parts were still inundated during the field period. This means that in the valley species, that start emerging after drying up of the valley, are missing in the relevés.

7.3.2 Number of relevés

Another reliability factor can be the number of relevés. For example the reliability of the *Cassia nigricans* and *Blepharis linariifolia* (type 1) is low because the number of relevés in this vegetation type is only three. Besides the fact that this is a very low amount of relevés, an additional fact is that two of these relevés were made in the upper north of the province (steppe zone) and one was made in the upper south (Sahelo-Soudanien zone). The number of relevés is low for several reasons. One reason is that this vegetation type is found on the hills. The usage of hills in the mapping area seemed low (only some extensive grazing) which made this vegetation type less interesting to the principals of the map. Another reason was that the vegetation on the hills was very homogeneous so it was not considered necessary to make more relevés. The last reason was that the hills were far from the residences which made it impossible to spend much time on the hills because other land form units had to be sampled too. Observing the field knowledge it is sure that the vegetation structure is well described, but there might be species differences between the hills in the upper north and the hills in the upper south.
Despite the fact that the number of relevés of the *Mitragyna inermis* and *Deternanthera nodiflora* association is also very low, the reliability of this vegetation type is estimated high. This is possible because this type is very homogeneous. The number of relevés of the *Mitragyna inermis* and *Bractea lata* association could have been higher to make a better distinction between the natural vegetation and the vegetation in orchards.
On the contrary the number of relevés of the *Cenchrus biflorus* and *Brachiaria distichophylla* association is high, while this vegetation type is also quite homogeneous. The reason for this is that this vegetation type is represented by different colours on the RGB image of May. To be sure these different colours were not caused by vegetation a lot of relevés were made.
The number of relevés of the other vegetation types is according to the description of field methods mentioned in Paragraph 4.3.1.

7.4 Erosion risk

As explained in Paragraph 4.3.4, the erosion risk indices are the result of a qualitative evaluation of the field observations.

Estimating erosion risk in this sense is difficult and should only be regarded as indicative. This means that erosion risk indices do not indicate any quantity (ton/ha/yr) of soil loss, but only the amount of soil loss in relation to its agricultural potential.
Defining the agricultural potential is based on the present land use and their restrictions. Since farmers directly depend on the primary production, special attention is given to arable cropping. The land evaluation, which may take place in '95-'96, will indicate better which areas should be regarded as highly potential and which not.
An extra handicap to make the erosion risk map was the lack of observations during the wet season. Erosion features found were left over from the past wet season; tillage, harvesting and trampling of the surface crust hampered clear observations. Run-off and erosion estimates were based on surface characteristics. It is recommended to do observations during the wet season in order to get a better impression of run-off and erosion processes (velocities).
Often, as in this case, one has no option but to rely on the (partly intuitive) judgement of experts who can make a descriptive interpretation of erosion risk in relation to 'the production environment' and translate their interpretation into a qualitative erosion risk class. The fact that different experts interpret aspects of land use systems, e.g. erosion risk, differently explains the poor reproducibility of such assessments (Driessen & Konijn, 1992). Formalization of the interpretation procedure by the use of predefined rating and conversion tables mitigates this but it makes the procedure rigid and imposes restrictions on the expert whose unique local knowledge is the very strength of the approach (Driessen & Konijn, 1992).

8 CONCLUSIONS AND REMARKS

As in every research, errors were made from time to time, computer programs did not always work in the way they should and methods should have been done slightly different when looking back. In this chapter some conclusions and remarks to make live easier for (similar) studies to come.
Also remarks are made to give an impression about possible future developments; for what can the data be used in the future and what interesting subjects related to the field of study have not been dealt with in this report, but are surely worthwhile to look at.

8.1 Satellite images as a bases for mapping

For years remote sensing is a base tool for mapping soil and vegetation. In the last ten years, beside aerial photographs, satellite images are found to be also powerful tools in doing so. Nowadays landscape (related) inventories are more and more done with the aide of satellite images. The images contain a large amount of spectral data (Landsat TM: 7 bands) which can very well be used for analysing the landscape (surface).
Two methods are available for treating (i.e., classifying) remote sensing data with the aid of digital image processing: visual interpretation via image optimisation and computer-assisted classification (Tauer & Humborg, 1992). The first method was used in this study, the latter was subject of study in the reports of Pol (1995) and Steenis (1995); both near Barsalogho.
The decision to use Landsat Thematic Mapper images as a base for the inventory was justified by the scale of the map. Since every pixel measured 30 * 30m, the resolution of the pixels was high enough to give a clear view on a 1 : 100,000 hardcopy (11 pixels per square millimetre). The advantages are that the images are geo-referenced (UTM-coordinates). They could be printed at the map scale and since the images covered the whole area they gave a good overview of the area to be mapped. Further in the field that a very good correlation was found to exist between image colours and landscape features (ground truth). However, the latter conclusion is rather tricky, because the "groundtruth"-criteria used for mapping to a high degree depended on what was visible on the images. Concluding afterwards that the image colours were useful for mapping is therefore almost inevitable.
In this case, the vegetation density was a very important characteristic in determining the land form classification. It was a good tool as vegetation highly depends on water availability (nutrient status was generally low; low spatial variance) since rainfall is limited. For reasons explained in this report, water availability is strongly related to land form properties. However in areas where, due to a higher annual precipitation, vegetation density is higher, the described correlation between vegetation density and land form type does not work that well, especially not for images made at the end of the rainy season.
The vegetation can also be a problem when analysing satellite images. Surface characteristics like sealing and gravel abundancy are not visible when a vegetation cover is present. In case of perennial vegetation this even hampers analysing surface characteristics in the dry season. Due to the existing relation between surface characteristics, vegetation and land form type, this is not too much of a problem when visual interpretation is applied, as was the case. However when using technics like unmixing, as

done by Steenis (1995), this is a serious problem, since e.g. crusts or other vegetation underlying vegetation can not be classified. For this reason, unmixing is only a limited tool in analysing soil and vegetation properties. However, unmixing can be a powerful tool in (quantitatively) analysing and monitoring certain landscape features (Steenis, 1995) specially when applied in combination with visual interpretation of satellite images.
Also supervised classification is limited in analysing landscape related data, since only spectral data are used for analysing and not, for example, properties like morphology (pattern and shape on the image) and neighbouring land form types (van de Pol, 1995).

In this study aerial photographs were interpreted before going into the field. On that bases optimal colour composites of the available bands were created. It is, however, very well possible to make an unsupervised classification of the satellite image before going into the field. In that way, the spectral information (variability) is already grouped by the computer into units which can often very well be correlated to physiographic units.
Also supervised classification is possible before doing field research. In that case the knowledge, gained from the aerial photograph or satellite image interpretation, can be used to define training samples -a group of pixels of which some physiographic properties are known- on the satellite image. The supervised image can in that way be the bases for a physiographic map, which than has to be checked and corrected during field work.

Aerial photograph's are very useful creating a first insight in the landscape, but they can also serve as a source of information for land use and vegetation after the field work. On the physiographic map, land use and vegetation is given as a result of the extrapolation and generalisation of information from sample areas. Aerial photographs can very well be used to support and correct the land use and vegetation extrapolation of information. It is recommended to do so in the future, certainly if recent aerial photographs are available.

8.2 GIS-tools for mapping and data base management

As explained in Chapter 3.2 ArcInfo 7.0 was used. The main reason for working with GIS was that it is a useful tool in making maps. One can simultaneously display the geo-referenced satellite image and the digitised interpretation. This enables you to easily correct and draw lines and polygons. The Arcplot module of the ArcInfo GIS allows you to display a (derived) map and to display and create a legend. Therefore GIS is a useful tool in making, editing and printing map lay-outs on any scale.
A second reason for working with GIS is that it allows you to store, edit, reproduce, enquire (combine) and visualise data. Storing the soil, vegetation land use and erosion risk data can therefore be easily used in future applications, such as land evaluation, determining the place where to implement soil and water conservation measures and creating derived maps (on a different scale). Important is that the use of GIS in future applications can be done in a relatively short time. Storing data and making maps, as in this case, is however the most time-consuming step, when using GIS.
The data can be split in two major groups, the vector data (i.e. points, lines and polygons) and the thematic data (i.e. geology, physiographic, soil-, vegetation, land use and erosion information).
The vector data were obtained by scanning the overlay (interpretation of the satellite images). The advantage of this step is that the relatively time-consuming digitising of an

interpretation could be skipped. However, it was found out that the quality of the scan was not to our satisfaction. The quality of the scan was mostly depending on the line thickness of the interpretation overlay; lines thinner than 0.2 mm were found to be imperfectly scanned. Improving the quality of the created TIF-file was necessary in order to vector the file. The correction took about 250 man hours. After vectoring the file it was imported into ArcInfo. Here a second correction was needed in order to remove errors. A same amount of hours was needed to do so. Finally, about 250 hours were needed to label the created polygons. Together with the drawing of the satellite interpretation (120 hrs.) and with the writing of an AML-file (100 hrs.) this resulted in a total of 970 hours to create the physiographic map in ArcInfo; more than 4000 polygons and over 30.000 line pieces were drawn. The ordering steps creating a map with use of a GIS are presented in Figure 8.1.

The work could probably have been less time-consuming, when the interpretation would have been digitised. This can be done by scanning the interpretation overlay and using at in combination with the satellite image for digitising on the monitor; in that case the scan does not have to be of superior quality, a normal text scanner can do the job. The second method is by digitising the overlay directly from a digitiser board.
Digitising has the advantage that there is no TIF-file to correct and that errors can be corrected while, and labelling takes place immediately after, digitising the polygon. This means that the total of 750 hours could probably have been done in much less (half?) time. Precaution has to be taken in planning when using GIS (ArcInfo 7.0) as a bases data collection, editing and visualisation.

INTERPRETATION OF SATELLITE IMAGE <120 hours>
↓
SCANNING INTERPRETATION OVERLAY
↓
IMPROVING THE TIF-FILE <250 hours>
↓
IMPORTING THE RASTER TIF-FILE
↓
VECTORISING THE RASTER TIF-FILE
↓
EDITING (REMOVING ERRORS) IN ARC-INFO <250 hours>
↓
LABELLING POLYGONS IN ARC-INFO <250 hours>
↓
WRITING AN AML-FILE <100 hours>
↓
PRINTING MAP

Figure 8.1: The ordering steps in creating a physiographic map using a GIS

Beside from labelling polygons on their physiographic- and erosion risk unit, no data have yet been stored in the GIS. The terrain-, soil- and vegetation data are now stored in dBASE 4.0. It is however possible to convert this data and to store it in the GIS. This can be very useful since different types of data can be stored via their geo-reference. In this way it is possible to draw more accurate conclusions about variability and about the correlation between different data.

Combinations of different types of data can lead to new data. In this respect, GIS can also be a major platform for interdisciplinary studies. Models can be implemented within (tight model) or outside ArcInfo (loose model). Future four-dimensional (data is stored using x-, y-, z-, co-ordinates and time) geographical information systems only increase these possibilities.
A good database management is therefore a bases for land use planning and GIS can be an excellent tool for this. However, GIS can not be a purpose on itself. Gathering information has to correspond with its necessity in future applications, depending on the goals of the project. In co-operation with the users of data, one has not only to determine which data will be collected, but also what the role of GIS should and could be in this.

8.3 General remarks

Since the technique of mapping large areas in short time with satellite images is fairly new, more emphasis should be taken on the variability of the information. Using statistical programs (e.g. SPSS, Surfer) it is possible to quantify the reliability of you method and compare it to other reconnaissance maps made with aerial photographs.
Creating a terrain, soil and vegetation-landuse database in GIS (ArcInfo) would be of great help to state something about the spatial distribution of the collected data. Such a database would be also be an ideal bases for further researches in the area, also for other disciplines of study. The creation and presentation of new information by combining different data (queries) could be done in relatively short times using GIS. This could lead to a better insight (holistic approach) in relations between different disciplines of study. Down- and upscaling of information is easier in a GIS database, since site observations and general information (map units) are both stored. This is an important advantage of GIS, since projects are working on a regional as well as on a village level (scale).
Monitoring (in time) of physiographic properties, can be easily quantified using an GIS and is very important with regard to future developments

When vegetation is as sparse as in the northern part of Sanmatenga the observation forms should be adapted to these circumstances. Many times the coverage of a vegetation layer does not exceed 20%. But there are significant differences between coverages of physiographic units. The best thing to do is changing the amount of coverage classes on the front side of the form where the structure data are noted. Class 2: a coverage of 0-20%, should be split up in four classes of 5% each: 0-5%, 5-10%, 10-15% and 15-20%. Of course the "Key to the vegetation structure" should be adapted to these criteria also.

The description of the land use is only a rough impression. The first reason for this is the type of land use. In case of pasture the problem is that the herds are moving form the north to the south every year. So being there only three months of a year is not enough time to gain enough insight in how much is grazed, and were grazing takes place. In case of agriculture the problem is that people practise shifting cultivation. In fact we did not experience any form of shifting cultivation. It seemed that all good soils were in use. Anyway, both types of land use need deeper research. Because of the high variability in climate and landuse they cannot simply be mapped, by only monitoring the land use three months. At least the following three things are needed to do a proper research after land use:

1. Time, it is important so to find out what happens where throughout the year and from year to year (especially extremely dry and wet years). This is important as well for pasture as for agriculture.
2. An interpreter, to ask questions to herdsman and farmers concerning the land use. This gains more insight in the specific use of the several land form units and the spatial variance of it. In this way information can be collected concerning the crop patterns and cattle tracks.
3. Literature research, if available literature can supply detailed information concerning the land use in the specific area. Extensive literature research on land use was however not part of our research program, since it was too much time consuming.

An interpreter could also be of help incorporating the traditional Mossi soil classification, as described by Schutjes (1991) in 'Impact des réalisations des mesures antiérosives sur la gestion des terroirs dans la province du Bam au Burkina Faso', in a legend.

In paragraph 7.4 it is pointed out that the actual used interpretation method for evaluating erosion risk could be more formalized when using predefined rating and conversion tables. Ranking different characteristics related to erosion risk makes that the user of the information has a better insight in the importance of certain characteristics in the erosion process in the area. In the future, evaluating erosion risk in that way would better support the need of the user.

A last remarks is one of more practical sense: making augerings in completely dry soils can sometimes be a real problem. When choosing a field work period, one can do this best at the end of the wet season (September-December), since travelling is not hampered too much by the bad condition of tracks (because of heavy rains) and soils are not yet completely dried out.

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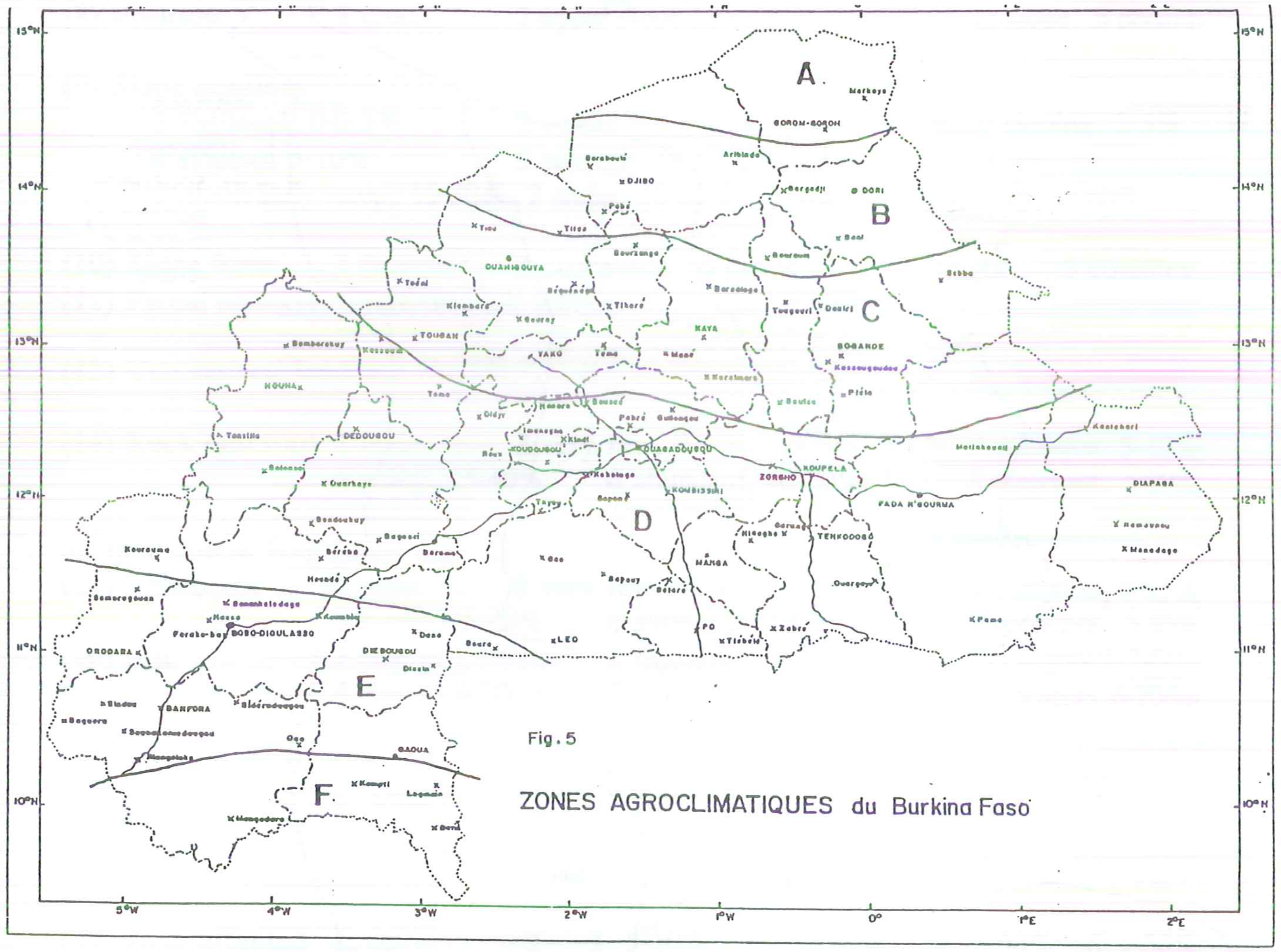
ANNEX 1 MAPS OF SANMATENGA

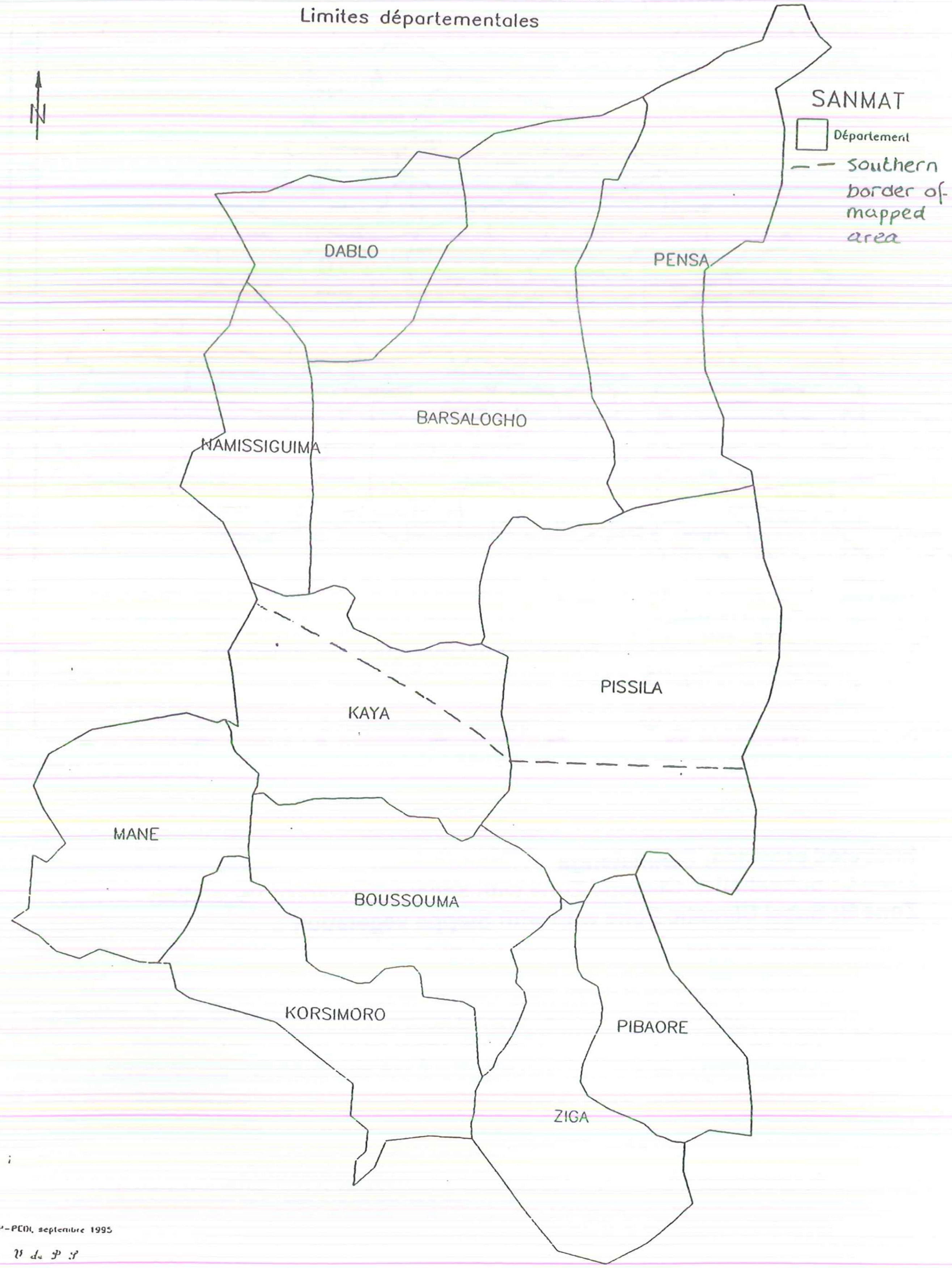
MAP OF SANMATENGA IN BURKINA FASO
(with climatic zones)



Encircled province: Sanmatenga
Zone C: Subsahelien Climatic Zone with Sahelo-Soudanian vegetation
Zone B: Sahel Climatic Zone with with Steppe vegetation

MAP WITH MAPPED PART OF SANMATENGA
(the mapped part is shaded)

PROVINCE DU SANMATENGA
Limites départementales



ANNEX 2

GENERAL SOIL INFORMATION Profile no. Date

(1) Autors (4) Elevation m

(2/3) Coordinates

(5) Topography 1 flat, 0-2% 2 gently undul., 2-5% 3 undulating, 5-10% 4 rolling, 10-15% 5 hilly, 15-30% 6 steeply dissected, >30%

(6) Landform (7) Land element

(8) Position 1 crest 2 upper slope 3 middle slope 4 lower slope 5 bottom

(9) Slope gradient
1 flat/level, 0-0.5% 2 nearly flat, 0.5-2% 3 gently sloping, 2-5%
4 sloping, 5-10% 5 strongly sloping, 10-15%
6 moderately steep, 15-30% 7 steep, 30-60% 8 very steep, >60%

(10) Slope form 1 straight 2 concave 3 convex 4. straight 5 complex

(11) Parent material (12) Micro top.

(13) Vegetation/ land use

(14) Rock outcrops 1 none 2 very few, 0-2% 3 few, 2-5% 4 common, 5-15% 5 many, 15-40% 6 abundant, 40-80% 7 dominant, >80%

Surface coarse fragments

(15) Abundance 1 none 2 very few 0-2% 3 few,2-5% 4 common, 5-15% 5 many, 15-40% 6 abundant, 40-80 7 dominant, >80%

(16) Size 1 fine gr., 2-6mm 2 medium gr., 6-20mm 3 crse gravel, 2-6cm 4 stones, 6-20cm 5 boulders, 20-60cm 6 l. bolders, 6-20dm

(17) Erosion deposition 1 none 2 water erosion 3 water deposition 4 wind erosion 5 wind deposition 6 mass movement

(18) Types 1 sheet 2 rill 3 gully

(19) Area affected 1 0% 2 0-5% 3 5-10% 4 10-25% 5 25-50% 6 >50%

(20) Degree 1 slight 2 moderate 3 severe 4 extreme

Surface sealing

(21) Thickness 1 none 2 <2mm 3 2-5mm 4 5-20mm 5 >20mm

(22) Consistency 1 sl. hard 2 hard 3 hard 4 extr.hard

(23) Surface cracks 0 none 1 fine, <1cm 2 medium, 1-2cm 3 wide, 2-5cm 4 very wide, 5-10 cm 5 extr. wide, >10cm

(24) Drainage class 1 excessively 2 somewhat exc. 3 well 4 mod. well 5 poorly

(25) Internal drainage 1 extremely/very slow 2 slow 3 moderately slow 4 moderately rapid 5 rapid 6 very rapid

(26) ~~External drainage~~ 1 ponded 2 neither receiving nor shedding water 3 slow run-off 4 mod. rapid run-off 5 rapid run-off

(27) Flooding 1 yes 2 no

FAO-guidelines (ANNEX 2)

1.7.1 Classes de drainage

Le concept de drainage du sol utilisé dans les Directives pour la Description des Sols de la FAO (1977) basées sur le SSM se rapporte à la fréquence et à la durée des périodes pendant les-quelles le sol n'est pas saturé ou ne l'est que partiellement. Les classes de drainage du sol définies reflètent donc les effets combinés du climat, du paysage et du sol. Les

précipitations, l'infiltration, la perméabilité du sol, le taux d'infiltration en surface, le mouvement interne vertical et latéral de l'eau ainsi que le ruissellement et l'écoulement externe en surface peuvent tous affecter la classe de drainage.

Le drainage du sol est généralement reflété par les couleurs des matériaux du sol, mais des caractères relictes peuvent persister après amélioration naturelle ou artificielle du drainage. La profondeur de la présence et de l'intensité des caractères du gley indique habituellement, mais pas toujours, l'état de drainage du sol; certains matériaux ne développent pas de caractères tranchés de gleyification à cause de leur composition chimique, de leur texture, de leur structure et de leur porosité spécifiques.

Les classes originales de drainage (SSM) sont utiles pour une appréciation rapide des conditions de drainage; cependant, les définitions nécessitent des modifications suivant les différents climats et les conditions culturales. Sept classes sont différenciées et des classes intermédiaires, telles que bien à modérément bien drainé (BM) et imparfaitement ou médiocrement drainé (ID) peuvent également être décrites.

E (E) excessivement drainé: l'eau s'élimine très rapidement du sol. Les sols sont généralement de texture grossière ou sont rocheux, superficiels ou sur pente escarpée.

S (P) quelque peu excessivement drainé: l'eau s'élimine rapidement du sol. Les sols sont généralement sableux et très perméables.

W (B) bien drainé: l'eau s'élimine facilement du sol, mais pas rapidement. Les sols retiennent généralement les quantités optimales d'eau, mais l'humidité n'inhibe pas la croissance des racines pendant des périodes importantes.

M (M) modérément bien drainé: L'eau s'élimine du sol assez lente-ment au cours de certaines périodes de l'année. Les sols sont trempés pour de courtes périodes dans la zone des racines. Ils ont généralement une couche presque imperméable ou reçoivent périodiquement des précipitations importantes.

I (I) assez médiocrement (imparfaitement) drainé: l'eau s'élimine tellement lentement que le sol reste généralement trempé à faible profondeur pendant des périodes importantes. Les sols ont généralement une couche presque imperméable, un niveau phréatique élevé et des apports d'eau par infiltration ou par des précipitations fréquentes.

P (D) médiocrement drainé: l'eau s'élimine tellement lentement que les sols restent le plus souvent trempés à faible profondeur pendant des périodes très importantes. Les sols ont généralement un niveau phréatique peu profond dû habituellement à une couche presque imperméable, à une infiltration ou à des précipitations très fréquentes.

V (T) très médiocrement drainé: l'eau s'élimine tellement lentement que les sols restent trempés à de faibles profondeurs pendant de longues périodes. Les sols ont un niveau phréatique très peu profond et sont généralement dans des positions horizontales ou dans des dépressions ou reçoivent des précipitations très élevées tombant presque tous les jours.

1.6.2 Eléments grossiers en surface

La présence, en surface, d'éléments grossiers de même que ceux qui sont partiellement exposés est décrite en pourcentage de couverture de la surface et en dimensions des éléments. Les classes de présence, en surface, d'éléments grossiers ont été mis en corrélation avec les affleurements rocheux de la façon suivante:

N (O)	aucun	0%		M (N)	nombreux	15 - 40%
V (T)	très peu	0 - 2%		A (A)	abondants	40 - 80%
F (P)	peu	2 - 5%		D (D)	dominants	> 80%
C (C)	communs	5 - 15%				

Les classes granulométriques indiquant les plus grandes dimensions sont les suivantes:

F (F)	gravier fin	0,2 -	0,6 cm
M (M)	gravier moyen	0,6 -	2,0 cm
C (G)	gravier grossier	2 -	6 cm
S (P)	pierres	6 -	20 cm
B (B)	blocs	20 -	60 cm
L (V)	blocs volumineux	60 -	200 cm

Horizon		Colour		Mottling				Texture	Rocks				Structure					Consist				
sym	depth	Dry	Moist																				
B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y

Pores				Cutans			Cementation			Nodules					Roots				Various	Boundary	
1		2													1		2				
Z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u

COLOUR dry (D) moist (M)

MOTTLING
F 1 none 2 very few 0-2%
3 few 2-5% 4 common 5-15%
5 many 15-40% 6 abundant >40%
G 1 very fine <2mm 2 fine 2-6mm
3 medium 6-20mm 4 coarse >20mm
H 1 faint 2 distinct 3 prominent
I Munsell colour

TEXTURE
J 1 sand 2 loamy sandy 3 sandy loam
4 sandy clay loam 5 loam 6 silt loam
7 silt 8 clay loam 9 silty clay loam
10 sandy clay 11 silty clay 12 clay

ROCKS
L 1 none 2 very few 0-2% 3 few 2-5%
4 common 5-15% 5 many 15-40%
6 abundant 40-80% 7 dominant >80%
M 1 fine, 2-6mm 2 medium gr 6-20mm
3 coarse gr. 2-6cm 4 stones 6-20cm
5 boulders 2-6dm 6 l.boulders >6dm

STRUCTURE
P 1 apedal 2 pedal
Q 1 weak 2 moderate 3 strong
R platy/gran prismatic blocky
1 very fine < 1mm <10 <5
2 fine 1-2 10-20 5-10
3 medium 2-5 20-50 10-20
4 coarse 5-10 50-100 20-50
5 very c >10 >100 >50
S 1 granular 2 blocky 3 prismatic
4 columnar 5 platy 6 parallelepiped
T 1 angular 2 subangular

CONSISTENCE
U 1 loose 2. soft 3. slightly hard 4 hard
5 very hard 6 extremely hard
V 1 loose 2 very friable 3 friable
4 firm 5 very firm 6 extremely firm
W 1 non sticky 2 slightly sticky
3 sticky 4 very sticky
X 1 non plastic 2 slightly plastic
3 plastic 4 very plastic

PORES
Z 1 very fine <0.5mm 2 fine 0.5-2mm
+ 3 medium 2-5mm 4 coarse 5-20
b 5 very coarse >20mm
a 1 none 2 very few 1-2(0)%
+ 3 few 2(0)-5(0)% 4 common 5(0)- 20(0)%
c 5 many >20(0)%

CUTANS
d 1 none 2 very few 0-2% 3 few 2-5
4 common 5-15% 5 many 15-40%
6 abundant 40-80% 7 dominant >80%

CEMENTATION
g 1 broken 2 discontinuous 3 continuous
h 1 none 2 platy 3 vesicular
4 pisolithic 5 nodular
i 1 iron 2 iron-manganese

NODULES
j 1 none 2 very few 0-2% 3 few 2-5%
4 common 5-15% 5 many 15-40%
6 abundant 40-80% 7 dominant >80%
k 1 very fine <2mm 2 fine 2-6mm
3 medium 6-20 mm 4 coarse >20mm
l 1 hard 2 soft
m 1 iron 2 iron manganese
n 1 Munsell colour

ROOTS
o 1 no 2 very few 1-2(0)%
+ 3 few 2(0)-5(0)% 4 common5(0)-20(0)%
q 5 many >20(0)%
p 1 very fine <0.5mm 2 fine 0.5-2mm
r 3 medium 2-5mm 4 coarse >5mm

VARIOUS
s 1 krotovinas 2 termite burrows
3 dung beetles 4 artefacts 5charcoal

BOUNDARY
t 1 abrupt 0-2mm 2 clear 2-5mm
3 gradual 5-15mm 4 diffuse >15mm
u 1 smooth 2 wavy
3 irregular 4 broken

D (D) distinct	Bien que non frappantes, les taches se voient facilement. Hue, chroma et value de la matrice se distinguent aisément de ceux des taches. Ils peuvent varier de 2,5 unités en hue et de quelques unités en chroma et value.
P (P) proéminent	Les taches sont voyantes et la marmorisation est un des caractères saillants de l'horizon. Hue, chroma et value, seul ou en combinaison diffèrent d'au moins quelques unités.

Limite

La limite entre la tache et la matrice est décrite en fonction de l'épaisseur de la zone dans laquelle la transition de couleur peut être localisée en dehors de la tache ou de la matrice.

S	(N)	nette	0	-	0,5 mm
C	(C)	claire	0,5	-	2 mm
D	(D)	diffuse		>	2 mm

Couleur

Il est habituellement suffisant de décrire la couleur des taches en termes généraux correspondant à la Charte Munsell de Couleurs des Sols. Si c'est nécessaire, toutes les notations Munsell peuvent être données. Les noms de couleurs ainsi que les codes suivants sont suggérés (ils sont semblables aux couleurs des nodules minéraux).

WH	(BL)	blanc	YE	(JA)	jaune
RE	(RO)	rouge	RY	(JR)	jaune rougeâtre
RS	(RT)	rougeâtre	GE	(VE)	verdâtre, vert
YR	(RJ)	rouge jaunâtre	GR	(GR)	gris
BR	(BU)	brun	GS	(GT)	grisâtre
BS	(BT)	brunâtre	BU	(BL)	bleu
RB	(BR)	brun rougeâtre	BB	(NB)	noir-bleuâtre
YB	(BJ)	brun jaunâtre	BL	(NO)	noir

2.3 Constituants primaires

Dans cette section, la distribution granulométrique et la nature de la roche primaire et des fragments minéraux sont décrites, subdivisées en (1) fraction terre fine et (2) fraction fragments grossiers.

2.3.1 Texture de la terre fine

Classes granulométriques

Les classes granulométriques de la fraction terre fine (< 2 mm) sont définies ci-dessous. Les noms des classes correspondent le plus exactement possible à la terminologie standard utilisée couramment, y compris dans le système USDA.

argile		<	2 µm
limon fin	2	-	20 µm
limon grossier	20	-	63 µm
sable très fin	63	-	125 µm
sable fin	125	-	200 µm
sable moyen	200	-	630 µm
sable grossier	630	-	1250 µm
sable très grossier	1250	-	2000 µm

Classes texturales

C	(A)	argile	CSL	(LSG)	loam sableux grossier
L	(L)	loam	LS	(SL)	sable loameux
CL	(LA)	loam argileux	LVFS	(STFL)	sable très fin loameux
Si	(Li)	limon	LFS	(SFL)	sable fin loameux
SiC	(ALi)	argile limoneuse	LCS	(SLG)	sable loameux grossier
SiCL	(LALi)	loam argilo-limoneux	VFS	(STF)	sable très fin
SiL	(SiL)	loam limoneux	FS	(SF)	sable fin
SC	(AS)	argile sableuse	MS	(SM)	sable moyen
SCL	(LAS)	loam argilo-sableux	CS	(SG)	sable grossier
SL	(LS)	loam sableux	US	(SNC)	sable, non classé
FSL	(LSF)	loam sableux fin	S	(SNS)	sable, non spécifié

Profondeur

Les classes suivantes de profondeur de la nappe phréatique actuelle dans le sol avec les niveaux minimum et maximum sont suggérées:

N	(N)	non observée			
V	(T)	très superficielle	0	-	25 cm
S	(S)	superficielle	25	-	50 cm
M	(M)	modérément profonde	50	-	100 cm
D	(P)	profonde	100	-	150 cm
E	(E)	très profonde		>	150 cm

La présence de niveaux phréatiques plus profonds peut également être signalée si on la connaît. Les profondeurs suivantes sont suggérées:

S	(S)	nappe phréatique superficielle	2 - 3 m
M	(M)	nappe phréatique modérément profonde	3 - 5 m
D	(P)	nappe phréatique profonde	5 - 8 m
E	(E)	nappe phréatique extrêmement profonde	> 8 m
NK	(NC)	inconnue	

Qualité

Une indication peut également être donnée sur la qualité de la nappe phréatique.

SA	(SL)	saline	PO	(PO)	polluée
BR	(SM)	saumâtre	OX	(OX)	oxygénée
FR	(FR)	fraîche	SG	(SG)	stagnante

La salinité peut aussi être indiquée par une mesure, sur le terrain, de a conductivité électrique de l'eau.

.2.2 Marmorisation

La marmorisation de la matrice du sol est décrite en fonction de abondance, de la taille, du contraste, de la limite et de la couleur. De lus, la forme, la position ou tout autre caractère doivent être signalés. Les couleurs rouille, le long des conduits de racines, ne sont généralement pas considérées comme des taches.

Abondance

L'abondance des taches est décrite en fonction de classes indiquant le pourcentage que les taches occupent sur la surface exposée. Les limites de classes correspondent à celles des nodules minéraux.

N	(O)	aucune			0%
V	(T)	très peu nombreuses	0	-	2%
F	(P)	peu nombreuses	2	-	5%
C	(C)	communes	5	-	15%
M	(N)	nombreuses	15	-	40%
A	(A)	abondantes		>	40%

Lorsque l'abondance des taches ne permet pas de distinguer la couleur unique de la matrice, les couleurs prédominantes doivent être déterminées et introduites comme couleurs de la matrice du sol.

Dimension

Les classes suivantes sont utilisées pour indiquer les diamètres approximatifs des taches individuelles. Ces classes correspondent aux classes de dimension des nodules minéraux.

V	(T)	très fines		<	2 mm
F	(F)	fines	2	-	6 mm
M	(M)	moyennes	6	-	20 mm
C	(G)	grossières		>	20 mm

Contraste

Le contraste de couleur entre les taches et la matrice du sol peut être décrit de la manière suivante:

F (F) faible	Les taches ne sont évidentes qu'après examen attentif. Les couleurs du sol,en ce qui concerne la matrice et les taches,sont très proches relativement aux hues, chromas et values.

2.6.3 Nodules minéraux

Les nodules minéraux couvrent une grande variété de concentrations de substances non organiques amorphes, cristallines et microcristallines. Des transitions graduelles existent avec les taches dont certaines peuvent être considérées comme des formes tendres de nodules. Les nodules minéraux sont décrits suivant leur abondance, leur type, leur dimension, leur forme, leur dureté, leur nature et leur couleur.

Abondance (en volume)

N	(O)	aucun			0 %
V	(T)	très peu	0	-	2 %
F	(P)	peu	2	-	5 %
C	(C)	communs	5	-	15 %
M	(N)	nombreux	15	-	40 %
A	(A)	abondants	40	-	80 %
D	(D)	dominants		>	80 %

Type

T (T) Cristal

C (C) Concrétion: amas isolé à structure interne concentrique généralement cimenté.

S (S) Ségrégation tendre (ou accumulation tendre): diffère de la masse environnante par la couleur et la composition mais n'est pas facilement séparable comme masse isolée.

N (N) Nodule: amas isolé sans organisation interne.

R (R) Fragment rocheux résiduel: amas imprégné isolé montrant encore la structure de la roche.

Dimension

V	(T)	très fins	< 2 mm	M	(M)	moyens	6 - 20 mm
F	(F)	fins	2 - 6 mm	C	(G)	grossiers	> 20 mm

Forme

R	(R)	arrondie (sphérique)	I	(I)	irrégulière
E	(E)	étirée	A	(A)	angulaire
F	(P)	plate			

Dureté

H (D) Dur: le nodule ne peut être brisé entre les doigts.
S (T) Tendre: le nodule peut être brisé entre l'index et l'ongle du pouce.
B (B) A la fois dur et tendre.

Nature

Les nodules minéraux sont décrits suivant leur composition ou la substance qui les imprègne. Quelques exemples:

K	(K)	carbonates (calcaires)	S	(S)	soufre (sulfureux)
KQ	(X)	carbonates-silice	Q	(Q)	silice (siliceux)
C	(A)	argile (argileux)	F	(F)	fer (ferrugineux)
CS	(S)	argile-sesquioxydes	FM	(FM)	fer-manganèse (sesquioxydes)
GY	(Y)	gypse (gypseux)	M	(M)	manganèse (manganifères)
SA	(L)	sel (salins)	NK	(N)	non connus

Couleur

Les noms suivants de couleur sont généralement suffisants pour désigner la couleur des nodules (semblables aux taches):

WH	(BL)	blancs	YE	(JA)	jaunes
RE	(RO)	rouges	RY	(JR)	jaune rougeâtre
RS	(RT)	rougeâtres	GE	(VE)	verdâtres
YR	(RJ)	rouge jaunâtre	GR	(GR)	gris
BR	(BU)	bruns	GS	(GT)	grisâtres
BS	(BT)	brunâtres	BU	(BL)	bleus

ANNEX 3 FORM FOR DETAILED VEGETATION DESCRIPTION

DATE	CO-ORD.UTM
PLOTNR	CO-ORD.IMAGE
PLOTSIZE	PHOTONR.
TRACKNR	COLOUR MAY IMAGE
LEGEND CODE	COLOUR SEPT.IMAGE

FINAL CLASSIFICATION (not in field)

Final legend code	
Final physiographic unit	
Soil	
Vegetation composition structure	
Landuse	

(1) Type landcover 1 forest 2 semi-natural vegetation 3 arable land 4 garden/vegetables

TREE LAYER woody species larger than 5 metres
(2) Coverage (%) 1 0 2 0-20 3 20-40 4 40-60 5 60-80 6 80-100
(3) Av. height
(4) Dominant species

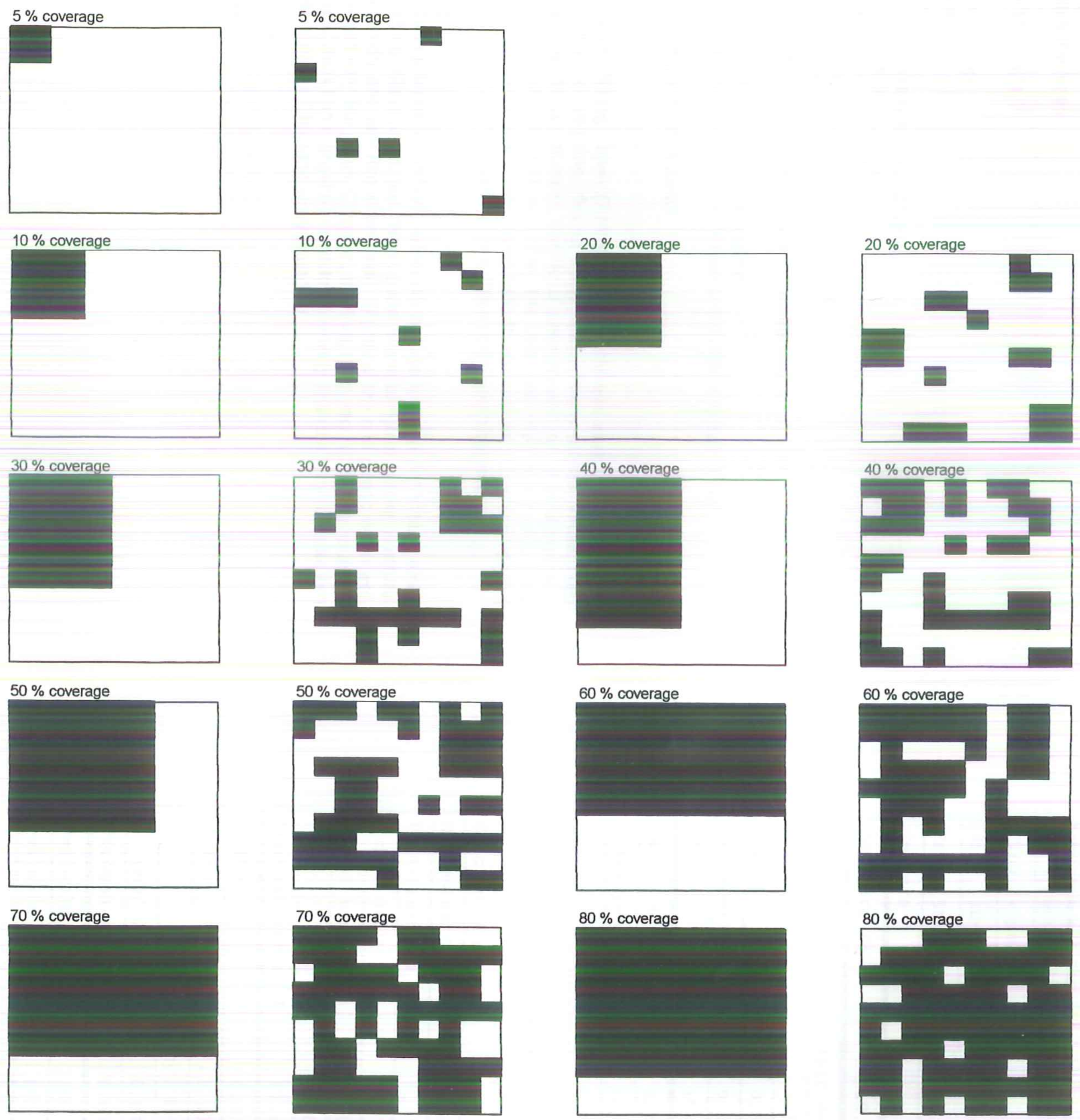
HIGH SHRUB LAYER woody species between 2 en 5 metres length
(6) Coverage (%) 1 0 2 0-20 3 20-40 4 40-60 5 60-80 6 80-100
(7) Av. height
(8) Dominant species

LOW SHRUB LAYER woody species smaller than 2 metres
(9) Coverage (%) 1 0 2 0-20 3 20-40 4 40-60 5 60-80 6 80-100
(10) Av. height
(11) Dominant species

HERB LAYER
(12) Coverage (%) 1 0 2 0-20 3 20-40 4 40-60 5 60-80 6 80-100
(13) Coverage perennial grasses (%)
1 0 2 0-20 3 20-40 4 40-60 5 60-80 6 80-100
(14) Coverage annual grasses (%)
1 0 2 0-20 3 20-40 4 40-60 5 60-80 6 80-100
(15) Coverage perennial herbs and climbers (%)
1 0 2 0-20 3 20-40 4 40-60 5 60-80 6 80-100
(16) Coverage annual herbs and climbers (%)
1 0 2 0-20 3 20-40 4 40-60 5 60-80 6 80-100
(17) Herb layer 1 under tree 2 not under tree 3 no difference
(18) Av. height
(19) Dominant species
(20) Real coverage of soil by total vegetation (%)
1 0 2 0-20 3 20-40 4 40-60 5 60-80 6 80-100

NR	SPECIES	1	2	3	4	Type coverage
						1. Abundancy:
						1. cov. < 5%,1-2 species
						2. cov. < 5%,2-4 species
						3. cov. < 5%,4-7 species
						4. cov. < 5%, > 7 species
						5. cov. between 5- 10%
						6. cov. between 10- 20%
						7. cov. between 20- 30%
						8. cov. between 30- 40%
						9. cov. between 40- 50%
						10. cov. between 50- 60%
						11. cov. between 60- 70%
						12. cov. between 70- 80%
						13. cov. between 80- 90%
						14. cov. between 90-100%
						2. Height (in cm)
						3. Growth stage
						1. vegetative
						2. flowering
						3. fruits
						4. dead
						5. harvested
						4. Use
						1. mixed cropped
						2. mono cropped
						3. grazed
						4. cut
						5. trampeled
						6. burned
						7. other use
						8. no use now

ANNEX 4 EXAMPLES FOR COVERAGE ESTIMATIONS



ANNEX 5 REPRESENTATIVE PROFILES

profile: 33.1

autors: D.Wijnalda & P.v.Asten
date: 4-1-'95
coordinates: 692410 1487377
landform: Hills (A)
landelement: Rock outcrop
topography: almost flat
position: middle slope
slope gradient and form: nearly flat and complex
micro topography: schist at the surface
parent material: schist
vegetation/land use: Acacia, other shrubs and grasses
rock outcrops: few rock outcrops
surface course fragments: very few, fine surface course fragments
erosion deposition: no erosion or deposition
surface sealing: < 2mm slightly hard surface sealing
drainage class: well drained, slow internal drainage and moderately fast run-off.
flooding: no flooding
FAO-UNESCO classification: Eutric leptosol

0-10cm: A-horizon

Sandy clay loam. Strong brown (7.5YR5/6) when dry and dark yellowish brown when moist. Very few, very fine, distinct black mottles. many stones. Weak pedal medium subangular blocky structure. Very hard when dry and very firm when moist. Slightly sticky and plastic when wet. Very few fine and very fine pores. Few, medium, hard, red (10R4/8) and dusky red (10R3/3) iron nodules. Common veryfine and very few course roots. termites burrows. Clear and smooth boundary.

10-25cm: Bcs-horizon

Sandy clay. Strong brown (7.5YR4/6) when dry and dark brown (7.5YR4/4) when moist. No mottling. Abundant stones. Weak pedal fine subangular blocky structure. Very hard when dry and very firm when moist. Slightly sticky and plastic when wet. Very few fine and very fine pores. Common, medium, hard, red (10R4/8) and dusky red 10R3/3 and black iron manganese nodules. few very fine and very few medium roots. termites burrows. Clear and wavy boundary.

25+cm: R-horizon

Schist/Saprolite

Analytical results profile 33.1:

Horizon	A	Bcs	R
Depth (cm)	0-10	10-25	25+
Partical size distribution in % weight			
Clay (<2µm)	17,65	33,33	
Silt (20-50µm)	37,25	23,53	
Sand (50-2000µm)	45,10	43,14	
Texture	L	CL	Schist
Moisture (%)	19,67?	1,95	
Organic matter.			
Total (%)	1,19	0,98	
Carbon C (%)	0,69	0,57	
Nitrogen N (%)	0,07	0,08	
C/N	10	7	
CaCO3 (%) total	0,25	0,50	
K available ppm	123,02	288,84	
P assimilable ppm	1,04	0,42	
Elec. cond. (ms/cm)	0,06	0,02	
Exchangeable bases (méq/100g soil)			
Calcium (Ca^{++})	6,93	10,36	
Magnesium (Mg^{++})	3,64	4,86	
Potassium (K^{+})	0,41	0,10	
Sodium (Na^{+})	0,07	0	
Sum of bases	11,06	15,32	
CEC	12,65	16,87	
Base saturation %	87,4	90,8	
pH H_2O	6,87	7,17	
pH KCl	5,23	5,00	
Total acidity. Exchangeable:			
Al meq/100g	0,04	0,04	
Hydrogen meq/100g	0,02	0,08	
Available Ca ppm	709	1583	
Available Mg ppm	101	424	

profile: 32.3
autors: D.Wijnalda & P.v.Asten
date: 27-1-'95
coordinates: 720345 1475519
landform: Eroded and/or less developed indurated cap (B2)
landelement: butte
topography: flat
position: crest
slope gradient and form: nearly flat convex slope
microtopography: -
parent material: hardened plinthite
vegetation/land use: bare, few grass, schrubs and baobab
rock outcrops: no rock outcrops
surface coarse fragments: abudant and medium sized
erosion/deposition: water erosion
types: sheet
degree: severe
surface sealing: no surface sealing
surface cracks: no surface cracks
drainage class: somewhat excessively : slow internal drainage and rapid run-off
flooding: no flooding

0-5cm: AR-horizon
Loamy sand. Light yellowish brown (10YR6/4) when dry and dark yellowish brown (10YR4/4) when moist. No mottling. Few medium rocks. Slightly hard when dry and friable when moist. Slightly sticky and slightly plastic when wet. Abudant medium hard iron-manganese. Dark reddish brown (2.5YR3/4), red (2.5YR5/8) and black. Abrupt boundary.

5+cm : R-horizon
Hardened plinthite.

profile: 19.4
autors: D.Wijnalda
date: 15-12-'94
coordinates: 744105 1538252
landform: Upper slope (C1)
landelement: bare surface
topography: flat
position: upper slope
slope gradient and form: nearly flat and straight slope
microtopography: flat
parent material: colluvium
vegetation/land use: bare
rock outcrops: none
surface coarse fragments: common boulders
erosion/deposition: water erosion
type: sheet and rill
degree: both moderate; 0-5% (rill) and >50% of the area affected (sheet)
surface sealing: <2 mm hard surface sealing
surface cracks: fine
drainage class: well drained, slow internal drainage and moderatly rapid run off
flooding: no

0-40cm: A-horizon
Sandy clay loam strong brown (7.5YR5/6) when dry and strong brown (7.5YR4/6) when moist. Very few fine distinct yellow (10YR7/8) and black (10YR 0/0) mottles. Very few medium rocks. Consistancy slightly hard when dry and friable when moist, sticky and very plastic when moist. No nodules. Abrupt boundary.

40+ cm:
rock (or ironstone?)

profile: 26.2
autors: D.Wijnalda & P.v.Asten
date: 6-1-'95
coordinates: 686074 1481038
landform: Hills (A)
landelement: footslope of what is probably a basalt hill
topography: hilly
position: footslope
slope gradient and form: gently sloping and concave
micro topography: little depression
parent material: basalt
vegetation/landuse: shrubs, grasses
rock outcrops: no rock outcrops
surface course fragments: very few stones
erosion/deposition: water deposition
surface sealing: < 2mm very hard surface sealing
surface cracks: fine surface cracks
drainage class: moderately well drained, slow internal drainage and moderately fast run-off
flooding: no flooding

0-20cm: A-horizon
Sandy clay loam. Strong brown (7.5YR5/6) when dry and dark brown (7.5YR3/4) when moist. No mottling. No rocks. Very hard when dry and very firm when moist. Sticky and plastic. No nodules. Clear boundary.

20-40cm: Bg-horizon
Sandy clay loam. Strong brown (7.5YR5/6) when dry and strong brown (7.5YR4/6) when moist. Very few fine dis- tinct brownish yellow (10YR6/6) and black mottles. Very few fine quarts rocks. Very hard when dry and very firm when moist. Very sticky and very plastic. Very few fine hard manganese nodules. Abrupt boundary.

40+cm: R-horizon
Rocks

profile: 2.4
autors: D.wijnalda & P.v.Asten
date: 30-10-'94
coordinates: 713540 1482382
landform: Indurated cap, Plateau (B1)
landelement: slope
topography: gently undulating (2-5%)
position: upper slope
slope gradient and form: gently sloping and concave
micro topography: flat
parent material: hardened plinthite, aeloic deposits, ?
vegetation/landuse: grass, shrubs or bare
rock outcrops: no rock outcrops
surface course fragments: common, fine gravel and stones
erosion/deposition: water erosion
types: sheet
degree: slight
surface sealing: 2-5mm slightly hard surface sealing
surface cracks: no surface cracks
drainage class: well drained, moderately slow internal drainage & moderately rapid run-off
flooding: no flooding

0-20cm: A-horizon
Sandy loam. Brown (10YR5/3) when dry and yellowish brown (10YR5/4) when moist. No mottling. No rocks. Hard when dry, friable when moist. Slightly sticky and plastic when wet. Few course pores. No nodules. Very few medium roots. Gradual boundary.

20-40cm: B-horizon
Sandy loam. Yellowish red (5YR5/8) when dry and strong brown (7.5YR5/8) when moist. No mottling. No rocks. Slightly hard when dry, very friable when moist.Slightly sticky and plastic when wet. Few medium sized iron nodules. Abrupt boundary.

40+cm: R-horizon
Hardened plinthite

profile: 12.2
autors: D.Wijnalda & P.v.Asten
date: 23-11-'94
coordinates: 715792 1482399
landform: Crusted Middle Slope (C21)
landelement: small dune (20 cm height)
topography: flat
position: middle slope
slope gradient and form: flat/level straight slope
microtopography: small rise
parent material: ? + eolian deposits
vegetation/land use: grass, small field with "pois de terre"
rock outcrops: no rock outcrops
surface coarse fragments: no surface coarse fragments
erosion deposition: wind deposition
surface sealing: 2-5mm slightly hard surface sealing
surface cracks: no surface cracks
drainage class: well drained, moderate internal drainage and moderate run off
flooding: no flooding
FAO-UNESCO classification: Albic lixisol

0-20cm: 1A-horizon
Sand. Light yellowish brown (10YR6/4) when dry and yellowish brown (10YR5/4) when moist. No mottling. Very few fine rocks. Apedal structure. Soft when dry. Loose when moist. Non sticky and non plastic when wet. Very few medium pores. No nodules. Few very medium roots. Charcoal and krotovinas with material from the 2A-horizon. Abrupt and smooth boundary

20-35cm: 2A-horizon
Sandy loam. Light brownish gray (10YR6/2) when dry and dark grayish brown (10YR4/2) when moist. No mottling. Very few fine rocks. Apedal structure. Hard when dry. Slightly sticky and plastic when wet. Very few medium pores. No nodules. Very few fine roots. Krotovinas. Gradual and smooth boundary.

35-60cm: 2B-horizon
Sandy clay loam. Light yellowish brown (10YR6/4) when dry and yellowish brown (10YR5/4) when moist. Very few very fine faint bright reddish brown mottles. Very few fine rocks. Apedal structure. Hard when dry. Firm when moist. Slightly sticky and plastic when wet. Very few fine pores. No nodules. Very few very fine roots. Charcoal, krotovinas and termite holes. Gradual and smooth boundary.

60-80cm: 2Bg-horizon
Sandy clay. Pink (7.5YR7/4) when dry and reddish yellow(7.5YR6/6) when moist. Common fine faint strong brown (7.5YR5/6) mottles. Very few fine rocks. Morerately strong fine subangular blocky pedal structure. Very hard when dry. Very firm when moist. Sticky and plastic when wet. Very few very fine pores. No nodules. Very few very fine roots. No biological activity found present. Clear and smooth boundary.

80-120cm: 2Bcs-horizon
Sandy clay loam. Very pale brown (10YR7/4) when dry andbrownish yellow (10YR6/6) when moist. No mottling. Very few rocks. Apedal structure. Hard when dry. Friable when moist. Slightly sticky and very plastic when wet. Few fine pores. Abundant few hard iron nodules. Dark brown (7.5YR4/4) from the outside and dark reddish brown (2.5YR3/4), black (N2/0) and light red (2.5YR6/8). Very few fine roots. No biological activity found present.

Analytical results profile 12.2:

Horizon	1A	2A	2B
Depth (cm)	0-20	20-35	35-60
Partical size distribution in % weight			
Clay (<2μm)	7	18	20
Silt (20-50μm)	4	14	10
Sand (50-2000μm)	89	68	69
Texture	S	SL	S(C)L
Organic matter.			
Carbon C (%)	0,1	0,7	0,5
N-NO_3 (cmol/kg)	0	0	0
N-NH_4 (cmol/kg)	0	0	0
N-total (cmol/kg)	0	0	0
Results of $BaCl_2$-extraction (cmol+/kg).			
Calcium (Ca^{++})	0,53	2,67	1,66
Magnesium (Mg^{++})	0,18	0,76	0,67
Potassium (K^+)	0,34	0,10	0,05
Sodium (Na^+)	0,32	0,11	0,09
Results of $CaCl_2$-extraction (cmol+/kg).			
Magnesium (Mg^{++})	0,13	0,68	0,53
Potassium (K^+)	0,02	0,02	0,01
Sodium (Na^+)	0	0,01	0,04
P (mg/100g)	0	0	0
pH (KCl)	5,0	4,6	4,9
CEC (cmol+/kg)	0,2	2,5	1,3

profile: 12.1
autors: D.Wijnalda & P.v.Asten
date: 22-11-'94
coordinates: 715792 1482382
landform: Crusted Middle Slope (C21)
landelement: crust
topography: flat
position: middle slope
slope gradient and form: nearly flat and straight slope
microtopography: flat
parent material: ? (no clear alluvial characteristics)
vegetation/land use: bare
rock outcrops: none
surface coarse fragments: few fine to medium gravel
erosion/deposition: water erosion
type: sheet and gully
degree: both moderate: 0-5% of the area affected by gullies
and >50% of the area affected by sheet erosion
surface sealing: 2-5mm thick hard surface sealing
surface cracks: none
drainage class: (moderately) well drained, very slow internal drainage & moderately rapid run off
flooding: no
FAO-UNESCO classification: Ferralic cambisol

0-3cm: A-horizon
Sandy loam. Very pale brown (10YR7/3) when dry and dark yellowish brown (10YR4/4) when moist. Very few very fine faint reddish yellow (5YR6/8) mottles. No rocks. Weak pedal coarse subangular blocky structure. Very hard when dry. Firm when moist. Slightly sticky and plastic when wet. Common fine pores. No nodules. Very few very fine roots. Wormcasts. Clear and smooth boundary.

3-40cm: Bg-horizon
Sandy loam. Very pale brown (10YR7/4) when dry and dark yellowish brown (10YR4/4) when moist. Few fine faint yellowish red (5YR5/8) mottles. No rocks. Weak pedal medium subangular blocky structure. Hard when dry. Friable when moist. Slightly sticky and plastic when wet. Few fine pores. Few fine hard iron nodules. Very few fine roots. Wormcasts. Clear and smooth boundary.

40-60cm: Bcs1-horizon
Sandy clay loam. Very pale brown (10YR7/4) when dry and brownish yellow (10YR6/6) when moist. Many fine faint yellowish red (5YR5/6) mottles. No rocks. Weak fine subangular pedal structure. Hard when dry. Friable when moist. Slightly sticky and very plastic when wet. Few fine pores. Common medium hard yellowish red (5YR5/6) iron nodules. Very few fine roots. Earthwormcasts. Abrupt and smooth boundary.

60-120cm: Bcs2-horizon
Sandy clay loam. Very pale brown (10YR7/4) when dry and brownish yellow (10YR6/6) when moist. No mottling. No rocks. Apedal structure. Hard when dry. Friable when moist. Slightly sticky and very plastic when wet. Few fine pores. Abundant medium hard iron manganese nodules. Strong brown (7.5YR4/6) at the outside and dark reddish brown (2.5YR3/4), black (N2/0) and light red (2.5Y6/8) from the inside. Very few fine roots. No biological activity found present.

Analytical results profile 12.1:

Horizon	A	Bg	Bcs
Depth (cm)	0-3	3-40	40-60
Partical size distribution in % weight			
Clay (<2μm)	27	26	27
Silt (20-50μm)	18	16	16
Sand (50-2000μm)	55	58	56
Texture	SCL	SCL	SCL
Organic matter.			
Carbon C (%)	0,5	0,5	0,4
N-NO_3 (cmol/kg)	0,0	0,2	0,1
N-NH_4 (cmol/kg)	0,59	0,05	0,05
N-total (cmol/kg)	0,7	0,3	0,2
Results of $BaCl_2$-extraction (cmol+/kg).			
Calcium (Ca^{++})	2,24	2,84	3,51
Magnesium (Mg^{++})	0,74	1,07	0,95
Potassium (K^+)	0,78	0,09	0,12
Sodium (Na^+)	0,24	0,11	0,05
Results of $CaCl_2$-extraction (cmol+/kg).			
Magnesium (Mg^{++})	0,61	0,80	0,80
Potassium (K^+)	0,40	0,05	0,07
Sodium (Na^+)	0,01	0,06	0,04
P (mg/100g)	0	0	0
pH (KCl)	4,8	4,3	4,6
CEC (cmol+/kg)	3,2	5,1	4,0

profile: 22.1
autors: D.Wijnalda & P.v.Asten
date: 17-12-'94
coordinates: 276964 1511227
landform: Pente moyenne croûte (C21)
landelement: crust with cattle tracks
topography: flat
position: middle slope
slope gradient and form: nearly flat and complex
micro topography: flat
parent material: ?
vegetation/land use: bare, grass and shrubs
rock outcrops: no rock outcrops
surface course fragments: very few, fine gravel
erosion deposition: water erosion and wind deposition
types: sheet
degree: slight
surface sealing: < 2mm hard surface sealing
drainage class: moderately well, slow internal drainage and moderately rapid run-off
flooding: no flooding

0-20cm: A-horizon
Sandy clay loam. Strong brown (7.5YR5/8) when dry and strong brown (7.5YR 4/6) when moist. No mottling. No rocks. Very hard when dry, friable when moist. Sticky and plastic when wet. Few, fine, hard, iron manganese nodules.

20-60cm: Bg-horizon
Sandy clay loam. Strong brown (7.5YR5/8) when dry and yellowish red (5YR4/6) when moist. Very few, very fine, distinct black manganese mottles. No rocks. Very hard when dry, friable when moist. Sticky and plastic when wet. Few, fine, hard, iron manganese nodules.

60-70cm: Bcs-horizon
Sandy clay loam. Yellowish red (5YR5/8) when dry and yellowish red (5YR4/6) when moist. Common, fine, distinct red and black mottles. No rocks. Very hard when dry, friable when moist. Sticky and plastic when wet. Many, medium, soft and hard, iron manganese nodules, weak red, red and black.

70+cm: R-horizon
Gravel/Hardened plinthite.

profile: 12.7
autors: P.v.Asten & D. Wijnalda
date: 24-11-'94
coordinates: 7135529 1482131
landform: Pente moyenne croûté (C21)
landelement: crust
topography: flat
position: middle slope
slope gradient and form: straight flat slope
microtopography: flat
parent material: not known
vegetation/land use: grass and shrubbs
rock outcrops: no rock outcrops
surface coarse fragments: no surface coarse fragments
erosion deposition: water erosion
types: rill
degree: moderate and 5-10% of the area affected
surface sealing: 5-20mm slightly hard surface sealing
surface cracks: no surface cracks
drainage class: moderatly well drained: very slow internal drainage and a rapid run-off
flooding: no flooding
FAO-UNESCO classification: Albic lixisol

0-10cm: A-horizon
Sandy clay loam. Light brownish gray (10YR6/2) when dry and dark brown (10YR4/3) when moist. Very few fine distinct yellowish red (5YR5/8) mottles. No rocks. Weak pedal coarse subangular blocky structure. Very hard when dry. Friable when moist. Slightly sticky and plastic when wet. Few fine pores. No nodules. Very few very fine roots. Worm casts and krotovinas. Gradual and irregular boundary.

10-60cm: B-horizon
Sandy clay loam. Reddish yellow (7.5YR6/6) when dry and reddish yellow (7.5YR6/8) when wet. Very few fine faint red (2.5YR5/8) mottles. No rocks. Moderatly pedal medium subangular blocky structure. Hard when dry. Friable when moist. Slightly sticky and plastic when wet. Many very fine pores and few fine pores. No nodules. Very few fine roots. Worm casts, termite activity and krotovinas. Gradual and smooth boundary.

60-120cm: Bg-horizon
Sandy clay loam. Very pale brown (10YR7/4) when dry and reddish yellow (7.5YR6/8) when moist. Common medium distinct red (2.5YR4/8) mottles. Very fine rocks. Weak pedal fine subangular blocky structure. Slightly hard when dry. Friable when moist. Slightly sticky and plastic when wet. Common fine pores. Few fine hard manganese black (N2/) nodules and few fine hard iron manganese dark reddish brown (2.5YR3/4) nodules. Very few fine roots.

Analytical results profile 12.7:

Horizon	A	Bt	Bg
Depth	0-10	10-60	60-120
Partical size distribution in % weight			
Clay (<2µm)	21,75	31,37	29,41
Silt (20-50µm)	9,80	29,41	5,88
Sand (50-2000µm)	68,63	39,22	64,71
Texture	SCL	CL	SCL
Moisture (%)	0,48	0,64	0,59
Organic matter.			
Total (%)	0,94	0,74	0,51
Carbon C (%)	0,54	0,43	0,30
Nitrogen N (%)	0,04	0,04	0,04
C/N	14	11	8
CaCO3 (%) total	0	0	0
K available ppm	112,33	112,33	133,72
P assimilable ppm	1,82	1,25	0,83
Elec. cond. (ms/cm)	0,19	0,22	0,20
Exchangeable bases (méq/100g soil)			
Calcium (Ca^{++})	1,93	2,71	2,43
Magnesium (Mg^{++})	1,22	1,36	0,85
Potassium (K^{+})	0	0	0,02
Sodium (Na^{+})	0	0,04	0
Sum of bases	3,15	4,11	3,30
CEC	4,61	4,96	6,13
Base saturation %	68,4	82,7	53,9
pH H_2O	5,19	5,90	5,40
pH KCl	4,24	4,05	4,46
Total acidity. Exchangeable:			
Al meq/100g	0,16	0,36	0,08
Hydrogen meq/100g	0,16	0,24	0,12
Available Ca ppm	312,80	343,60	397,70
Available Mg ppm	87,20	87,00	121,30

profile: 33.2
autors: D.Wijnalda & P.v.Asten
date: 5-1-'95
coordinates: 693526 1483204
landform: Pente moyenne non-croûté (C22)
landelement: semi-natural vegetated land
topography: flat
position: middle slope
slope gradient and form: flat/level and straight
micro topography: flat
parent material:
vegetation/land use: small trees, shrubs and grasses
rock outcrops: no rock outcrops
surface course fragments: no surface course fragments
erosion deposition: water erosion
type: sheet
degree: slight
surface sealing: < 2mm hard surface sealing
drainage class: moderately well drained, moderately slow internal drainage and slow run-off
flooding: no flooding
FAO-UNESCO classification: Ferric lixisol

0-30cm: A-horizon
Sandy loam. Pale brown (10YR6/3) when dry and dark yellowish brown (10YR4/4) when moist. Very few fine distinct red (2.5YR5/8), reddish yellow (7.5YR7/8) and black mottles. No rocks. Weak pedal fine subangular blocky structure. Hard when dry and friable when moist. Sticky and plastic when wet. Common very fine and very few fine pores. Very few fine hard red (2.5YR4/8) and black nodules. Few very fine and very few medium roots. Activity of termites, ants and worms. Clear and irregular boundary.

30-60cm: Bg-horizon
Sandy clay loam. Reddish yellow (7.5YR6/6) when dry and strong brown (7.5YR5/8) when moist. Common fine distinct red (2.5YR5/8), reddish yellow (7.5YR7/8) and black mottles. No rocks. Moderate pedal medium subangular blocky structure. Hard when dry and friable when moist. Sticky and very plastic when wet. Many very fine and few fine pores. Very few fine hard red (2.5YR4/8) and black nodules. Few very fine and very few fine roots. Activity of termites, ants and worms. Clear and smooth boundary.

60-120cm: Bcs-horizon
Sandy clay. Light reddish brown (5YR6/4) when dry and strong brown (7.5YR5/6) when moist. Many medium distinct (10YR4/6), Light gray (5Y7/1) and black mottles. No rocks. Moderate pedal medium subangular blocky structure. Very hard when dry and friable when moist. Sticky and plastic when wet. Common very fine and very few fine pores. Many fine hard red (10R4/6) and black nodules.
Very few fine roots. Activity of termites.

Analytical results profile 33.2:

Horizon	A	Bg	Bcs
Depth	0-30	30-60	60-120
Partical size distribution in % weight			
Clay (<2μm)	13,37	21,57	41,18
Silt (20-50μm)	17,65	17,65	15,69
Sand (50-2000μm)	68,63	60,78	43,14
Texture	SL	SCL	C
Moisture (%)	0,28	0,42	0,75
Organic matter.			
Total (%)	0,76	0,55	0,44
Carbon C (%)	0,44	0,32	0,25
Nitrogen N (%)	0,04	0,04	0,06
C/N	12	9	4
CaCO3 (%) total			
K available ppm	219,30	192,56	278,14
P assimilable ppm	0,94	0,99	0,47
Elec. cond. (ms/cm)	0,01	0,13	0,12
Exchangeable bases (méq/100g soil)			
Calcium (Ca^{++})	1,79	1,08	4,42
Magnesium (Mg^{++})	0,72	0,56	2,35
Potassium (K^{+})	0,07	0,07	0,14
Sodium (Na^{+})	0,04	0,04	0,07
Sum of bases	2,62	1,74	6,98
CEC	3,54	2,69	8,40
Base saturation %	74,1	64,7	83,1
pH H_2O	6,30	5,80	5,89
pH KCl	4,44	4,05	3,90
Total acidity. Exchangeable:			
Al meq/100g	0,08	0,68	0,76
Hydrogen meq/100g	0,12	0,44	0,56
Available Ca ppm	225,00	168,00	613,00
Available Mg ppm	188,20	54,30	234,80

profile: 12.8
autors: D.Wijnalda & P.v.Asten
coordinates: 7135529 1482131
landform: Pente moyenne non-croûté (C22)
landelement: small sand cover
topography: flat
position: middle slope
slope gradient and form: flat straight slope
microtopography: near crust
parent material: ? + eolian deposit
vegetation/land use: grass and shrubs
rock outcrops: no rock outcrops
surface coarse fragments: no surface coarse fragments
erosion deposition: wind deposition
surface sealing: 2-5cm slightly hard surface sealing
surface cracks: no surface cracks
drainage class: moderatly well drained: moderate internal drainage and moderatly slow run-off
flooding: no flooding
FAO-UNESCO classification: Ferric alisol

0-5cm: 1A-horizon
Sand. Dull yellow orange (10YR7/3) when dry and brown (10YR4/6) when wet. No mottles. No rocks. Apedal structu-re. Loose when dry. Loose when moist. Non sticky and non plastic when wet. No pores. No nodules. Few fine roots. Abrupt and smooth boundary.

5-15cm: 2A-horizon
Sandy loam. Very pale brown (10YR6/3) when dry and dark yellowish brown (10YR4/4) when moist. Very few fine distinct reddish yellow (5YR6/8) mottles. No rocks. Weak pedal fine subangular blocky structure. Very hard when dry. Firm when moist. Slightly sticky and plastic when wet. Many very fine pores and few fine pores. No nodules. Few very fine roots. Worm casts and a lot of biological activity. Clear and irregular boundary.

15-45cm: 2B-horizon
Sandy clay loam. Reddish yellow (7.5YR7/6) when dry and strong brown (7.5YR5/6) when moist. No mottling. No rocks. Moderatly pedal medium subangular blocky structure. Very hard when dry. Firm when moist. Slightly sticky and plastic when wet. Many very fine pores and few fine pores. No nodules. Very few very fine roots. Worm casts and termite activity. Gradual and smooth boundary.

45-120cm: 2Bg-horizon
Sandy clay loam. Pink (7.5YR7/4) when dry and reddish yellow (7.5YR7/6) when moist. Common medium distinct strong brown (7.5YR5/8) mottles. No rocks. Strong pedal medium subangular blocky structure. Hard when dry. Firm when moist. Slightly sticky and plastic when wet. Many very fine pores and few fine pores. Few medium hard red (2.5YR5/6) iron manganese nodules. Very few very fine roots.

Analytical results profile 12.8:

Horizon	1A	2A	2Bt	2Bg
Depth (cm)	0-5	5-15	15-45	45-120
Partical size distribution in % weight				
Clay (<2μm)	1,96	19,61	29,41	29,41
Silt (20-50μm)	0	9,80	3,92	3,92
Sand (50-2000μm)	98,04	70,59	66,67	66,67
Texture	S	SL	SCL	SCL
Moisture (%)	0,05	0,44	0,52	0,75
Organic matter.				
Total (%)	0,35	0,88	0,71	0,51
Carbon C (%)	0,20	0,51	0,41	0,29
Nitrogen N (%)	0,01	0,03	0,02	0.05
C/N	23	16	17	6
CaCO3 (%) total	0	0	0	0
K available ppm	90,93	85,58	85,58	128,37
P assimilable ppm	0,99	1,98	0,83	0,68
Elec. cond. (ms/cm)	0,02	0,03	0,03	0,07
Exchangeable bases (méq/100g soil)				
Calcium (Ca^{++})	0,34	1,46	2,05	3.57
Magnesium (Mg^{++})	0,13	0,72	0,74	2,30
Potassium (K^{+})	0	0	0	0
Sodium (Na^{+})	0	0,04	0	0,08
Sum of bases	0,47	2,22	2,79	5,94
CEC	0,67	5,54	7,03	11,61
Base saturation %	70,2	40,1	39,7	51,2
pH H_2O	6,30	5,30	5,33	4,95
pH KCl	5,39	3.96	4,05	4,45
Total acidity. Exchangeable:				
Al meq/100g	0,06	0,28	0,32	0,12
Hydrogen meq/100g	0,04	0,22	0,28	0,08
Available Ca ppm	66,60	234,20	220,00	496,50
Available Mg ppm	4,99	53,00	63,30	167,60

profile: 27.1
autors: D.Wijnalda & P.van Asten
date: 10-01-'95
coordinates: 698956 1519045
landform: Pente moyenne non-croûté
landelement: on gras next to field
topography: flat
position: middle slope
slope gradient and form: nearly flat and concave slope
microtopography: flat
parent material: schist
vegetation/land use: little trees, shrubs and fields
rock outcrops: no rock outcrops
erosion/deposition: water erosion and wind deposition
type: sheet
degree: severe
surface sealing: < 2mm thick hard surface sealing
surface cracks: no surface cracks
drainage class: well drained, slow internal drainage and moderately rapid runn-off
flooding: no flooding

0-25cm: A-horizon
Sandy loam. Light yellowish brown (10YR6/4) when dry and dark yellowish brown (10YR4/4) when moist. No mottling. No rocks. Slightly hard when dry and firm when moist. Slightly sticky and slightly plastic when wet. Common fine hard iron dark reddish gray (10R3/1) and red nodules. Clear boundary.

25+ : R-horizon
Hardened plinthite.

profile: 30.4
autors: D.Wijnalda & P.v.Asten
date: 24-1-'95
coordinates: 716220 1476918
landform: Pente moyenne non-croûté (C22)
landelement: peanut-field
topography: gently undulating
position: middle slope
slope gradient and form: gently sloping and concave
micro topography: flat
parent material:
vegetation/land use: peanut, shrubs
rock outcrops: no rock outcrops
surface course fragments: no surface course fragments
erosion deposition: wind deposition
surface sealing: no surface sealing
drainage class: somewhat excessively: moderately rapid inter nal drainage and moderately rapid run-off
flooding: no flooding

0-20cm: A-horizon
Loamy sand. Strong brown (7.5YR4/6) when dry) and dark brown (7.5YR3/4) when moist. No mottling. No rocks. Slightly hard when dry. Slightly sticky and non plastic when wet. No nodules. Clear boundary.

20-40cm: B-horizon
Sandy loam. Strong brown (7.5YR4/6) when dry) and dark brown (7.5YR3/4) when moist. Very few, fine, distinct, manganese mottles. No rocks. Hard when dry. Sticky and plastic when wet. Very few, fine, hard, manganese nodules.

40-70cm: Bg-horizon
Sandy loam. Strong brown (7.5YR5/6) when dry and strong brown (7.5YR4/6) when moist. Very few, very fine, distinct, red (2.5YR5/8) mottles. No rocks. Hard when dry. Sticky and plastic when wet. Very few, fine, hard, manganese nodules.

70-90cm: Bcs-horizon
Sandy clay loam. Strong brown (7.5YR4/6) when dry and dark brown (7.5YR4/4) when moist. Few, fine, distinct, black, red (2.5YR4/8) and brownish yellow (10YR6/8) mottles.No rocks. Hard when dry. Sticky and plastic when wet. Many, medium, hard and soft manganese nodules.

90+cm: R-horizon
Gravel/hardened plinthite

profile: 13.5
autors: D.Wijnalda & P.v.Asten
date: 1-12-'94
coordinates: 697665 1516163
landform: Pente moyenne non-croûté
landelement: transition to B2
topography: flat
position: middle slope
slope gradient and form: nearly flat complex slope
microtopography: depression
parent material: ?
vegetation/land use: sorghum, grass, shrubs or bare
rock outcrops: no rock outcrops
surface coarse fragments: very few fine gravel in field upto common fine gravel on the crust
erosion/deposition: water erosion
types: sheet
degree: slight
surface sealing: <2mm hard surface sealing
surface cracks: no surface cracks
drainage class: well drained; moderatly slow internal drainage and moderatly rapid run-off
flooding: no flooding
FAO-UNESCO classification: Eutric leptosol

0-25cm: A-horizon
Sandy clay loam. Reddish yellow (7.5YR6/6) when dry and strong brown (7.5YR5/6) when moist. No mottling. No rocks. Moderatly pedal medium subangular blocky structure. Very hard when dry. Friable when moist. Sticky and plastic when wet. Few very fine pores and very few fine pores. Very few fine hard iron nodules. Few very fine roots. Termite activity and worm casts. Clear and wavy boundary

25-50cm: B-horizon
Sandy clay loam. Reddish yellow (7.5YR6/6) when dry and strong brown (7.5YR5/6) when moist. No mottling.Few quartz rocks. Weak pedal very fine subangular blocky structure. Hard when dry.Friable when moist. Sticky and plastic when wet. Very few very fine pores and very few fine pores. Dominant hard iron nodules.Very few very fine roots. Few worm casts. Clear and smooth boundary

50+cm: R-horizon
Hardened plinthite

Analytical results profile 13.5:

Horizon	A	Bcs	R
Depth	0-25	25-50	50+
Partical size distribution in % weight			
Clay (<2μm)	27,45		
Silt (20-50μm)	17,65		
Sand (50-2000μm)	54,90		
Texture	SCL	SCL	Hardened plinthite
Moisture (%)	0,60		
Organic matter.			
Total (%)	0,74		
Carbon C (%)	0,43		
Nitrogen N (%)	0,06		
C/N	7		
CaCO3 (%) total	0,38		
K available ppm	123,02		
P assimilable ppm	27,61		
Elec. cond. (ms/cm)	0,09		
Exchangeable bases (méq/100g soil)			
Calcium (Ca^{++})	5,50		
Magnesium (Mg^{++})	0,77		
Potassium (K^{+})	0,44		
Sodium (Na^{+})	0,25		
Sum of bases	6,96		
CEC	8,69		
Base saturation %	80,1		
pH H_2O	7,18		
pH KCl	6,98		
Total acidity. Exchangeable:			
Al meq/100g	0,04		
Hydrogen meq/100g	0,04		
Available Ca ppm	400,00		
Available Mg ppm	107,40		

profile: 12.4
autors: D.Wijnalda & P.v.Asten
date: 24-11-'94
coordinates: 7161444 1482185
landform: Pente inférieur non érodée (C32)
landelement:
topography: flat
position: lower slope
slope gradient and form: straight flat slope
microtopography: no micro relief
parent material: not known
vegetation/land use: grass. shrubs and millet
rock outcrops: no rock outcrops
surface coarse fragments: no surface coarse fragments
erosion deposition: water deposition
surface sealing: <2mm slightly hard surface sealing
surface cracks: no surface cracks
drainage class: moderatly well drained: moderatly slow internal drainage and neither receiving nor shedding water
flooding: no flooding
FAO-UNESCO classification: Ferric lixisol

0-20cm: A-horizon
Sandy loam. Brown (10YR5/3) when dry and very dark grayish brown (10YR3/2) when moist. No mottling. No rocks. Weak pedal medium subangular blocky structure. Slightly hard when dry. Friable when moist. Slightly sticky and plastic when wet. Few fine pores. No nodules. Few very fine and fine pores. Worm casts. Clear and smooth boundary.

20-40cm: B-horizon
Sandy clay loam. Dark brown (7.5YR4/4) when moist. No mottling. No rocks. Moderatly pedal medium subangular blocky structure. Hard when dry. Firm when moist. Sticky and plastic when wet. Common fine pores. No nodules. Very few very fine pores. Krotovinas. Abrupt and smooth boundary.

40-130cm: Bcs-horizon
Sandy clay. Yellowish red (5YR5/6) when dry and yellowish red (5YR4/6) when moist. No mottling. No rocks. Apedal structure. Slightly hard when dry. Friable when moist. Slightly sticky and plastic when wet. Very few very fine pores. Dominant coarse hard iron manganese nodules. Dark red (2.5YR3/6), light red (2.5YR6/8), olive yellow (2.5Y6/8) and black (N2). Very few very fine roots.

Analytical results profile 12.4:

Horizon	A	B	Bcs
Depth (cm)	0-20	20-40	40-130
Partical size distribution in % weight			
Clay (<2μm)	15	41	33
Silt (20-50μm)	11	7	12
Sand (50-2000μm)	74	52	55
Texture	SL	SC	SL
Organic matter.			
Carbon C (%)	0,6	0,5	0,3
N-NO_3 (cmol/kg)	0	0	0
N-NH_4 (cmol/kg)	0	0	0
N-total (cmol/kg)	0	0	0
Results of $BaCl_2$-extraction (cmol+/kg).			
Calcium (Ca^{++})	4,04	6,24	4,21
Magnesium (Mg^{++})	1,69	2,88	2,77
Potassium (K^+)	0,23	0,22	0,26
Sodium (Na^+)	0,05	0,10	0,11
Results of $CaCl_2$-extraction (cmol+/kg).			
Magnesium (Mg^{++})	1,27	1,82	1,84
Potassium (K^+)	0,10	0,07	0,11
Sodium (Na^+)	0,01	0,01	0,04
P (mg/100g)	0	0	0
pH (KCl)	5,8	6,0	6,3
CEC (cmol+/kg)	4,3	7,9	6,2

profile: 13.4
autors: D.Wijnalda & L.de Boer
date: 30-11-'94
coordinates: 697497 1516048
landform: Pente inférieur érodée
landelement: crust
topography: flat
position: middle slope
slope gradient and form: flat straight slope
microtopography: flat
parent material: not known
vegetation/land use: shrubs, trees, bare un the crust
rock outcrops: no rock outcrops
surface coarse fragments: very few stones (6-2cm)
erosion deposition: water erosion and wind erosion
types: sheet
area affected: >50%
degree: moderate
surface sealing: 2-5mm hard surface sealing
surface cracks: fine (2mm) surface cracks
drainage class: moderatly well drained: slow internal drainage and moderatly rapid run-off.
flooding: no flooding
FAO-UNESCO classification: Albic lixisol

0-25cm: A-horizon
Sandy clay loam. Dull yellow orange (10YR7/2) when dry and dull yellowish brown (10YR5/4) when moist. No mottling. No rocks. Moderatly pedal medium subangular blocky structure. Very hard when dry. Friable when moist. Slightly sticky and very plastic when wet. Many very fine pores and few fine pores. No roots Termite activity and worm casts. Gradual and irregular boundary.

25-70cm: B-horizon
Sandy clay loam. Very pale brown (10YR7/4) when dry and yellowish brown (10YR5/6) when moist. No mottling. Moderatly pedal fine subangular blocky structure. Very hard when dry. Friable when moist. Slightly sticky and plastic when wet. Many very fine pores and very few fine pores. Very few medium iron manganese nodules. No roots. Termite activity. Clear and wavy boundary.

70-130cm: Bcs-horizon
Sandy clay loam. Yellow (10YR7/8) when dry and brownish yellow (10YR6/8) when moist. No mottling. No Rocks. Weak pedal fine to medium subangular blocky structure. Hard when dry. Friable when moist. Sticky and plastic. Many very fine pores and very few fine pores. Common fine to medium hard iron manganese nodules. No roots. Termite activity.

Analytical results profile 13.4:

Horizon	A	B	Bcs
Depth (cm)	0-20	25-70	70-120
Partical size distribution in % weight			
Clay (<2μm)	25,49	43,13	31,37
Silt (20-50μm)	17,65	5,88	23,53
Sand (50-2000μm)	56,86	50,98	45,10
Texture	SCL	SC	SCL
Moisture (%)	0,68	0,47	0,56
Organic matter.			
Total (%)	1,18	0,69	0,37
Carbon C (%)	0,68	0,40	0,21
Nitrogen N (%)	0,03	0,02	0,01
C/N	26	20	19
CaCO3 (%) total			
K available ppm	230,00	165,81	208,60
P assimilable ppm	1,25	0,47	0,36
Elec. cond. (ms/cm)	0,30	0,09	0,07
Exchangeable bases (méq/100g soil)			
Calcium (Ca^{++})	4,63	4,47	4,62
Magnesium (Mg^{++})	2,11	1,71	1,18
Potassium (K^+)	0,01	0,05	0,05
Sodium (Na^+)	0,08	0,06	0,08
Sum of bases	6,83	6,30	5,93
CEC	11,04	9,17	6,91
Base saturation %	61,8	68,7	85,8
pH H_2O	5,84	5,93	7,14
pH KCl	4,79	4,45	5,59
Total acidity. Exchangeable:			
Al meq/100g	0,04	0,08	0,04
Hydrogen meq/100g	0,08	0,08	0,04
Available Ca ppm	571,00	522,30	520,00
Available Mg ppm	157,80	126,80	72,30

profile: 31.6
autors: D.Wijnalda & P.v.Asten
date: 25-1-'95
coordinates: 730495 1468928
landform: Pente inférieur non-érodée (C32)
landelement: next to field
topography: flat
position: lower slope
slope gradient and form: nearly flat and straight
micro topography: flat
parent material: unknown
vegetation/land use: field, grass, trees
rock outcrops: no rock outcrops
surface course fragments: no surface course fragments
erosion deposition: no erosion
surface sealing: no surface sealing
drainage class: well drained, moderately rapid internal drainage and slow run-off
flooding: no flooding

0-35cm: A-horizon
loamy sand. Light yellowish brown (10YR6/4) when dry and dark yellowish brown (10YR4/4) when moist. No mottling. No rocks. Slightly hard when dry and friable when moist. Slightly sticky and non plastic when wet. No nodules. Clear boundary.

35-80cm: Bg1-horizon
Sandy loam. Brownish yellow (10YR6/6) when dry and yello- wish brown (10YR5/4) when moist. Very few fine distinct dark red (2.5YR3/6) and black mottles. No rocks. Hard when dry and firm when moist. Sticky and plastic when wet. Few very fine hard red (2.5YR5/8) and dark reddish brown (2.5YR3/4) nodules. Clear boundary.

80-90cm: Bg2-horizon
Sandy clay loam. Yellowish brown (10YR5/6) when dry and yellowish brown (10YR5/4) when moist. Few fine distinct red (2.5YR5/8) and black mottles. No rocks. Very hard when dry and firm when moist. Very sticky and very plastic when wet. Common fine hard red (2.5YR5/8), dark reddish gray (10R3/1) and black iron manganese nodules. Clear boundary.

90+ cm: C-horizon
hardened plinthite/gravel

profile: 33.3
autors: D.Wijnalda & P.v.Asten
date: 5-1-'95
coordinates: 690581 1485762
landform: Pente inférieur non-érodée (C32)
landelement: next to path
topography: flat
position: lower slope
slope gradient and form: flat /level and straight
micro topography: flat
parent material: alluvium
vegetation/land use: some trees, shrubs
rock outcrops: no rock outcrops
surface course fragments: no surface course fragments
erosion deposition: no erosion or deposition
surface sealing: < 2mm slightly hard surface sealing
drainage class: moderately well drained, moderately slow internal drainage and neither receiving nor shedding water.
flooding: yes flooding
FAO-UNESCO classification: Ferric luvisol

0-14cm: 1A-horizon
Loamy sand. Light yellowish brown (10YR6/4) when dry and dark yellowish brown (10YR4/4) when moist. No mottling. No rocks. Weak pedal fine subanngular blocky structure. Hard when dry and friable when moist. Slightly sticky and slightly plastic when wet. Common very fine and few fine pores. Very few fine hard dark yellowish brown (10YR3/4) and black iron manganese nodules. Common very fine roots. Termites, crotovina's and ants. Clear and wavy boundary.

14-20cm: 2Ag-horizon
Loamy sand. Light yellowish brown (10YR6/4) when dry and dark yellowish brown (10YR4/4) when moist. Very few very fine distinct Red (2.5YR4/8), yellow (10YR7/8) and black mottles. Few course rocks. Weak pedal fine subangular granular structure. Slightly hard and dry and friable when moist. Slightly sticky and slightly plastic when wet. Few very fine and very few fine pores. Many medium hard dark yellowish brown (10YR3/4) and black iron manganese nodules. Common very fine roots. Termites, crotovina's and ants. Clear and wavy boundary.

20-28cm: Bg1-horizon
Sandy loam. Light yellowish brown (10YR6/4) when dry and dark yellowish brown (10YR4/4) when moist. Very few very fine distinct light red (2.5YR6/8) mottles. No rocks, moderate pedal course subangular blocky structure. Hard when dry and friable when moist. Slightly sticky and slightly plastic when wet. Common very fine and few fine pores. Few fine hard red (2.5YR4/8), dusky red (10R3/4) and black iron manganese nodules. Common very fine roots. Termites, crotovina's and ants. Clear and wavy boundary.

28-50cm: Bg2-horizon
Sandy clay loam. Dark yellowish brown (10YR4/4) when dry and dark brown (10YR4/3) when moist. Very few very fine faint light red (2.5YR6/8), reddish brown (2.5 YR4/4) and black mottles. No rocks. Moderate pedal course subangular blocky

profile: 33.5
autors: D.Wijnalda & P.v.Asten
date: 5-1-'95
coordinates: 692344 1484518
landform: Pente inférieur non-érodée (C32)
landelement: close to gully
topography: flat
position: lower slope
slope gradient and form: flat/level and straight
micro topography: flat
parent material:
vegetation/land use: shrubs, reed
rock outcrops: no rock outcrops
surface course fragments: no surface course fragments
erosion deposition: water erosion
type: gully
area affected: 5-10%
degree: moderate
surface sealing: < 2mm slightly hard
drainage class: moderately well drained, slow internal drainage and slow run-off.
flooding: yes flooding
FAO-UNESCO classification: Ferric lixisol

0-30cm: A-horizon
Sandy loam. Pale brown (10YR6/3) when dry and dark brown (10YR3/3) when moist. Very few fine distinct red (2.5YR5/8) and black mottles. No rocks. Moderate pedal medium subangular blocky structure. Very hard when dry and friable when moist. Sticky and plastic when wet. Many very fine and very few fine pores. Very few fine hard red (2.5YR5/8) and dusky red (10R3/2) iron nodules. Few Very fine and very few fine roots. Termite activity. Abrubt and wavy boundary.

30-120cm: Bcs-horizon
Sandy clay loam. Reddish yellow (7.5YR6/6) when dry and strong brown (7.5YR5/6) when moist. No mottling. No rocks. Apedal Very hard when dry and friable when moist. Sticky and plastic when wet. Dominant medium hard red (10R4/8), dusky red (10R3/3) and black iron manganese nodules. Very few very fine roots.

Analytical results profile 33.5:

Horizon	A	Bcs
Depth (cm)	0-30	30-120
Partical size distribution in % weight		
Clay (<2µm)	21,57	31,37
Silt (20-50µm)	33,33	7,84
Sand (50-2000µm)	45,10	60,78
Texture	L	SCL
Moisture (%)	0,54	0,76
Organic matter.		
Total (%)	1,36	0,85
Carbon C (%)	0,79	0,49
Nitrogen N (%)	0,03	0,02
C/N	24	22
CaCO3 (%) total	0	0
K available ppm	181,86	203,26
P assimilable ppm	0,52	0,31
Elec. cond. (ms/cm)	0,02	0,20
Exchangeable bases (méq/100g soil)		
Calcium (Ca^{++})	2,84	2,99
Magnesium (Mg^{++})	0,71	0,88
Potassium (K^{+})	0,07	0,07
Sodium (Na^{+})	0	0
Sum of bases	3,62	3,93
CEC	4,60	4,92
Base saturation %	78,7	80,0
pH H_2O	6,47	6,57
pH KCl	4,87	4,76
Total acidity. Exchangeable:		
Al meq/100g	0,08	0,08
Hydrogen meq/100g	0,04	0,04
Available Ca ppm	564,00	340,00
Available Mg ppm	51,90	62,50

Analitical results profile 33.3:

Horizon	Bg2	Bg3	Bg4
Depth (cm)	28-50	50-70	70-120
Partical size distribution in % weight			
Clay (<2μm)	27,45	27,45	35,29
Silt (20-50μm)	11,76	7,84	23,53
Sand (50-2000μm)	60,78	64,71	41,18
Texture	SCL	SCL	CL
Moisture (%)	1,12	1,14	1,95
Organic matter.			
Total (%)	1,13	0,67	0,43
Carbon C (%)	0,65	0,39	0,25
Nitrogen N (%)	0,04	0,03	0,02
C/N	17	14	13
CaCO3 (%) total	0	0	1,00
K available ppm	240,70	262,09	363,72
P assimilable ppm	0,47	0,47	0,03
Elec. cond. (ms/cm)	0,02	0,02	0,04
Exchangeable bases (méq/100g soil)			
Calcium (Ca^{++})	8,62	7,53	8,80
Magnesium (Mg^{++})	3,59	2,82	3,15
Potassium (K^{+})	0,12	0,14	0,12
Sodium (Na^{+})	0,07	0,04	0
Sum of bases	12,40	10,52	12,07
CEC	16,99	14,68	13,11
Base saturation %	73,0	71,7	92,1
pH H_2O	6,65	6,65	7,52
pH KCl	4,80	4,82	5,00
Total acidity. Exchangeable:			
Al meq/100g	0,04	0,04	0,08
Hydrogen meq/100g	0,12	0,12	0,08
Available Ca ppm	1300,00	1017,00	1519,00
Available Mg ppm	400,60	243,70	359,90

profile: 2.6
autors: D.Wijnalda & P.v.Asten
date: 30-10-'94
coordinates: 713430 1480750
landform: Pente inférieur non-érodée (C32)
landelement:
topography: flat
position: bottom
slope gradient and form: nearly flat
micro topography: flat
parent material:
vegetation/land use: trees. shrubs and grass
rock outcrops: no rock outcrops
surface course fragments: no surface course fragments
erosion deposition: water deposition
surface sealing: < 2mm slightly hard surface sealing
drainage class: moderately well drained, moderately slow internal drainage and ponded
flooding: no flooding

0-30cm: A-horizon
Loamy sand. Brown (10YR5/3) when dry and dark brown (10YR4/3) when moist. No mottles. Soft when dry and very friable when moist. Slightly sticky and non plastic when wet. No nodules. Gradual boundary.

30-80cm: B-horizon
Sandy clay loam. Reddish yellow (7.5YR6/8) when moist. Friable when moist. Sticky and plastic when wet. No nodules. Gradual boundary.

80-120cm: Bg-horizon
Sandy clay loam. Strong brown (7.5YR5/8) when moist. Many medium distinct red (2.5YR4/8) and black mottles. Firm when moist. Sticky and plastic when wet. No nodules.

structure. Very hard when dry and firm when moist. Sticky and plastic when wet. Common very fine and few fine pores. Few fine hard dusky red (10R3/4) and black iron manganese nodules. Common very fine and very few fine roots. Termites, crotovina's. Gradual and smooth boundary.

50-70cm: Bg3-horizon
Sandy clay loam. Yellowish brown (10YR5/4) when dry and dark yellowish brown (10YR4/4) when moist. Few very fine faint strong brown (7.5YR5/8), yellowish red (5YR5/6) and black mottles. No rocks. Moderate pedal course subangular blocky structure. Very hard when dry and firm when moist. Sticky and plastic when wet. Common very fine and very few fine pores. Common fine hard red (2.5YR4/8), dusky red (10R3/4) and black iron manganese nodules. Few very fine roots. Termites, crotovina's. Clear and wavy boundary.

70-120cm: Bg4-horizon
Sandy clay. Brownish yellow (10YR6/6) when dry and brownish yellow (10YR6/6) when moist. Common fine distinct red (2.5YR5/8), gray (5Y6/1) and black mottles. Very few course rocks. Moderate pedal course subangular blocky structure. Very hard when dry and firm when moist. Very sticky and very plastic when wet. Few very fine and very few fine pores. Common fine hard red (2.5YR4/8), dusky red (10R3/4) and black iron manganese nodules. Very few very fine roots. Termites, crotovina's.

Analitical results profile 33.3:

Horizon	1A	2Ag	Bg1
Depth (cm)	0-14	14-20	20-28
Partical size distribution in % weight			
Clay (<2μm)	7,84	7,84	15,69
Silt (20-50μm)	11,76	1,96	1,96
Sand (50-2000μm)	80,39	90,20	82.35
Texture	LS	S	SL
Moisture (%)	0,63	0,46	0,64
Organic matter.			
Total (%)	0,59	0,47	0,76
Carbon C (%)	0,34	0,27	0,44
Nitrogen N (%)	0,02	0,03	0,02
C/N	16	11	18
CaCO3 (%) total	0	0,50	0
K available ppm	246,05	128,37	197,91
P assimilable ppm	0,94	0,83	0,57
Elec. cond. (ms/cm)	0,01	0,01	0,02
Exchangeable bases (méq/100g soil)			
Calcium (Ca^{++})	2,49	1,84	7.72
Magnesium (Mg^{++})	1,29	1,08	2,03
Potassium (K^{+})	0,12	0,05	0,07
Sodium (Na^{+})	0	0	0
Sum of bases	3,90	2,97	9,82
CEC	6,06	4,86	17,08
Base saturation %	64,4	61,1	57,5
pH H_2O	6,33	6,76	6,55
pH KCl	4,67	5,06	4,83
Total acidity. Exchangeable:			
Al meq/100g	0,12	0,08	0,08
Hydrogen meq/100g	0,04	0,04	0,04
Available Ca ppm	420,00	397,00	531,00
Available Mg ppm	86,60	69,70	141,30

profile: 34.4
autors: A.Fermont & P.v.Asten
date: 4-2-'95
coordinates: 736108 1508676
landform: Pente inférieur non-érodée
landelement:
topography: flat
position: lower slope
slope gradient and form: nearly flat
micro topography: flat
parent material: wind deposition
vegetation/land use: fields, semi-natural
rock outcrops: no rock outcrops
surface course fragments: No surface course fragments
erosion deposition: wind deposition
surface sealing: no surface sealing
drainage class: somewhat excessively, Rapid internal drainage and neither receiving nor shedding water
flooding: no flooding
FAO-UNESCO classification: Chromic cambisol

0-25cm: 1A-horizon
Loamy sand. Strong brown (7.5YR5/8) when dry and strong brown (7.5YR4/6) when wet. No mottling. Weak pedal medium subangular blocky structure. Slightly hard when dry and friable when moist. Slightly sticky and slightly plastic when wet. Common very fine and few medium pores. No nodules. Common very fine and very few fine roots. Krotovina's. Abrubt and smooth boundary.

25-40cm: 2A-horizon
Loamy sand. Strong brown (7.5YR5/6) when dry and strong brown (7.5YR4/6) when wet. No mottling. Weak pedal medium subangular blocky structure. Slightly hard when dry and friable when moist. Slightly sticky and slightly plastic when wet. Common very fine and few fine pores. Very few very fine hard Dusky red(10R3/3) iron nodules. Common very fine and very few fine roots. Krotovina's. Gradual and smooth boundary.

40-75cm: 2B1-horizon
Sandy loam. Strong brown (7.5YR5/8) when dry and strong brown (7.5YR5/6) when wet. No mottling. Moderate pedal medium subangular blocky structure. Slightly hard when dry and friable when moist. Sticky and slightly plastic when wet. Common very fine and common fine pores. Very few very fine hard dusky red (10R3/3) iron nodules. Few very fine and very few fine roots. Krotovina's, charcoal. Gradual and smooth boundary.

75-120cm: B2-horizon
Sandy loam. Brownish yellow (10YR6/8) when dry and yello wish brown (10YR5/8) when wet. No mottling. Moderate pedal medium angular blocky structure. Hard when dry and firm when moist. Sticky and plastic when wet. Common very fine and few fine pores. Very few very fine hard dusky red (10R3/3) iron nodules. Very few very fine and very few fine roots. Krotovina's.

Analytical results profile 34.4:

Horizon	1A	2A	2B1	2B2
Depth (cm)	0-25	25-40	40-75	75-120
Partical size distribution in % weight				
Clay (<2μm)	9,80	11,76	13,73	13,73
Silt (20-50μm)	1,96	1,96	1,96	5,88
Sand (50-2000μm)	88,24	86,27	84,31	80,39
Texture	LS	LS	LS	SL
Moisture (%)	0,35	0,77	0,47	0,60
Organic matter.				
Total (%)	0,41	0,49	0,40	0,38
Carbon C (%)	0,24	0,28	0,23	0,22
Nitrogen N (%)	0,03	0,03	0,03	0,03
C/N	9	10	8	8
CaCO3 (%) total	0	0	0	0
K available ppm	379,77	149,77	203,26	160,47
P assimilable ppm	1,04	0,36	0,36	0,31
Elec. cond. (ms/cm)	0,17	0,14	0,02	0,04
Exchangeable bases (méq/100g soil)				
Calcium (Ca^{++})	2,25	3,83	4,28	5,36
Magnesium (Mg^{++})	1,05	2,27	2,54	2,97
Potassium (K^{+})	0,19	0,05	0,07	0,07
Sodium (Na^{+})	0	0	0	0,14
Sum of bases	3,49	6,15	6,88	8,53
CEC	4,45	8,58	12,19	11,72
Base saturation %	78,5	71,7	56,5	72,8
pH H_2O	6,07	6,48	6,63	6,34
pH KCl	4,00	4,16	4,41	4,41
Total acidity. Exchangeable:				
Al meq/100g	0,16	0,08	0,08	0,04
Hydrogen meq/100g	0,20	0,10	0,10	0,10
Available Ca ppm	272,00	404,00	501,00	559,00
Available Mg ppm	84,30	188,20	224,90	244,50

profile: 13.1
autors: D.Wijnalda & L.de Boer
date: 29-11-'94
coordinates: 697267 1515966
landform: Pente inférieur non-érodée (C32)
landelement: field
topography: gently undulating
position: lower slope
slope gradient and form: nearly flat straight slope
microtopography: flat
parent material: not known
vegetation/land use: trees, shrubs, grass and sorghum
rock outcrops: no rockoutcrops
surface coarse fragments: no surface coarse fragments
erosion deposition: water erosion
type: rill
area affected: 0-5%
surface sealing: no surface sealing
surface cracks: no surface cracks
drainage class: well drained: rapid internal drainage and slow run-off
flooding: no flooding
FAO-UNESCO classification: Ferric alisol

0-65cm: A-horizon
Loamy sand. Reddish yellow (7.5YR6/6) when dry and strong brown (7.5YR5/6) when moist. No mottling. Very few medium rocks. Apedal structure. Loose when dry. Very friable when moist. Slightly sticky and non plastic when wet.Common very fine pores and very few very coarse pores. Very few fine hard black (N2/) iron manganese nodules. Very few very fine roots. Worm casts. Clear and wavy boundary.

65-80cm: B1-horizon
Sandy loam. Yellowish red (5YR5/8) when dry and moist. No mottling. No rocks. Apedal structure. Hard when dry. Hard when moist. Sticky and non plastic. Common very fine pores and very few very coarse pores. Many medium hard iron manganese nodules. Very few very fine roots. Worm casts. Clear and wavy boundary.

80-130cm: B2-horizon
Sandy loam. Yellowish red (5YR5/8) when dry and moist. No mottling. No rocks. Weak pedal fine to medium subangular blocky structure. Slightly hard when dry. Friable when moist. Sticky and slightly plastic when wet. Common very fine pores and very few very coarse pores. Very few fine hard black (N2/) and red iron manganese nodules. Very few very fine roots. Worm casts and ants.

Analytical results profile 13.1:

Horizon	A	B1	B2
Depth (cm)	0-65	65-80	80-120
Partical size distribution in % weight			
Clay (<2μm)	3,92	11,76	17,65
Silt (20-50μm)	0	0	1,96
Sand (50-2000μm)	96,08	88,24	80,39
Texture	S	LS	SL
Moisture (%)	0,16	0,14	0,24
Organic matter.			
Total (%)	0,69	0,49	0,41
Carbon C (%)	0,40	0,28	0,24
Nitrogen N (%)	0,02	0,02	0,02
C/N	18	16	14
CaCO3 (%) total	0	0	0
K available ppm	353,02	192,56	139,07
P assimilable ppm	2,86	2,08	4,06
Elec. cond. (ms/cm)	0,01	0,02	0,01
Exchangeable bases (méq/100g soil)			
Calcium (Ca^{++})	1,79	1,72	1,62
Magnesium (Mg^{++})	0,44	0,88	0,95
Potassium (K^{+})	0,07	0,01	0
Sodium (Na^{+})	0,04	0,08	0,04
Sum of bases	2,34	2,69	2,61
CEC	4,55	4,36	5,58
Base saturation %	51,5	61,7	46,8
pH H_2O	5,92	6,66	6,11
pH KCl	4,43	5,15	4,62
Total acidity. Exchangeable:			
Al meq/100g	0,16	0,04	0,04
Hydrogen meq/100g	0,08	0,04	0,12
Available Ca ppm	127,50	287,00	237,00
Available Mg ppm	8,10	63,40	61,30

profile: 13.3
autors: D.Wijnalda & L.de Boer
date: 30-11-'94
coordinates: 697408 1516065
landform: Pente inférieur non-érodée
landelement: millet field
topography: flat
position: lower slope
slope gradient and form: nearly flat straight slope
microtopography: no microrelief
parent material: not known
vegetation/land use: trees, shrubs, akkertje
rock outcrops: no rock outcrops
surface coarse fragments: very few fine gravel
erosion deposition: water erosion
types: rill
area affected: 0-5%
degree: slight
surface sealing: 2-5mm slightly hard surface sealing
surface cracks: no surface cracks
drainage class: moderatly well drained: morderatly rapid internal drainage and slow run-off
flooding: no flooding
FAO-UNESCO clasification: Chromic luvisol

0-25cm: A-horizon
Sandy loam. Light yellowish brown (10YR6/4) when dry and dark yellowish brown (10YR4/4) when moist. No mottling. No rocks. Moderatly pedal fine subangular blocky structure. Very hard when dry. Friable when moist. Slightly sticky and plactic when wet. Many very fine pores and very few fine pores. No nodules. Very few very fine roots. Termite activity and wormcasts. Clear and wavy boundary.

25-35cm: B1-horizon
Sandy clay loam. Reddish yellow (7.5YR6/6) when dry and strong brown (7.5YR5/6) when moist. No mottling. No rocks. Moderatly pedal fine subangular blocky structure. Very hard when dry. Friable when moist. Slightly sticky and very plastic. Many very fine pores and very few fine pores. Many medium hard red iron manganese nodules. Very few very fine roots. Termite activity and wormcasts. Clear and wavy boundary.

35-115cm: Bg-horizon
Sandy clay loam. Yellow (10YR7/8) when dry and dark yellowish brown (10YR4/6) when moist. Very few fine distinct yellowish red (5YR5/8) mottles. No rocks. Moderatly pedal medium subangular blocky structure. Very hard when dry. Friable when moist. Sticky and very plastic when wet. Very few medium hard iron manganese nodules. Abrupt and wavy boundary.

115-125cm: R-horizon
Hardened plinthite.

Analytical results profile 13.3:

Horizon	A	B	Bg	R
Depth (cm)	0-25	25-35	35-115	115+
Partical size distribution in % weight				
Clay (<2µm)	15,69	21,57	21,57	
Silt (20-50µm)	11,76	5,88	7,84	
Sand (50-2000µm)	78,43	70,59	74,51	
Texture	SL	SCL	SCL	Hardened plinthite
Moisture (%)	0,28	0,61	0,69	
Organic matter.				
Total (%)	0,67	0,52	0,44	
Carbon C (%)	0,39	0,30	0,25	
Nitrogen N (%)	0,03	0,03	0,05	
C/N	14	9	5	
$CaCO_3$ (%) total	0	0	1,25	
K available ppm	331,63	208,60	353,02	
P assimilable ppm	0,99	2,29	1,61	
Elec. cond. (ms/cm)	0,04	0,20	0,09	
Exchangeable bases (méq/100g soil)				
Calcium (Ca^{++})	2,93	3,93	7,55	
Magnesium (Mg^{++})	1,95	1,99	2,61	
Potassium (K^{+})	0,07	0,02	0,05	
Sodium (Na^{+})	0	0,25	0,32	
Sum of bases	4,96	6,19	10,54	
CEC	6,17	6,32	10,63	
Base saturation %	80,4	98,0	99,2	
pH H_2O	6,77	6,85	7,69	
pH KCl	5,58	5,76	7,08	
Total acidity. Exchangeable:				
Al meq/100g	0,04	0,02	0,04	
Hydrogen meq/100g	0,04	0,02	0,02	
Available Ca ppm	381,00	494,00	908,00	
Available Mg ppm	82,10	125,10	206,40	

profile: 12.3
autors: D.Wijnalda & P.v.Asten
date: 24-11-'94
coordinates: 7160947 1482210
landform: Pente inférieur non-érodée (C32)
landelement:
topography: flat
position: lower slope
slope gradient and form: straight and flat slope
microtopography: no micro relief
parent material: not known
vegetation/land use: grass, shrubs, trees and millet
rock outcrops: no rock outcrops
surface coarse fragments: no surface coarse fragments
erosion/deposition: no erosion or deposition
surface sealing: <2mm very hard surface sealing
surface cracks: no surface cracks
drainage class: moderatly well drained: slow internal drainage and a moderatly rapid run off
flooding: no flooding
FAO-UNESCO classification: Ferric luvisol

0-4cm: A-horizon
Sandy loam. Yellowish brown (10YR5/4) when dry and dark yellowish brown (10YR3/4) when moist. No mottling. No rocks. Moderate pedal coarse subangular platy structure. Hard when dry. Friable when moist. Slightly sticky and plastic when wet. Common very fine pores. No nodules. Common very fine roots. Worm casts. Abrupt and smooth boundary.

4-20cm: B-horizon
Sandy clay loam. Dark brown (10YR3/3) when dry and very dark grayish brown (10YR3/2) when moist. No rocks. Moderate pedal medium subangular blocky structure. Hard when dry. Friable when moist. Slightly sticky and plastic. Common very fine pores. No nodules. Few very fine roots. Worm casts. Gradual and irregular boundary.

20-45cm: Bg-horizon
Sandy clay loam. Strong brown (7.5YR4/6) when dry and when moist. Common medium distinct light yellowish brown (10YR6/4) mottles. No rocks. Moderate pedal medium subangular blocky structure. Hard when dry. Friable when moist. Slichtly sticky and plastic. Few very fine pores. No nodules. Very few very fine roots. Krotovinas. Gradual and wavy boundary.

45-130cm: C-horizon
Sandy clay. Yellowish brown (10YR5/8) when moist. Many fine distinct light gray (10YR6/1) mottles. No rocks. Moderate pedal coarse subangular blocky structure. Very hard when dry. Very firm when moist. Slightly sticky and plastic when wet. Very few very fine pores. Few medium hard black (N2/) manganese nodules. Very few very fine roots. Big krotovinas.

Analytical results profile 12.3:

Horizon	A	B	Bg
Depth (cm)	0-4	4-20	20-40
Partical size distribution in % weight			
Clay (<2µm)	25	12	36
Silt (20-50µm)	12	19	8
Sand (50-2000µm)	63	69	57
Texture	SCL	SL	SC
Organic matter.			
Carbon C (%)	0,9	0,5	0,7
$N-NO_3$ (cmol/kg)	0	0	0
$N-NH_4$ (cmol/kg)	0,01	0	0
N-total (cmol/kg)	0	0	0
Results of $BaCl_2$-extraction (cmol+/kg).			
Calcium (Ca^{++})	5,45	9,14	9,17
Magnesium (Mg^{++})	2,08	4,26	4,40
Potassium (K^{+})	0,43	0,14	0,10
Sodium (Na^{+})	0,05	0,12	0,11
Results of $CaCl_2$-extraction (cmol+/kg).			
Magnesium (Mg^{++})	1,49	2,53	2,48
Potassium (K^{+})	0,19	0,03	0,02
Sodium (Na^{+})	0	0,01	0,03
P (mg/100g)	0	0	0
pH (KCl)	5,8	5,3	5,4
CEC (cmol+/kg)	6,5	12,1	10,6

profile: 17.2
autors: D.Wijnalda & P.v.Asten
date: 13-12-'94
coordinates: 736856 1512615
landform: Petit Basfond (D1)
landelement: gully
topography: flat
position: lower slope
slope gradient and form: flat/level
micro topography:
parent material:
vegetation/land use: bare, trees, fields
rock outcrops: no rock outcrops
surface course fragments: very few fine surface course fragments
erosion deposition: water erosion
type: gully
degree: severe
surface sealing: < 2mm slightly hard surface sealing
drainage class: moderately well drained, slow internal drainage and moderately rapid run-off
flooding: no flooding

0-30cm: A-horizon
Sandy loam. Strong brown (7.5YR5/6) when dry and dark brown (7.5YR3/4) when moist. No mottling. Few fine quarts rocks. Very hard when dry and very friable when moist. Sligtly sticky and slightly plastic when wet. No nodules. Clear and broken boundary.

30-70cm: B-horizon
Sandy clay loam. Strong brown (7.5YR5/6) when dry and strong brown (7.5YR4/6) when moist. No mottling. Few fine quarts rocks. Hard when dry and very friable when moist. Sticky and plastic. Many, fine, hard, red (2.5YR) iron and manganese nodules. Diffuse and wavy boundary.

70+ cm: C-horizon
gravel with quarts bands.

profile: 28.4
autors: D.Wijnalda & P.v.Asten
date: 11-1-'95
coordinates: 687737 1509995
landform: Petit Basfond (D1)
landelement:
topography: flat
position: bottom
slope gradient and form: flat/level
micro topography: flat
parent material: alluvium
vegetation/land use: trees, grasses and sorghum
rock outcrops: no rock outcrops
surface course fragments: no surface course fragments
erosion deposition: water deposition
surface sealing: 2-5mm slightly hard surface sealing
drainage class: poorly drained, slow internal drainage and ponded
flooding: yes flooding

0-50cm: A-horizon
Sandy clay. Very pale brown (10YR7/4) when dry and brown (10YR5/3) when moist. Common, fine, distinct, yellowish red (5YR5/8) mottles. No rocks. Very hard when dry and very firm when moist. Very sticky and plastic. No nodules.

50-120cm: Bg-horizon
Sandy clay. Light yellowish brown (10YR6/4) when dry and brown (10YR5/3) when moist. Many, fine, distinct, black and strong brown (7.5YR5/8) mottles also light gray (5Y7/1) reduction mottles. No rocks. Very hard when dry and very firm when moist. Very sticky and plastic. No nodules.

profile: 34.2
autors: A. Fermonnt & P.v.Asten
date: 2-2-'95
coordinates: 737206 1510356
landform: Pente inférieur non-érodée (C32)
landelement: field
topography: flat
position: lowerslope
slope gradient and form: nearly flat and concave
micro topography: flat
parent material: alluvium
vegetation/land use: fields, grains and trees
rock outcrops: no rock outcrops
surface course fragments: no surface course fragments
erosion deposition: no erosion
surface sealing: < 2mm slightly hard surface sealing
drainage class: well drained, moderately slow internaal drainage and slow run-off
flooding: no flooding
FAO-UNESCO classification: Ferric luvisol

0-20cm: A-horizon
Loamy sand. Light yellowish brown (10YR6/4) when dry and dark yellowish brown (10YR4/6) when moist. No mottling. No rocks. Weak pedal medium subangular blocky. Slightly hard when dry and friable when moist. Slightly sticky and slightly plastic when wet. Common very fine and few fine pores. No nodules. Very few very fine and very few medium roots. Many bio-activity.Clear and smooth boundary.

20-50cm: Bg1-horizon
Sandy clay loam. Light yellowish brown (10YR6/4) when dry and dark yellowish brown (10YR4/6) when moist. Very few very fine distinct red (2.5YR4/8) and black mottles. Stones common. Weak pedal course subangular blocky. Hard when dry and firm when moist. Very sticky and plastic when wet. Common very fine and very few fine pores. Very few very fine hard black nodules. Very few very fine roots. Many bio-activity many artefacts. Gradual and smooth boundary.

50-80cm: Bcs-horizon
Sandy clay loam. Yellowish brown (10YR5/6) when dry and dark yellowish brown (10YR4/6) when moist. Common fine distinct red (2.5YR5/8), yellow (10YR7/8) and black mottles. No rocks. Weak pedal medium subangular blocky. Very hard when dry and firm when moist. Very sticky and very plastic when wet. Common very fine and very few fine pores. Few very fine hard and soft red (2.5YR3/4), red (10R5/8) iron nodules. Very few very fine roots. Many bio-activity. Clear and smooth boundary.

80-120cm: Bg2-horizon
Sandy clay. Yellowish red (10YR5/6) when dry and yellowish red (10YR5/8) when moist. Common fine distinct red (2.5YR5/8), yellowish red (10YR5/8) and black mottles. No rocks. Weak pedal medium subangular blocky. Very hard when dry and very firm when moist. Slightly sticky and plastic when wet. Very few very fine and very few fine pores. Very few very fine hard and soft black nodules. Very few very fine roots. Moderate bio-activity.

Analytical results profile 34.2:

Horizon	A	Bg1	Bcs	Bg2
Depth (cm)	0-20	20-50	50-80	80-120
Partical size distribution in % weight				
Clay (<2µm)	9,80	31,37	33,33	33,33
Silt (20-50µm)	11,76	7,84	13,73	19,61
Sand (50-2000µm)	78,43	60,78	52,94	47,06
Texture	SL	SCL	SCL	SCl
Moisture (%)	0,42	1,24	1,22	1,31
Organic matter.				
Total (%)	0,91	0,72	0,55	0,36
Carbon C (%)	0,53	0,42	0,32	0,21
Nitrogen N (%)	0,03	0,03	0,02	0,02
C/N	20	16	13	10
CaCO3 (%) total	0,25	0,25	1,25	1,25
K available ppm	171,16	90,93	123,02	240,70
P assimilable ppm	15,39	83,82	19,55	14,20
Elec. cond. (ms/cm)	0,07	0,11	0,16	0,12
Exchangeable bases (méq/100g soil)				
Calcium (Ca^{++})	10,16	10,92	11,78	10,16
Magnesium (Mg^{++})	2,72	1,85	1,69	2,75
Potassium (K^{+})	0,60	0,29	0,31	0,65
Sodium (Na^{+})	0,11	0,04	0,14	0,14
Sum of bases	13,59	13,10	13,91	13,70
CEC	14,37	15,59	13,70	12,53
Base saturation %	94,5	84,1	101,5	109,3
pH H_2O	7,32	7,42	8,33	8,30
pH KCl	6,03	5,93	7,16	7,21
Total acidity. Exchangeable:				
Al meq/100g	0,02	0,04	0,06	0,02
Hydrogen meq/100g	0,02	0,04	0,02	0,06
Available Ca ppm	443,00	1408,00	1461,00	1142,00
Available Mg ppm	61,10	165,70	135,40	251,20

profile: 33.4
autors: D.Wijnalda & P.v.Asten
date: 5-1-'95
coordinates: 686177 1490572
landform: Grand Basfond (D2)
landelement:
topography: flat
position: bottom
slope gradient and form: flat/level
micro topography: cattle tracks
parent material: alluvium
vegetation/land use: herbs and trees
rock outcrops: no rock outcrops
surface course fragments: no surface course fragments
erosion deposition: water deposition
surface sealing: 2-5mm hard surface sealing
drainage class: poorly drained, slow internal drainage and ponded
flooding: yes flooding
FAO-UNESCO classification: Eutric gleysol/plinthosol

0-45cm: Ag-horizon
Silty clay. Gray (10YR6/1) when dry and dark gray (10YR4/1) when moist. Many, fine, faint, yellowish red (5YR5/8) mottles. No rocks. Moderate pedal medium subangular prismatic structure. Very hard when dry and firm when moist. Sticky and plastic. Many very fine and medium fine pores. No nodules. Very few fine and very fine roots. Gradual and smooth boundary.

45-70cm: Bg1- horizon
Silty clay. Dark gray (10YR4/1) when moist. Many fine distinct yellowish(5YR5/6) red and black mottles. No rocks. Moderate pedal medium subangular prismatic structure. Very hard when dry and firm when moist. Sticky and plastic. Common very fine and Very few fine pores. Very few fine hard yellowish red (5YR5/6) iron and manganese nodules. Very few fine and very fine roots. Gradual and smooth boundary.

70-120cm: Bcs-Horizon
Silty clay. Dark gray (10YR4/1) when moist. Many medium distinct yellowish red(5YR5/6), brownish yellow (10YR6/8)and black mottles. No rocks. Weak pedal fine subangular blocky structure. Very hard when dry and firm when moist. Sticky and plastic. Common very fine and Very few fine pores.Common medium hard yellowish red (5YR5/8), red (2.5YR4/8) iron and black manganese mottles. Very few fine roots.

Analytical results profile 33.4:

Horizon	Ag	Bg	Bcs
Depth	0-45	45-70	70-120
Partical size distribution in % weight			
Clay (<2μm)	58,82	80,39	52,94
Silt (20-50μm)	27,45	13,73	21,57
Sand (50-2000μm)	13,73	5,88	25,49
Texture	C	C	C
Moisture (%)	1,48	1,79	1,32
Organic matter.			
Total (%)	1,91	1,27	0,59
Carbon C (%)	1,11	0,73	0,34
Nitrogen N (%)	0,07	0,08	0,05
C/N	17	9	7
CaCO3 (%) total	0	0	0
K available ppm	385,12	139,07	123,02
P assimilable ppm	0,16	0,21	0,16
Elec. cond. (ms/cm)	0,05	0,02	0,02
Exchangeable bases (méq/100g soil)			
Calcium (Ca^{++})	6,25	7,08	6,28
Magnesium (Mg^{++})	1,75	1,98	1,79
Potassium (K^{+})	0,17	0,36	0,38
Sodium (Na^{+})	0	0,07	0,15
Sum of bases	8,17	9,49	8,59
CEC	10,66	12,08	11,65
Base saturation %	76,7	78,6	73,7
pH H_2O	6,20	6,36	6,57
pH KCl	4,47	4,32	4,70
Total acidity. Exchangeable:			
Al meq/100g	0,08	0,12	0,04
Hydrogen meq/100g	0,08	0,14	0,10
Available Ca ppm	1072,00	1127,00	958,00
Available Mg ppm	155,60	194,70	147,30

profile: 13.2
autors: D.Wijnalda & L.de Boer
date: 29-11-'94
coordinates: 697178 1516010
landform: Petit Basfond (D1)
landelement: 15 meters from gully
topography: flat
position: bottom
slope gradient and form: nearly flat straight slope
microtopography: flat
parent material: not known
vegetation/land use: grass, trees, shrubs
rock outcrops: no rock outcrops
surface coarse fragments: no surface coarse fragments
erosion deposition: water erosion
type: gully
area affected: 5-10%
degree: severe
surface sealing: slightly hard 2-5mm surface sealing
surface cracks: no surface cracks
drainage class: moderatly well drained: moderatly slow internal drainage and moderatly rapid run-off
flooding: no flooding
FAO-UNESCO classification: Chromic luvisol

0-20cm: A-horizon
Sandy loam. Light yellowish brown (10YR6/4) when dry and dark yellowish brown (10YR4/4) when moist. No mottling.No rocks. Weak pedal very fine subangular blocky structure. Very hard when dry. Very friable when moist. Non sticky and slightly plastic when wet. Many very fine pores and few fine pores. Very few hard iron nodules. Few very fine roots. Remnants of termite activity and worm casts. Clear and wavy boundary.

20-120cm: Bg-horizon
Sandy loam. Strong brown (7.5YR5/8) when dry and strong brown (7.5YR4/6) when moist. Very few very fine distinct red (2.5YR5/8) mottles. No rocks. Weak pedal fine subangular blocky structure. Hard when dry. Very friable when moist. Slightly sticky and plastic when wet. Many very fine pores and few fine pores. Few fine hard black (N2/) and red iron manganese nodules. Krotovinas, termite activity and wormcasts.

Analytical results profile 13.2:

Horizon	A	Bg
Depth (cm)	0-20	20-120
Partical size distribution in % weight		
Clay (<2μm)	7,84	15,69
Silt (20-50μm)	15,69	11,76
Sand (50-2000μm)	76,47	72,55
Texture	SL	SL
Moisture (%)	0,07	0,52
Organic matter.		
Total (%)	0,78	0,53
Carbon C (%)	0,45	0,31
Nitrogen N (%)	0,02	0,02
C/N	27	17
CaCO3 (%) total	0	0
K available ppm	213,95	192,56
P assimilable ppm	2,03	0,68
Elec. cond. (ms/cm)	0,05	0,12
Exchangeable bases (méq/100g soil)		
Calcium (Ca^{++})	1,49	4,63
Magnesium (Mg^{++})	0,62	1,19
Potassium (K^{+})	0,05	0,02
Sodium (Na^{+})	0,04	0
Sum of bases	2,20	5,84
CEC	4,93	10,08
Base saturation %	44,6	58,0
pH H_2O	5,42	6,41
pH KCl	4,24	5,53
Total acidity. Exchangeable:		
Al meq/100g	0,16	0,04
Hydrogen meq/100g	0,04	0,04
Available Ca ppm	271,20	445,00
Available Mg ppm	35,80	69,70

profile: 34.3
autors: A.Fermont & P.v.Asten
date: 3-2-95
coordinates: 737401 1510649
landform: Grand Basfond (D2)
landelement:
topography: flat
position: bottom
slope gradient and form: nearly flat
micro topography:
parent material: alluvium
vegetation/land use: bare, trees and vegetable gardens
rock outcrops: no rock outcrops
surface course fragments: no surface course fragments
erosion deposition: water deposition
surface sealing: < 2mm hard surface sealing
drainage class: moderately well drained, slow internal drainage and slow run off.
flooding: yes flooding
FAO-UNESCO classification: Haplic nitisol

0-20cm: A-horizon
Sandy loam. Pale brown (10YR6/3) when dry and dark yellowish brown (10YR4/6) when moist. Common fine faint yellowish red (5YR5/8) mottles. No rocks. Weak pedal course subangular blocky structure. Slightly hard when dry and friable when moist. Slightly sticky and slightly plastic when wet. Common fine and very few medium pores. No nodules. Few very fine roots. Moderately bio-activity. Clear and irregular boundary.

20-40cm: Bg1-horizon
Sandy clay loam. Dark yellowish brown (10YR4/6) when dry and dark yellowish brown (10YR3/6) when moist. Common very few distinct yellowish red (5YR5/8) mottles. No rocks. Moderate pedal course subangular blocky structure. Hard when dry and firm when moist. Sticky and plastic. Common fine and very few medium pores. Very few fine soft manganese nodules. Few very fine roots. Many bio-activity. Clear and irregular boundary.

40-120cm: Bg2-horizon
Sandy clay loam. Brownish yellow (10YR6/8) when dry and yellowish brown (10YR5/6) when moist. Abundant medium distinct black and yellowish red (5YR5/8) mottles. No rocks. Strong pedal medium angular blocky structure.Hard when dry and firm when moist. Sticky and plastic. Common very fine and very few fine pores. Few fine soft manganese nodules. Very few very fine roots. Moderately bio-activity.

Analytical results profile 34.3:

Horizon	A	Bg1	Bg2
Depth (cm)	0-20	20-40	40-120
Partical size distribution in % weight			
Clay (<2μm)	7,84	27,45	31,37
Silt (20-50μm)	29,41	13,73	19,61
Sand (50-2000μm)	62,75	58,82	49.02
Texture	SL	SCL	SCL
Moisture (%)	0,58	0,93	0,80
Organic matter.			
Total (%)	0,97	0,69	0,60
Carbon C (%)	0,56	0,40	0,35
Nitrogen N (%)	0,04	0,04	0,04
C/N	14	11	9
CaCO3 (%) total	0	0	1,00
K available ppm	106,98	117,67	96,28
P assimilable ppm	7,54	2,34	0,78
Elec. cond. (ms/cm)	0,02	0,02	0,02
Exchangeable bases (méq/100g soil)			
Calcium (Ca^{++})	3,59	6,24	6,08
Magnesium (Mg^{++})	1,08	2,00	2,12
Potassium (K^+)	0,38	0,40	0,26
Sodium (Na^+)	0,07	0,21	0,14
Sum of bases	5,12	8,85	8,60
CEC	6,94	10,37	10,18
Base saturation %	73,7	85,3	84,5
pH H_2O	6,29	6,26	6,79
pH KCl	4,17	4,22	4,69
Total acidity. Exchangeable:			
Al meq/100g	0,12	0,08	0,04
Hydrogen meq/100g	0,08	0,12	0,08
Available Ca ppm	372,00	674,00	743,00
Available Mg ppm	77,80	166,40	196,50

profile: 13.7
autors: D.Wijnalda & P.v.Asten
date: 1-12-'94
coordinates: 698448 1517222
landform: Grand Basfond (D2)
landelement: wet vegetation close to gully
topography: flat
position: bottom
slope gradient and form: flat complex slope
microtopography: close to gully
parent material: alluvial
vegetation/land use: grass, shrub, tree
rock outcrops: no rock outcrops
surface coarse fragments: no surface coarse fragments
erosion deposition: water deposition
surface sealing: 2-5mm hard surface sealing
surface cracks: no surface cracks
drainage class: moderatly well drained: moderatly slow internal drainage and ponded
flooding: subject to flooding
FAO-UNESCO classification: Eutric fluvisol

0-40cm: A-horizon
Sandy clay loam. Light yellowish brown (10YR6/4) when dry and dark yellowish brown (10YR4/4) when moist. No mottling. No rocks. Moderatly pedal medium subangular blocky structure. Very hard when dry. Friable when moist. Sticky and plastic. Common very fine pores and few fine pores. No nodules. Common very fine roots and very few medium roots. Krotovinas, worm casts and termite activity. Gradual and smooth boundary.

40-90cm: B-horizon
Sandy clay loam. Light brownish gray (10YR6/2) when dry and dark grayish brown (10YR4/2) when moist. Very few very fine distinct black (N2/) and strong brown (7.5YR5/8) mottles. No rocks. Moderatly pedal medium subangular blocky structure. Very hard when dry. Friable when moist.Slightly sticky and plastic when wet. Few very fine pores and very few fine pores. No nodules. Common very fine roots and very few coarse roots. Charcoal, krotovinas, worms and termite activity. Gradual and smooth boundary.

90-120cm: Bg-horizon
Sandy loam. Brown (10YR5/3) when dry and dark brown (10YR4/3) when moist. Abundant medium faint strong brown (7.5YR5/6) and yellowish red (5YR4/6). No rocks. Weak pedal medium subangular blocky structure. Hard when dry. Very friable when moist. Slightly sticky and plastic when wet. Few very fine pores and few fine pores. Very few fine hard iron nodules. Very few very fine roots and very few medium roots. Krotovinas including hardened worm activity and termite activity.

Analytical results profile 13.7:

Horizon	A	B	Bg
Depth (cm)	0-40	40-90	90-120
Partical size distribution in % weight			
Clay (<2μm)	19,61	19,61	7,84
Silt (20-50μm)	33,33	5,88	5,88
Sand (50-2000μm)	47,06	74,51	86,27
Texture	L	SL	LS
Moisture (%)	0,69	0,80	0,38
Organic matter.			
Total (%)	1,28	0,92	0,49
Carbon C (%)	0,74	0,53	0,29
Nitrogen N (%)	0,03	0,03	0,02
C/N	22	17	14
CaCO3 (%) total	0	0	0
K available ppm	294,19	192,56	149,77
P assimilable ppm	1,04	3,43	5,67
Elec. cond. (ms/cm)	0,03	0,02	0,17
Exchangeable bases (méq/100g soil)			
Calcium (Ca^{++})	5,54	4,62	3,75
Magnesium (Mg^{++})	1,57	0,98	0,57
Potassium (K^+)	0,12	0,10	0,10
Sodium (Na^+)	0	0	0
Sum of bases	7,23	5,70	4.42
CEC	10,49	9,41	5,99
.Base saturation %	68,9	60,5	73,8
pH H_2O	5,99	5,78	6,32
pH KCl	4,74	4,37	4,78
Total acidity. Exchangeable:			
Al meq/100g	0,04	0,16	0,04
Hydrogen meq/100g	0,08	0,20	0,06
Available Ca ppm	646,00	507,00	264,50
Available Mg ppm	141,50	78,00	33,10

Analytical results profile 13.6:

Horizon	A	B	Bg1
Depth (cm)	0-7	7-25	25-55
Partical size distribution in % weight			
Clay (<2µm)	11,76	35,29	45,10
Silt (20-50µm)	15,69	27,45	15,69
Sand (50-2000µm)	72,55	37,25	39,22
Texture	SL	CL	C
Moisture (%)	0,46	1,18	0,91
Organic matter.			
Total (%)	1,00	1,58	0,74
Carbon C (%)	0,58	0,92	0,43
Nitrogen N (%)	0,04	0,07	0,04
C/N	13	14	11
CaCO3 (%) total	0	0	0
K available ppm	476,05	246,05	230,00
P assimilable ppm	3,17	0,94	0,57
Elec. cond. (ms/cm)	0,04	0,02	0,02
Exchangeable bases (méq/100g soil)			
Calcium (Ca^{++})	2,42	6,43	6,96
Magnesium (Mg^{++})	1,19	2,39	2,14
Potassium (K^{+})	0,17	0,12	0,12
Sodium (Na^{+})	0,08	0,07	0,04
Sum of bases	3,86	9,01	9,26
CEC	6,24	12,94	10,78
Base saturation %	61,9	69,7	85,9
pH H_2O	6,19	6,36	6,33
pH KCl	4,93	4,58	4,52
Total acidity. Exchangeable:			
Al meq/100g	0,04	0,04	0,04
Hydrogen meq/100g	0,04	0,12	0,08
Available Ca ppm	400,70	969,00	764,00
Available Mg ppm	82,50	122,80	184,00

Analytical results profile 13.6:

Horizon	Bg2	Bcs
Depth (cm)	55-85	85-120
Partical size distribution in % weight		
Clay (<2µm)	31,37	37,25
Silt (20-50µm)	15,69	21,57
Sand (50-2000µm)	52,94	41,18
Texture	SCL	CL
Moisture (%)	0,67	0,98
Organic matter.		
Total (%)	0,59	0,51
Carbon C (%)	0,34	0,30
Nitrogen N (%)	0,02	0,03
C/N	16	10
CaCO3 (%) total	0	0
K available ppm	224,65	288,84
P assimilable ppm	0,47	0,21
Elec. cond. (ms/cm)	0,02	0,02
Exchangeable bases (méq/100g soil)		
Calcium (Ca^{++})	5,51	5,97
Magnesium (Mg^{++})	1,79	2,30
Potassium (K^{+})	0,10	0,14
Sodium (Na^{+})	0,07	0
Sum of bases	7,48	8,41
CEC	10,56	12,65
Base saturation %	70,8	66,5
pH H_2O	6,33	6,48
pH KCl	4,65	4,75
Total acidity. Exchangeable:		
Al meq/100g	0,04	0,04
Hydrogen meq/100g	0,08	0,08
Available Ca ppm	573,00	654,00
Available Mg ppm	143,10	186,90

profile: 13.6
autors: D.Wijnalda & P.v.Asten
coordinates: 698354 1517172
landform: Grand Basfond (D2)
landelement: field next to gully
topography: flat
position: bottom
slope gradient and form: flat straight slope
microtopography: flat
parent material: alluvial
vegetation/land use: sorghum field
rock outcrops: no rock outcrops
surface coarse fragments: no surface coarse fragments
erosion deposition: water deposition
surface sealing: <2mm slightly hard surface sealing
surface cracks: no surface cracks
drainage class: moderatly well drained: moderatly slow internal drainage and ponded
flooding: subject to flooding
FAO-UNESCO classification: Eutric fluvisol

0-7cm: A-horizon

Sandy loam. Light yellowish brown (10YR6/4) when dry and dark yellowish brown (10YR4/4) when moist. No mottling. No rocks. Weak pedal medium subangular blocky structure. Hard when dry. Friable when moist. Slightly sticky and plastic when wet. Common very fine pores and few fine pores. No nodules. Common very fine roots. Termite activity, worm casts and krotovinas. Clear and smooth boundary.

7-25cm: B-horizon

Sandy clay loam. Grayish brown (10YR5/2) when dry and very dark grayish brown (10YR3/2) when moist. No mottling. No rocks. Moderatly pedal medium subangular blocky structure. Very hard when dry. Friable when moist. Slightly sticky and plastic when wet. Many very fine pores and few fine pores. No nodules. Common very fine roots. Termite burrows, worm casts and krotovinas. Gradual and smooth boundary.

25-55cm: Bg1-horizon

Sandy clay loam. Dark brown (10YR4/3) when dry and light yellowish brown (10YR6/4) when moist. Many fine distinct yellowish red (5YR5/8) mottles. No rocks. Moderatly pedalmedium subangular blocky structure. Hard when dry. Firm when moist. Slightly sticky and plastic when wet. Common very fine pores and very few fine pores. No nodules. Very few very fine roots. Termite activity and worm casts. Clear and wavy boundary.

55-85cm: Bg2-horizon

Sandy loam. Very pale brown (10YR7/3) when dry and dark yellowish brown (10YR4/4) when moist. Many coarse distinct dark reddish brown (5YR3/3) mottles. No rocks. Weak pedal medium subangular blocky structure. Hard when dry. Firm when moist. Slightly sticky and plastic when moist. Common very fine pores and very few fine pores. No nodules. Very few very fine roots. Termite activity and wormcasts. Clear and wavy boundary.

85-120cm: Bcs-horizon

Sandy clay loam. Light gray (7.5YR7/1) when dry and light brownish gray (10YR6/2) when moist. Many medium prominent dark red (2.5YR3/6) and black (N2/) mottles. No rocks. Moderatly pedal fine subangular blocky structure. Very hard when dry. Friable when moist. Slightly sticky and plastic when wet. Common very fine pores and common fine pores. Very few medium soft black (N2/) iron manganese nodules. Very few very fine roots. Termite burrows and worm casts.

profile: 12.5
autors: D.Wijnalda & P.v.Asten
date: 25-11-'94
coordinates: 716999 1482068
landform: Plaine (D3)
landelement: adjacent to a little lake
topography: flat
position: lower slope
slope gradient and form: nearly flat and straight slope
microtopography: flat
parent material: not known
vegetation/land use: grass, shrubs, trees and drinking place
rock outcrops: no rock outcrops
surface coarse fragments: no surface coarse fragments
erosion deposition: no erosion or deposition
surface sealing: 2-5mm hard surface sealing
surface cracks: no surface cracks
drainage class: poorly drained: slow internal drainage and moderatly rapid run-off
flooding: subject to flooding
FAO-UNESCO classification: Eutric plinthosol

0-70cm: Ag-horizon

Sandy clay. Pinkish gray (7.5YR6/2) when dry and gray (7.5YR5/0) when moist. Common fine distint strong brown (7.5YR5/8) mottles. No rocks. Weak pedal medium subangular blocky structure. Extremely hard when dry. Friable when moist. Sticky and very plastic when wet. Few very fine pores and few fine pores. No nodules. Few very fine roots and very few coarse roots. Worm casts. Abrupt and smooth boundary.

70-100cm: Bcs-horizon

Pinkish gray (7.5YR6/2) when dry and gray (7.5YR5/1)when moist. No mottling. No rocks. Apedal. Extremely hard when dry. Extremely firm when moist. Non sticky and non plastic when wet. No pores. Continues nodular iron manganese cementation. Dominant medium hard red (10R4/8), brownish yellow (10YR6/8) and black (N2/) nodules. No roots. No biological activity found.

100+ cm: R-horizon

Hardened plinthite/Plinthite

Analytical results profile 12.5:

Horizon	Ag	Bcs
Depth (cm)	0-70	70-100
Partical size distribution in % weight		
Clay (<2μm)	44	
Silt (20-50μm)	15	
Sand (50-2000μm)	40	
Texture	C	Hardened plinthite
Organic matter.		
Carbon C (%)	0,5	
N-NO_3 (cmol/kg)	0	
N-NH_4 (cmol/kg)	0	
N-total (cmol/kg)	0	
Results of $BaCl_2$-extraction (cmol+/kg).		
Calcium (Ca^{++})	7,13	
Magnesium (Mg^{++})	2,33	
Potassium (K^+)	0,13	
Sodium (Na^+)	0,55	
Results of $CaCl_2$-extraction (cmol+/kg).		
Magnesium (Mg^{++})	1,39	
Potassium (K^+)	0,07	
Sodium (Na^+)	0,07	
P (mg/100g)	0	
pH (KCl)	4,6	
CEC (cmol+/kg)	0,8 (??)	

profile: 34.5
autors: A.Fermont & P.v.Asten
date: 4-2-'95
coordinates: 737746 1508724
landform: Grand Basfond (D2)
landelement: gully
topography: flat
position: bottom
slope gradient and form: flat/level and complex
micro topography: little gullies
parent material: alluvium
vegetation/land use: trees
rock outcrops: no rock outcrops
surface course fragments: no surface course fragments
erosion deposition: water deposition
surface sealing: 2-5mm slightly hard surface sealing
drainage class: moderately well drained, moderately rapid internal drainage and ponded
flooding: no flooding
FAO-UNESCO classification: Ferric luvisol

0-5cm: A-horizon

Sandy loam. Yellowish brown (10YR5/4) when dry and dark yellowish brown (10YR4/4) when moist. No mottling. No rocks. Moderate pedal medium subangular blocky structure. Hard when dry and firm when moist. Sticky and slightly plastic when wet. Common very fine and few fine pores. No nodules. Very few very fine and course roots. Many bio-activity. Abrubt and wavy boundary.

5-25cm: Bg1-horizon

Sandy clay loam. Yellowish brown (10YR5/4) when dry and dark yellowish brown (10YR3/4) when moist. Few course distinct red (2.5YR5/8) and black mottles. No rocks. Moderate pedal medium subangular blocky structure. Hard when dry and firm when moist. Sticky and plastic when wet. Many very fine and very few course pores. No nodules. Few very fine and very few course roots. Many bio-activity. Gradual and smooth boundary.

25-55cm: Btg-horizon

Sandy clay. Strong brown (7.5YR4/6) when dry and dark brown (7.5YR3/4) when moist. Common fine faint pink (7.5YR8/4) and black mottles. No rocks. Strong pedal fine angular blocky structure. Very hard when dry and firm when moist. Slightly sticky and plastic when wet. Many very fine and very few course pores. Very few medium reddish yellow (5YR6/8) nodules. Few very fine and very few course roots. Many bio-activity. Gradual and smooth boundary.

25-120cm: Bg2-horizon

Sandy clay loam. Reddish yellow (7.5YR6/8) when dry and strong brown (7.5YR5/8) when moist.Common fine faint red (2.5 YR5/8) and black mottles. No rocks. Moderate pedal coarse subangular blocky structure. Hard when dry and firm when moist. Sticky and plastic when wet. Many very fine and few fine pores. No nodules. Few very fine and very few course roots. Moderate bio-activity.

Analytical results profile 34.5:

Horizon	A	Bg1	Btg	Bg2
Depth	0-5	5-25	25-55	55-120
Partical size distribution in % weight				
Clay (<2μm)	15,69	21,57	41,18	23,53
Silt (20-50μm)	23,53	17,65	3,92	13,73
Sand (50-2000μm)	60,78	60,78	54,90	62,75
Texture	SL	SCL	SC	SCL
Moisture (%)	0,80	1,11	2,00	1,06
Organic matter.				
Total (%)	1,20	1,13	0,88	0,46
Carbon C (%)	0,70	0,66	0,51	0,27
Nitrogen N (%)	0,04	0,04	0,05	0,03
C/N	18	18	11	9
CaCO3 (%) total	0	0,13	0	0
K available ppm	139,07	123,02	133,72	106,98
P assimilable ppm	1,98	1,72	0,31	0,36
Elec. cond. (ms/cm)	0,04	0,02	0,02	0,02
Exchangeable bases (méq/100g soil)				
Calcium (Ca^{++})	4,78	7,26	8,14	4,50
Magnesium (Mg^{++})	2,32	2,74	6,23	3,71
Potassium (K^+)	0,50	0,50	0,48	0,31
Sodium (Na^+)	0,21	0,21	0,21	0,14
Sum of bases	7,81	10,71	15,07	8,66
CEC	13,34	12,40	17,34	12,26
Base saturation %	58,5	86,4	86,9	70,6
pH H_2O	6,15	6,80	6,56	6,59
pH KCl	4,76	4,87	4,48	4,54
Total acidity. Exchangeable:				
Al meq/100g	0,04	0,04	0,04	0,06
Hydrogen meq/100g	0,06	0,08	0,12	0,06
Available Ca ppm	774,00	841,00	936,00	571,00
Available Mg ppm	230,60	203,20	435,90	228,50

profile: 12.6
autors: D.Wijnalda & P.v.Asten
date: 26-11-'94
coordinates: 716944.7 1482098
landform: Plaine (D3)
landelement: under grass close to drinking place
topography: flat
position: bottom
slope gradient and form: flat straight slope
microtopography: no micro relief
parent material: not known
vegetation/land use: shrubs, trees and many types of grasses
rock outcrops: no rock outcrops
surface coarse fragments: no surface coarse fragments
erosion deposition: water erosion and wind deposition
surface sealing: 5-20mm slightly hard surface sealing
surface cracks: no surface cracks
drainage class: imperfectly drained: slow internal drainage and slow run-off
flooding: subject to flooding
FAO-UNESCO classification: Eutric plinthosol

0-15cm: A-horizon

Loamy sand. Pale brown (10YR6/3) when dry and yellowish brown (10YR5/4) when moist. Common very fine distinct brownish yellow (10YR6/8) mottles. No rocks. Apedal structure. Soft when dry. Very friable when moist. Non sticky and slightly plastic when wet. Many very fine pores and few fine pores. No nodules. Common very fine roots. Worm casts and krotovinas. Clear and irregular boundary.

15-50cm: Bg-horizon

Sandy clay loam. Light yellowish brown (10YR6/4) when dry and yellowish brown (10YR5/6) when moist. Common fine faint gray (5Y5/1) mottles and very few fine faint yellowish red (5YR4/6) mottles. No rocks. Weak pedal fine subangular blocky structure. Slightly hard when dry. Friable when moist. Slightly sticky and plastic when wet. Many very fine pores. Few fine hard iron nodules. Few very fine roots. Krotovinas and wormcasts. Clear and smooth boundary.

50-130cm: Bcs-horizon

Sandy clay loam. Gray (5Y6/1) when moist. Many fine distinct bright brown mottles. No rocks. Apedal structure. Very hard when dry. Firm when moist. Sticky and plastic when wet. Common very fine pores. Few fine soft black (N2/) and red iron/manganese nodules. Very few very fine roots. Worm casts.

Analytical results profile 12.6:

Horizon	Ag	Bg	Bcs
Depth (cm)	0-15	15-50	50-130
Partical size distribution in % weight			
Clay (<2μm)	10	42	60
Silt (20-50μm)	17	13	8
Sand (50-2000μm)	73	45	31
Texture	SL	(S)C	C
Organic matter.			
Carbon C (%)	0,6	0,3	0,2
N-NO_3 (cmol/kg)	0	0	0
N-NH_4 (cmol/kg)	0	0	0
N-total (cmol/kg)	0	0	0
Results of $BaCl_2$-extraction (cmol+/kg).			
Calcium (Ca^{++})	1,95	4,29	7,29
Magnesium (Mg^{++})	0,62	2,10	2,45
Potassium (K^+)	0,32	0,33	0,10
Sodium (Na^+)	0,08	0,51	0,97
Results of $CaCl_2$-extraction (cmol+/kg).			
Magnesium (Mg^{++})	0,53	1,53	1,47
Potassium (K^+)	0,15	0,11	0,03
Sodium (Na^+)	0,04	0,03	0,51
P (mg/100g)	0	0	0,02
pH (KCl)	5,2	4,9	5,4
CEC (cmol+/kg)	2,0	7,0	8,1

profile: 16.2
autors: D.Wijnalda & P.v.Asten
date: 3-12-94
coordinates: 698960 1508240
landform: D3 (Plaine)
landelement: minor depression in aeolian complex
topography: flat
position: bottom
slope gradient and form: flat/level
micro topography: dry drinking pool
parent material: alluvium
vegetation/land use: trees
rock outcrops: no rock outcrops
surface course fragments: no surface course fragments
erosion deposition: water deposition
surface sealing: 5-20mm exstremely hard surface sealing
drainage class: poorly drained, extremely slow internal drainage and ponded
flooding: yes flooding

0-80cm: A-horizon

Silty clay. Light gray (10YR7/1) when dry and gray (10YR5/1) when moist. Many fine distinct strong brown (10YR-5/8), red (2.5YR4/6) and black mottles. No rocks. Exstremely hard when dry and friable when moist. Sticky and very plastic. No nodules. Moderate bio-activity. Clear boundary.

80-120cm: Bg-horizon

Silty clay. Light gray (10YR7/1) when dry and gray (10YR5/1) when moist. Many fine distinct strong brown (10YR5/8), red (2.5YR4/6) and black mottles. No rocks. Exstremely hard when dry and friable when moist. Sticky and very plastic. Abundant fine hard dark brown (7.5YR3/4) iron manganese nodules.

ANNEX 6 DETAILED VEGETATION STRUCTURE DATA

DATE	: day/month/year	LEG	: legend reference (map)	DOMTRSPEC:	dominant tree species
GPSUTM	: east-west UTM coordinates	VE	: vegetation type	H	: coverage class high shrublayer
GPSUTM'	: north-south UTM coordinates	COLMEI	: colour on image of May	HH	: av.height high shrublayer (m)
TPN	: track- and plotnumber	COLSEPT	: colour on image of Sept.		
PL	: plotlength (m)	L	: type of landcover		
PW	: plotwidth (m)	T	: coverage class treelayer		
PHN	: aerial photonumber	TH	: av.height treelayer (m)		

DATE	GPSUTM	GPSUTM	TPN	PL	PW	PHN	LEG	VE	COLMEI	COLSEPT	L	T	TH	DOMTRSPEC	H	HH
11/11/94	702954	1486628	91	50	50	2513	D1	-	PURPLE	RED	2	3	12.0	BUTEPARK,ANOGLEIO	3	4.0
11/11/94	70380'	148670'	92	25	25	2513	D1	-	PURPLERED	REDGREY	2	3	9.0	ANOGLEIO,MITRINER,TAMAINDI	3	4.0
11/11/94	702900	1485453	93	25	25	2513	D1	-	REDPURPLE	RED	3	2	12.0	MITRINER,BUTEPARK	2	5.0
4/11/94	705531	1485973	61	25	25	2514	C32	-	GREENBLUE	RED	3	2	10.0	TAMAINDI	2	5.0
1/11/94	713974	1486096	41	50	50	8663	C22	-	PURPLEBLUE	BLUE	2	2	9.3	ADANDIGI	2	5.0
31/10/94	716243	1489080	34	25	25	8662	C22	-	PURPLE	BLUE	3	1			2	4.0
13/12/94	734133	1516642	176	25	25	2536	D1	-	GREENYELLOW		2	3	16.0	BUTEPARK,ANOGLEIO	2	3.5
1/12/94	698448	1517222	1319	25	25	2408	D1	-	REDGREEN	BLUERED	2	2	7.0	ACACALBI,DIOSMESP	2	4.0
29/11/94	697178	1516010	131	25	25	2408	D1	-	REDGREY	GREYRED	2	2	11.0	DIOSMESP	2	4.5
22/11/94	715792	1482345	125	25	25	2523	C22	-	PINK	PINK	3	1			1	
16/12/94	738837	1513061	203	25	25	8437	C32	-	GREY		2	2	10.0	BUTEPARK,KHAYSENE,ACACNILO,PILIRETI	2	4.0
13/12/94	736856	1512615	172	25	25	8436	C2?	-	GREY		2	2	8.0	BALAAEGY	2	4.0
1/12/94	698383	1517173	1316	25	25	2408	C32	-	REDGREY	RED	3	2	9.0	DIOSMESP,MYTRINER,COMBACEU,PILIRETI	2	3.0
29/11/94	697408	1516065	133	25	25	2408	C32	-	REDGREY	RED	3	2	11.0	PILIRETI	2	4.0
23/11/94	716144	1482203	128	25	25	2513	C32	-	REDGREY	REDPINK	3	2	14.0	ADANDIGI,TAMAINDI	2	5.0
5/1/95	689826	1486826	245	25	25	2510	B1	-	PURPLEBLACK	TURQUOISE	2	1			2	4.5
6/1/95	686596	1481293	261	25	25	2529	A	1	PURPLEGREY		2	2	7.0	ACACSEYA,SCLEBIRR	2	3.0
15/12/94	744634	1538265	192	25	25	8379	A	1			2	1			2	2.5
15/12/94	744768	1538242	191	25	25	8379	A	1			2	1			2	3.0
2/12/94	698099	1516003	136	25	25	2408	B2	2A	GREENRED	PINK	2	1			2	3.5
23/11/94	714692	1482084	123	25	25	2523	C22	2A	REDGREY	GREYPINK	2	1			2	4.5
6/1/95	693048	1484273	273	25	25	2528	B2	2A	BLACKPINK	LIGHTBLUE	2	2	8.0	COMBGLUT,COMBMICR	2	5.0
16/12/94	739696	1515019	205	25	25	8437	B2	2A	GREENBLUE		2	2	7.0	ACACSENE	2	5.0
13/12/94	733443	1517747	178	25	25	2536	B2	2A	BLUEGREEN		2	1			2	5.0
4/12/94	698486	1516513	1312	25	25	2408	B2	2A	ARMYGREEN	LIGHTBLUE	2	1			2	4.0
5/1/95	684340	1490575	243	25	25	2509	B1	2A	BLUEPURPLE	TURQUOISE	2	1			1	
13/12/94	736472	1514787	174	25	25	8436	B1	2A	BLUEGREEN		2	2	6.0	PTERLUCE,ACACLAET	2	5.0
2/12/94	697850	1516320	137	25	25	2408	B1	2A	BLUEBLACK	TURQUOISE	1	1			1	
2/12/94	697795	1516229	136	25	25	2408	B2	2A	BLUEBLACK	TURQUOISE	2	1			2	3.0
22/11/94	714572	1482119	122	25	25	2523	B1	2A	BLACKBLUE	TURQUOISE	2	1			1	
22/11/94	714561	1482108	121	25	25	2523	B2	2A	BLACKBLUE	TURQUOISE	2	1			2	3.5
12/11/94	706850	1478354	101	25	25	2525	B1	2A	PURPLEBLUE	TURQUOISE	2	1			2	3.0
10/11/94	724637	1489226	81	25	25	8663	C22	2B	REDGREY	BLUERED	2	2	6.0	PTERLUCE	2	4.5
30/10/94	713173	1481708	21	25	25	2523	C21	2B	PINKBLUE	WHITERED	2	1			1	
3/11/94	713556	1482011	22	25	25	2524	C21	2B	PINK	WHITE	2	1			2	3.0

profile: 16.3
autors: D.Wijnalda & P.v.Asten
date: 3-12-'94
coordinates: 699295 1507570
landform: Complex éolien (E)
landelement: next to crust
topography: flat
position: middle slope
slope gradient and form: flat/level and straight
micro topography: flat
parent material: wind deposit
vegetation/land use: grasses, crust
rock outcrops: no rock outcrops
surface course fragments: no surface coarse fragments
erosion deposition: wind deposition
surface sealing: < 2mm slightly hard surface sealing
drainage class: well drained, moderately slow internal drainage and moderately rapid run off.
flooding: no flooding

0-30cm: A-horizon
Loamy sand. Yellowish brown (10YR5/8) when dry and dark yellowish brown (10YR4/4) when moist. No mottling. No rocks. slightly hard when dry and very friable when moist. No nodules. Clear boundary.

30-80cm: B-horizon
Sandy loam. Reddish yellow (7.5YR7/8) when dry and strong brown when moist. No mottling. No rocks. Slightly hard when dry. Slightly sticky and slightly plastic when wet. No nodules. Gradual boundary.

80-140cm: Bg1-horizon
Loamy sand. Very pale brown (10YR8/4) when dry and yellow(10YR7/6) when moist. Few fine faint brownish yellow (10YR6/8) mottles. No rocks. Non sticky and slightly plastic when wet. Common fine and medium hard dark brown (7.5YR4/3) iron nodules. Gradual boundary.

140-220cm: Bg3-horizon
Sandy clay. Yellowish brown (10YR5/4) when moist. Many fine distinct dark red (2.5YR3/6) and light gray (5Y7/1) mottles. Sticky and plastic when wet. Few fine hard dark brown (7.5YR4/3) nodules.

profile: 16.4
autors: D.Wijnalda & P.v.Asten
date: 3-12-'94
coordinates: 699177 1507526
landform: Complex éolien (E)
landelement: depression
topography: flat
position: lower slope
slope gradient and form: nearly flat and straight
micro topography: flat
parent material: Aeolian + alluvium?
vegetation/land use: grasses, shrubs and trees
rock outcrops: no rock outcrops
surface course fragments: no surface course fragments
erosion deposition: water deposition
surface sealing: 2-5mm hard surface sealing
drainage class: moderately well drained, moderately slow internal drainage and ponded
flooding: yes flooding

0-30cm: A-horizon
Sandy loam. Pale brown (10YR6/3) when dry and dark grayish brown (10YR4/2) when moist. No mottling. No rocks. Slightly sticky and sightly plastic when wet. No nodules. Clear boundary.

30-50cm: B-horizon
Sandy clay loam. Yellowish brown (10YR5/4) when dry and dark yellowish brown when moist. No mottling. No rocks. Very sticky and very plastic when wet. No nodules. Clear boundary.

50-80cm: Bg-horizon
Sandy clay loam. Yellowish brown (10YR5/4) when dry and dark yellowish brown when moist. Common fine distinct reddish yellow (7.5Yr6/8), yellowish red (5YR5/6)and black mottles. No rocks. Very sticky and very plastic when wet. No nodules. Clear boundary.

80+ very dense soil. to difficult to auger.

ANNEX 6 CONTINUATION

DOMHSSPEC : dominant high shrub species
L : coverage class low shrublayer
LH : av.height low shrub layer (m)
DOMLSSPEC : dominant low shrub species
H : coverage class herbal layer
P/P' : coverage class perannual grasses/ herbs
A/A' : coverage class annual grasses/ herbs

KH/KH' : height first/ second herbal layer
DOMHESPEC : dominant herbal species
V : coverage class total vegetation

DOMHSSPEC	L	LH	DOMLSSPEC	K	M	N	M'	N'	K'	KH	KH'	DOMHESPEC	V
PILIRETI,DIOSMESP,BALAAEGY	3	1.5	PILIRETI,DIOSMESP	4	2	3	2	3	2	100		PENNPEDI,ZORNGLOC	6
COMBMICR	2	1.7	COMBMICR,DIOSMESP	4	2	3	2	3	3	30		ZORNGLOC,PANILAET,TEPHPURP	5
MITRINER,DIOSMESP	2	1.2	PILIRETI,DIOSMESP	5	2	4	2	4	3	250	100	SORGBICO,HYPTSPIC,PENNPEDI,CYPEROTU	6
BUTEPARK	2	1.5	PILIRETI	4	2	2	1	4	3	230	60	SORGBICO,HIBISABD,VOANSUBT,SCHOGRAC	4
PILIRETI,BALAAEGY	2	1.5	PILIRETI,COMBMICR	2	1	2	1	2	2	60		SCHOGRAC,ARISADSC	2
BALAAEGY,ACACSEYA	2	1.5	ACACSENE	3	1	3	1	2	3	60	15	SCHOGRAC,VOANSUBT	3
COMBMICR	2	1.5	PILIRETI,GUIESENE	5	2	3	2	3	3	150		CASSOBTU,PENNPEDI	5
DIOSMESP	2	1.3	DIOSMESP,PILIRETI	5	2	3	2	4	3	55	250	CORCOLIT,ALYSOVAL,ANDRGAYA,IPOM????	5
PILIRETI,COMBMICR	2	1.0	PILIRETI	4	2	3	2	2	3	130	250	ANDRGAYA,SCHOGRAC,PENNPEDI,BORRRAD	4
	2	1.2	BOSCSENE,COMBMICR,BALAAEG	4	1	3	2	2	3	20	90	ANDRPSEU,ARISADSC,VOANSUBT	4
PILIRETI,ZIZIMAUR	2	1.8	PILIRETI,ZIZIMAUR	4	2	3	2	3	3	130		CASSOBTU,ANDRGAYA,PENNPEDI	4
BALAAEGY	2	1.5	BALAAEGY	2	2	2	2	2	3	100		SCHOGRAC,CASSOBTU	3
DIOSMESP	2	1.0	DIOSMESP	3	2	2	2	2	3	120	250	ANDRGAYA,ARACHYPO,SESBSESB	3
BALAAEGY	2	1.1	PILIRETI	3	2	2	2	2	3	40	300	PENNTYPH,ERAGTREM	3
BALAAEGY,ZIZIMAUR	2	1.0	PILIRETI,GUIESENE,COMBMICR,BOSCSEN	4	2	3	2	3	3	50	250	PENNPEDI,ERAGTREM,ANDRGAYA,ARACHYP	4
PTERLUCE,COMBNIGR	2	1.5	ACACMACR,COMBMICR	5	1	5	1	2	3	70		LOUDTOGO,ANDRPSEU,CTENELEG	5
ACACSENE	2	1.2	ACACSENE	6	5	2	1	1	3	120	300	ANDRGAYA,CYMBSCHO	6
ACACSENE	2	1.5	CALEPROC,ZIZIMAUR	5	1	5	2	2	3	100		SCHOGRAC	5
BALAAEGY	2	1.5	GUIESENE,PILIRETI,ACACSENE	5	1	5	2	2	3	70		ANDRPSEU	5
PILIRETI,COMBMICR	3	1.8	GUIESENE,PILIRETI,COMBMICR	3	2	3	2	2	3	90		SETAPALL,PENNPEDI,ERAGTENE	3
GUIESENE,COMBMICR	3	1.5	GUIESENE	4	1	4	2	2	3	75		ANDRPSEU,CTENELEG,ARISFUNI,SCHOGRAC	4
COMBMICR,PILIRETI,BOSCSENE	2	1.6	GARDSOKO,COMBMICR	2	1	2	2	2	3	50		LEPTHAST,WALTINDI,SCHOGRAC	3
COMBMICR,PTERLUCE	2	1.8	COMBMICR	3	1	2	2	2	3	60		SCHOGRAC,ANDRPSEU,LEPTHAST,CTENELEG	3
COMBGLUT	2	1.0	COMBGLUT,ACACMACR	3	1	3	1	2	3	10	70	ANDRPSEU,SCHOGRAC,PENNPEDI,TRIPMINI	4
PILIRETI	2	1.3	BOSCSENE	2	2	2	1	2	1	100		SCHOGRAC,CTENELEG,ARISADSC	2
	2	1.5	GUIESENE,COMBMICR	3	1	3	1	2	3	10	50	LOUDTOGO,CTENELEG,TRIPMINI	3
COMBGLUT	2	1.3	COMBMICR	4	1	4	2	2	3	15	60	SCHOGRAC,FIMBEXIL,LEPTHAST	4
	2	0.9	COMBMICR	2	1	2	2	2	3	20	60	ANDRPSEU,FIMBEXIL	2
COMBMICR,GUIESENE	3	1.8	COMBMICR,GUIESENE	3	1	3	2	2	2	90		ANDRPSEU,PENNPEDI	4
	2	1.5	COMBMICR,GUIESENE	3	1	3	1	2	3	45		ERAGTURG,ANDRPSEU,TRIPMINI	3
COMBMICR	3	2.0	COMBMICR,GUIESENE,BOSCSENE	3	1	3	1	1	3	55		ANDRPSEU,ARISADSC	4
PTERLUCE	4	1.7	COMBMICR	3	1	3	1	2	3	40		PENNPEDI	5
GUIESENE,COMBMICR,BALAAEGY,ACACSEN	2	1.2	PILIRETI,BOSCSENE	5	1	5	2	2	3	110		ANDRPSEU,SCHOGRAC,ARISFUNI	5
	2	0.9	GUIESENE	2	1	2	1	1	3	80		SCHOGRAC	2
GUIESENE	2	1.5	GUIESENE	2	1	2	1	1	3	90		SCHOGRAC,ARISADSC	2

DATE	GPSUTM	GPSUTM	TPN	PL	PW	PHN	LEG	VE	COLMEI	COLSEPT	L	T	TH	DOMTRSPEC	H	HH
30/10/94	713710	1481435	25	25	25	2523	C22	2B	REDGREY	REDBLUE	2	1			2	4.5
3/12/94	699295	1507570	163	25	25	2425	E	2B	PINKGREY	LIGHTGREY	2	1			1	
3/12/94	698833	1508269	161	25	25	2452	E	2B	GREYPINK	GREYRED	2	2	8.0	ANOGLEIO,COMBMICR	2	4.5
6/1/95	693526	1483204	272	25	25	2528	C32	2B	REDGREY	REDGREY	2	2	9.0	COMBGLUT,BOMBCOST	4	5.0
10/11/94	724332	1489154	82	25	25	8663	C32	3	RED	RED	2	3	8.0	ANOGLEIO,PTERLUCE	3	4.0
17/12/94	726524	1512242	223	25	25	8434	C22	3	PURPLEGREY	GREYPINK	2	2	10.0	PTERLUCE,ACACSENE,COMBMICR,ACACMACF	3	4.0
17/12/94	726675	1511987	222	25	25	8434	C22	3	KHAKIGREY	PINKBLUE	2	2	7.0	COMBMICR,PTERLUCE,ACACMACR,GUIESENE	2	4.5
17/12/94	726964	1511227	221	25	25	8434	C22	3	KHAKIGREY	REDGREY	2	2	12.0	ANOGLEIO,COMBGLUT	2	5.0
3/12/94	699177	1507526	164	25	25	2452	E	3	GREYPURPLE	GREYRED	2	2	6.0	ACACMACR,ACACNILO	3	5.0
14/12/94	732391	1509666	183	25	25	8723	C32	3	PINKGREY	PINK	2	2	10.0	BALAAEGY	2	4.5
5/1/95	684452	1489673	242	25	25	2509	C21	4	WHITEPINK	WHITEPINK	2	1			1	
16/12/94	739843	1508070	213	25	25	8724	C21	4	PINKISHGREY	LIGHTBLUE	2	2	7.0	BALAAEGY	1	
16/12/94	740080	1516099	206	25	25	8437	C21	4	GREY		2	2	7.0	ACACSENE,COMMAFRI	1	
16/12/94	738469	1512588	202	25	25	8437	C22	4	LIGHTBLUE		2	2	8.0	BALAAEGY	2	3.0
16/12/94	738137	1511550	201	25	25	8437	C22	4	GREEN	RED	3	1			2	5.0
15/12/94	747054	1530898	198	25	25	8421	C1	4	-		2	2	7.0	BALAAEGY	2	5.0
15/12/94	744105	1538252	194	25	25	8379	C1	4	-		2	1			2	2.5
14/12/94	730132	1509616	184	25	25	8722	C22	4	LIGHTGREEN	REDISHBLUE	2	1			2	3.0
13/12/94	733423	1517465	177	25	25	2536	C21	4	WHITEBLUE		2	2	7.0	ACACLAET	1	
13/12/94	735167	1515650	175	25	25	2536	C22	4	GREYGREEN		2	2	6.0	ACACLAET	1	
13/12/94	736512	1512178	171	25	25	8436	C22	4	GREEN		2	2	5.5	BALAAEGY	2	4.0
2/12/94	698081	1515960	1310	25	25	2408	C21	4	LILABROWN	WHITE	2	2	6.0	MAERCRAS	2	5.0
24/11/94	697384	1501182	141	25	25	2466	C22	4	LIGHTGREEN	PINK	2	1			2	5.0
25/11/94	698302	1514256	151	25	25	2408	C21	4	LIGHTBLUE	WHITE	2	1			2	5.0
4/12/94	698100	1515417	232	25	25	2408	C21	4	LILA		2	1			1	
16/12/94	740101	1507702	212	25	25	8724	B2	4	BLUE	BLUE	2	1			1	
2/12/94	698386	1515689	231	25	25	2408	B2	4	ARMYGREEN		2	2	8.0	BALAAEGY	1	
4/11/94	705541	1482061	62	25	25	2514	C32	5	BLUEGREEN	RED	2	2	7.0	BALAAEGY	2	4.0
1/11/94	722164	1484499	51	25	25	8663	C31	5	PINK	WHITE	2	1			1	
19/11/94	700627	1470982	111	25	25	2571	C22	5	GREY	REDGREY	2	2	6.5	LANNMICR	2	3.5
6/1/95	684597	1480139	264	25	25	2530	C22	5	GREYGREEN	PINKGREY	2	2	6.0	ZIZIMUCR	2	5.0
16/12/94	740465	1509778	211	25	25	8724	C22	5	GREY	PINK	2	2	8.0	BALAAEGY	2	4.5
1/12/94	698334	1516997	1314	25	25	2408	C32	5	ARMYGREEN	PINK	2	2	8.0	BALAAEGY,ACACSEYA	2	5.0
2/12/94	698413	1516296	1311	25	25	2408	C22	5	ARMYGREEN	LIGHTBLUE	2	2	9.0	BALAAEGY	2	5.0
29/11/94	697665	1516163	135	25	25	2408	B2	5	GREYBLUE	BROWN	2	1			2	3.0
14/12/94	737733	1510272	186	25	25	8724	C32	5	GREY	RED	2	2	9.0	BALAAEGY,ACACNILO,ACACSEYA	2	4.5
13/12/94	738287	1512823	173	25	25	8436	B1	5	DARKBLUE		2	1			1	
12/11/94	706001	1478334	103	25	25	2525	C32	6	GREY	RED	2	3	9.0	FICUPLAT	2	4.0
31/10/94	716132	1489176	33	25	25	8662	C32	6	GREEN	RED	3	2	12.0	SCLEBIRR	1	
30/10/94	713430	1480750	26	25	25	2523	D1	6	REDGREY	RED	2	2	9.5	TAMAINDI,SCLEBIRR,LANNMICR,CASSSIEB	3	3.5
19/11/94	701037	1471390	113	25	25	2571	D3	6	PURPLEGREEN	BROWNBLUE	2	2	7.0	SCLEBIRR,LANNMICR	2	2.0
6/1/95	684666	1480118	263	25	25	2530	D1	6	PINKGREY	RED	2	4	10.0	ANOGLEIO,SCLEBIRR,ACACSEYA,TAMAINDI	2	5.0
15/12/94	744350	1535248	195	25	25	8379	D1	6			2	3	12.0	ANOGLEIO,TAMAINDI,COMBGLUT	2	4.0
23/11/94	716780	1482068	129	25	25	8837	D3	6	REDGREY	REDBROWN	2	2	10.5	ADANDIGI,ANOGLEIO	3	4.0
26/11/94	716945	1482098	1210	25	25	8837	D3	6	PINKGREY	BLACKRED	2	2	12.0	ADANDIGI	2	5.0
6/1/95	686074	1481038	262	25	25	2529	C22	6	PURPLEGREY	REDGREY	2	2	7.0	ACACSEYA,ACACNILO,BALAAEGY,GUIESENE	2	4.0

DOMHSSPEC	L	LH	DOMLSSPEC	K	M	N	M'	N'	K'	KH	KH'	DOMHESPEC	V
COMBGLUT,COMBNIGR,COMBMICR	2	1.0	COMBGLUT	3	1	3	1	1	3	120		ANDRPSEU,SCHOGRAC,LOUDTOGO,PENNPEDI	3
	2	1.3	PILIRETI,GUIESENE	4	2	4	2	2	3	130		ANDRPSEU	4
GUIESENE,ACACNILO,COMBMICR	2	1.5	GUIESENE,BOSCSENE	3	2	3	2	2	3	100		ANDRPSEU,SCHOGRAC,TRIPMINI	5
GUIESENE,BALAAEGY,COMBMICR	2	1.8	COMBNIGR,COMBMICR,GUIESENE	5	1	5	2	2	3	120		PENNPEDI,ANDRPSEU	5
GUIESENE,COMBMICR,PILIRETI,ACACMACR	2	1.0	BOSCSENE	4	1	4	2	2	3	100		ANDRPESU,SCHOGRAC,TRIPMINI,ZORNGLOC	6
GUIESENE,ACACSENE,COMBMICR	2	1.2	GUIESENE,COMBMICR	6	2	6	1	2	3	110		ANDRPSEU,PENNPEDI,SCHOGRAC,LOUDTOGO	6
COMBMICR,GUIESENE,ACACSENE	2	1.3	GUIESENE,COMBMICR	3	1	3	1	2	3	30	80	SCHOGRAC,ANDRPSEU,PENNPEDI	3
GUIESENE,COMBGLUT,ACACMACR	2	1.2	COMBGLUT,GREWMOLL,GUIESENE	4	1	4	2	2	3	100		ANDRPSEU,SCHOGRAC,PENNPEDI	4
FICUPLAT,PILIRETI,COMBMICR,GREWBICO	2	1.5	PILIRETI,GUIESENE	3	2	3	2	2	2	140		ANDRPSEU,PENNPEDI,SCHOGRAC,ERAGTENE	5
COMBMICR,BALAAEGY	2	1.7	BALAAEGY,COMBMICR	3	1	3	2	2	3	70		CASSOBTU,SCHOGRAC	4
	2	1.5	COMBMICR	3	1	2	2	2	3	50		SCHOGRAC,CENCBIFL,LEPTHAST	3
	2	0.7	MAERCRAS	2	1	2	1	2	3	70		SCHOGRAC	2
	1			2	1	2	1	2	3	70		SCHOGRAC,CASSOBTU	2
BOSCSENE	2	0.6	ACACNILO	4	1	4	2	2	3	50		SCHOGRAC,LEPTHAST,CASSOBTU	4
BALAAEGY,ACACNILO	2	1.2	BALAAEGY	2	2	2	1	2	3	250		PENNTYPH	2
ACACSENE	2	1.8	ACACSENE	3	1	3	1	2	3	80		SCHOGRAC	3
ACACSENE	2	1.3	ACACSENE	2	1	2	1	2	3	110		SCHOGRAC,ARISADSC	2
MAERCRAS	2	1.0	BOSCSENE	3	1	3	1	2	3	80		SCHOGRAC,ARISADSC	3
	2	1.1	BOSCSENE	3	1	3	1	2	3	80		SCHOGRAC,ARISADSC	3
	2	0.4	ACACLAET	5	2	4	2	3	3	80	130	SCHOGRAC,CASSOBTU	6
MAERCRAS,ACACLAET	2	0.6	MAERCRASS,ACACLAET,BALAAEGY	3	1	3	2	2	3	100		SCHOGRAC	3
PILIRETI	2	1.4	BALAAEGY	2	1	2	2	2	3	50		ERAGTENE,SCHOGRAC	2
PTERLUCE	2	1.2	COMBMICR,BOSCSENE	4	1	4	2	2	3	100		SCHOGRAC,ARISADSC	4
BALAAEGY	2	1.7	BALAAEGY	4	1	4	2	2	3	80		SCHOGRAC	4
	2	1.2	BOSCSENE	2	1	2	2	2	3	60		SCHOGRAC,CENCBIFL	2
	1			2	1	2	2	2	3	60		SCHOGRAC,ARISADSC	2
	1			2	1	2	2	2	3	70		SCHOGRAC	2
BALAAEGY,ACACSENE	2	1.2	PILIRETI,ACACSEYA,ACACSENE	4	1	4	1	2	2	70		SCHOGRAC	5
	2	1.0	GUIESENE	2	1	2	1	2	3	50		SCHOGRAC,ARISADSC	2
COMBMICR	2	1.5	EUPHBALS,CASSOCCI	4	1	3	2	3	3	40		LOUDTOGO,LEPTHAST	4
ACACSENE,ZIZIMUCR	2	1.0	PILIRETI,BOSCSENE	3	1	3	2	2	3	100		SCHOGRAC,ANDRPSEU,LEPTHAST	3
BALAAEGY,PILIRETI	2	1.5	PILIRETI,BALAAEGY	3	1	3	2	2	3	100		SCHOGRAC,ARISADSC,LEPTHAST	3
BALAAEGY,ACACSENE	2	1.8	PILIRETI,BALAAEGY	4	1	4	2	2	3	120		SCHOGRAC,ARISADSC,PENNPEDI	4
BALAAEGY	3	1.3	PILIRETI	3	2	3	2	2	3	120	250	ANDRGAYA,PENNPEDI,SCHOGRAC,ARISADSC	4
COMBMICR,PILIRETI	2	1.5	COMBMICR,PILIRETI	3	1	3	2	2	3	50		SCHOGRAC,CHLOPILO	4
ACACNILO,BALAAEGY	2	1.5	BALAAEGY,ACACSEYA	4	1	4	2	2	3	100		SCHOGRAC,ZORNGLOC,CASSOBTU	5
	2	1.5	COMBMICR	2	1	2	2	2	3	100		PENNPEDI,CENCBIFL,LEPTHAST,PUPALAPP	2
ACACSEYA,ACACALBI,DIOSMESP	3	1.5	PILIRETI,ACACSEYA,DIOSMESP	5	2	4	2	3	3	60		PENNPEDI,SCHOGRAC	6
	2	1.5	PILIRETI	3	2	3	1	2	3	130		PENNPEDI,SCHOGRAC,ARACHYPO,CASSOBTU	4
GUIESENE,COMBMICR	3	1.7	GUIESENE,PILIRETI	4	2	4	1	2	2	80		SCHOGRAC,ANDRPSEU,PENNPEDI	4
PILIRETI	2	1.2	PILIRETI	5	1	5	2	2	3	40		SCHOGRAC	5
ACACSEYA	2	1.5	BOSCSENE	3	1	3	2	2	2	120		PENNPEDI	5
COMBMICR,GREWBICO,PILIRETI	2	1.4	COMBMICR,ACACMACR	5	1	5	2	2	3	90		PENNPEDI,SCHOGRAC,CASSOBTU	5
BALAAEGY,GUIESENE,PILIRETI,COMBMICR	3	1.8	GUIESENE,PILIRETI	6	2	6	2	2	3	110		ANDRPSEU,LOUDTOGO,ERAGPILO,SCHOGRAC	6
ACACSEYA,BALAAEGY	2	1.5	PILIRETI,ACACSEYA,BOSCSENE	4	2	4	2	2	2	70		SCHOGRAC,CYPEROTU,CORCTRID,BORRRADI	5
,ZIZIMAUR,ACACSEYA,PILIRETI	2	2.0	GUIESENE,PILIRETI,BALAAEGY	6	3	3	2	2	3	80	300	ANDRGAYA,SCHOGRAC	6

DATE	GPSUTM	GPSUTM	TPN	PL	PW	PHN	LEG	VE	COLMEI	COLSEPT	L	T	TH	DOMTRSPEC	H	HH
3/12/94	698960	1508240	162	25	25	2452	E	6	GREYPURPLE	GREYRED	2	4	11.0	MYTRINER,ANOGLEIO	2	4.5
6/1/95	692480	1486523	253	25	25	2511	C32	6	BLACKPURPLE	RED	2	2	8.0	ANOGLEIO,PILIRETI	2	3.5
6/1/95	692436	1487656	252	25	25	2511	C32	6	PURPLE	REDGREY	2	3	7.0	ACACSEYA	2	4.5
23/11/94	716144	1482185	127	25	25	2523	C32	6	REDGREY	REDPINK	2	1			2	5.0
12/11/94	706287	1477494	102	25	25	2525	C32	7	GREEN	RED	3	2	13.0	TAMAINDI	2	4.0
4/11/94	705545	1486665	64	25	25	2514	C32	7	GREENRED	RED	3	2	7.0	BALAAEGY	2	5.0
1/11/94	722383	1484767	52	25	25	8663	C32	7	PURPLEGREY	RED	3	2	9.0	BOMBCOST	1	
1/11/94	713792	1485770	42	25	25	8662	C32	7	PINK	RED	3	1			2	3.5
31/10/94	716100	1489357	31	25	25	8662	C32	7	GREYGREEN	RED	3	2	9.0	LANNMICR	2	3.5
15/12/94	744553	1538205	193	25	25	8379	C32	7			3	2	8.0	PILIRETI,ACACSEYA	2	2.0
5/1/95	685732	1491157	244	25	25	2509	C32	7	PINK	RED	3	2	16.0	ANOGLEIO,TAMAINDI	2	2.5
15/12/94	743657	1529915	196	25	25	8421	D1	7	GREYGREEN	RED	3	2	18.0	ADANDIGI,MANGINDI	1	
1/12/94	698354	1517182	1318	10	10	2408	C32	7	REDGREY	BLUERED	4	1			1	
1/12/94	698354	1517172	1317	25	25	2408	C32	7	GREY	RED	3	2	7.0	PILIRETI	1	
15/12/94	747556	1530744	199	25	25	8421	C22	7	-		3	1			2	3.5
29/11/94	697497	1516048	134	25	25	2408	C22	7	LIGHTGREEN	RED	3	2	7.0	PILIRETI	2	3.0
22/11/94	715625	1482256	124	25	25	2523	C22	7	PINKGREY	RED	3	1			2	4.5
6/1/95	692344	1484518	271	25	25	2511	C32	7	PINK	RED	2	2	6.0	CASSSIEB	2	2.5
6/1/95	692569	1487643	251	25	25	2511	C32	7	GREENPURPLE	REDGREY	3	2	8.0	ACACSEYA	2	3.5
16/12/94	739021	1509758	214	25	25	8724	C32	7	GREY	RED	3	2	8.0	BALAAEG	1	
16/12/94	743193	1512042	207	25	25	8438	C32	7	GREEN		3	2	10.0	BALAAEGY,ACACNILO	2	5.0
16/12/94	738918	1513281	204	25	25	8437	C32	7	GREY		3	2	15.0	BUTEPARK	1	
14/12/94	735610	1509516	181	25	25	8723	C32	7	GREEN	RED	3	2	11.0	EUCACAMA	1	
1/12/94	698371	1517108	1315	25	25	2408	C32	7	ARMYGREEN	RED	3	2	11.0	TAMAINDI	2	5.0
2/12/94	697984	1516089	138	25	25	2408	C32	7	GREYGREEN	RED	3	2	6.0	MAERCRAS	2	4.0
29/11/94	697267	1515966	132	25	25	2408	C32	7	GREY	PINKRED	3	2	14.0	ACACALBI,PILIRETI	2	5.0
23/11/94	716094	1482210	126	25	25	2523	C32	7	REDGREY	REDPINK	3	2	11.5	FICUPLAT	1	
31/10/94	716057	1489300	32	25	25	8662	D2	8A	GREYPURPLE	RED	3	3	15.0	MITRINER,FICUPLAT,ANOGLEIO	2	3.0
5/1/95	686177	1490572	241	25	25	2509	D3	8A	GREYPURPLE	BLACKRED	3	3	14.0	FICUPLAT,PILIRETI	2	3.0
16/12/94	743805	1522486	208	25	25	8437	D2	8A			5	4	14.0	MANGINDI,MITRINER	1	
15/12/94	744177	1503429	197	25	25	8725	D2	8A			5	5	10.0	MANGINDI,CITRSINE	2	4.0
14/12/94	731045	1509015	185	25	25	8722	D2	8A	GREYPINK	REDGREY	2	2	10.0	MITRINER,ACACNILO	2	4.0
14/12/94	737701	1510607	187	25	25	8724	D2	8B	GREYPURPLE	RED	2	3	13.0	MITRINER	1	
14/12/94	732375	1509703	182	25	25	8723	D2	8B	PURPLEBLUE	BLACKRED	2	3	11.0	MITRINER	1	

DOMHSSPEC	L	LH	DOMLSSPEC	K	M	N	M'	N'	K'	KH	KH'	DOMHESPEC	V
ACACMACR	2	2.0	COMBMICR	2	1	2	1	2	1	50		LUDWABYS,ORYZLONG,HYGRBIUR	4
COMBGLUT,PILIRETI,GUIESENE	3	1.7	GUIESENE,PILIRETI,BOSCSENE	5	3	4	2	2	3	130		CYMBSCHO,PENNPEDI,ARISADSC	6
ACACSEYA	2	1.3	ACACSEYA,ZIZIMAUR,PILIRETI,BOSCSEN	3	1	3	1	2	3	80		SCHOGRAC	4
BALAAEGY,ACACSEYA,ZIZIMAUR	2	1.5	ZIZIMAUR,ACACSEYA,PILIRETI,GUIESEN	6	2	5	2	2	3	100		PENNPEDI,SCHOGRAC,ANDRPSEU	6
ACACSEYA,GREWBICO	2	1.3	ZIZIMAUR	5	2	4	2	3	3	250	60	SORGBICO,SCHOGRAC	5
BALAAEGY,ACACSENE	2	0.6	PILIRETI	4	2	3	1	3	3	60	30	ANDRPSEU,ERAGTREM,ARACHYPO	4
	1			5	1	2	1	5	2	300	60	SORGBICO,PENNPEDI,PENNTYPH	5
ACACSEYA,BALAAEGY	2	1.5	PILIRETI,CALEPROC	4	2	3	1	3	3	250	70	ERAGTREM,ANDRBICO,SORGBICO,ARACHYP(	4
PILIRETI	2	0.5	PILIRETI	5	2	3	1	3	3	200	80	SORGBICO,HIBISABD,HYPTSPIC,ANDRGAYA	5
CALEPROC	2	0.8	MAERCRAS	4	1	3	2	3	3	110		SCHOGRAC,CASSOBTU,BRACDIST	4
PILIRETI	2	1.5	PILIRETI	4	2	2	2	2	3	80	300	ANDRGAYA,PENNPEDI,SIDAALBA	5
	1			3	2	2	2	2	3	90	300	SORGBICO,HYPTSPIC,SESBSESB,PENNPEDI	4
				1	1	1	1	2	3	20	70	SOLAAETH,ALYSOVAL,ACANHISP	3
	2	0.7	PILIRETI	3	2	2	2	2	3	40	230	SORGBICO,SESAINDI,CORCTRID	3
ACACSEYA	2	1.0	ACACSEYA,PILIRETI	2	1	2	1	2	3	300		SORGBICO,HIBISABD	2
DICHCINE	1			3	1	2	2	2	3	40	250	SORGBICO,PENNTYPH,CORCTRID,MITRVILL	4
COMBMICR	2	1.5	GUIESENE,BOSCSENE	5	1	5	2	2	3	50	250	PENNTYPH,SORGBICO	5
PILIRETI,GUIESENE	3	1.3	PILIRETI	3	2	2	2	2	3	110	300	ANDRGAYA,PENNPEDI	4
ACACSEYA	2	1.5	ACACSEYA,PILIRETI,ZIZIMAUR	3	1	2	2	2	3	100	250	SORGBICO,SCHOGRAC	3
	2	1.0	PILIRETI,GUIESENE,CALEPROC	2	2	2	2	2	3	50	300	SORGBICO,SESAINDI	3
COMBMICR	2	1.3	BALAAEGY	3	2	2	2	2	3	70	250	SORGBICO,CORCOLIT	3
	2	1.0	ACACNILO	2	1	2	2	2	3	60	250	SORGBICO,PENNTYPH,SESAINDI	2
	2	1.5	ZIZIMAUR	3	2	3	2	2	3	40		SORGBICO,CORCOLIT,KOHA????	3
DIOSMESP	2	0.7	PILIRETI	3	2	2	2	2	3	120	250	SORGBICO,CORCOLIT,PENNPEDI	3
PILIRETI	2	1.0	PILIRETI	3	2	3	2	2	2	120	300	SORGBICO,PENNPEDI,HIBISABD	4
SCLEBIRR	2	1.0	PILIRETI	3	2	2	2	2	3	50	300	SORGBICO,ERAGTREM,ACANHISP,CORCTRID	3
	2	1.0	PILIRETI	5	2	5	2	2	3	80	200	SORGBICO,SCHOGRAC,PENNPEDI	5
MITRINER,PILIRETI	1			6	2	3	2	4	3	100		ORYZSATI,PENNPEDI,ANDRPSEU	6
PILIRETI	2	1.5	PILIRETI	5	1	2	2	5	2	120	350	????????,ASPIANTE,HYPTSPIC,LUDWABYS	6
	2	0.6	CITRSINE	3	2	2	2	3	2	20		CYMBSCHO,LEPTHAST,IPOM????,BLUMAURI	5
CITRSINE	1			4	2	2	1	3	3	60		IPOMERIO,BRACLATA	5
MITRINER	2	1.5	MITRINER,ACACNILO	2	2	2	2	2	3	20	140	CASSOBTU,CYMBSCHO,FIMBLITT	3
	1			2	2	1	2	2	2	20		CYMBSCHO,DETENODI	3
	1			1	1	1	1	1	3				3

ANNEX 7 RAPID ROAD SAMPLING DATA

DATE : date day/month/year
ROUTE : road that is used
GPSUTM : east-west UTM coordinates
GPSUTM' : north-south UTM coordinates
LEG : legend reference
COLMAY : colour on satellite image of May
COLSEPT : colour on satellite image of September
L : landuse code

T : coverage class of tree layer
DOMTRSP : dominant tree species
S : coverage class of shrub layer
DOMSHSP : dominant shrub species

DATE	ROUTE	GPSUTM	GPSUTM'	LEG	COLMAY	COLSEPT	L	T	DOMTRSP	S	DOMSHSP
21/12/94	BARSALOGHO-DABLO	697466	1510204	C21	GREYGREEN	PINKBLUE	1	1	ADANDIGI,ACACNILO,ACACSEYA	1	COMBGLUT,BOSCSENE,BALAAEGY,PILIRETI,GUIESENI
21/12/94	BARSALOGHO-DABLO	697323	1512606	C21	LIGHTBLUE	WHITE	1	1	BALAAEGY,COMBMICR	2	GUIESENE
21/12/94	BARSALOGHO-DABLO	697853	1515388	C21	LILA	WHITE	1	1	COMBGLUT	1	BOSCSENE
22/12/94	BARSALOGHO-PENSA	718705	1496782	C21	GREYGREEN	PINKGREY	1	1	COMBMICR	2	COMBMICR,GUIESENE
22/12/94	BARSALOGHO-PENSA	723193	1501570	C21	PINKLILA	WHITEBLUE	1	1		1	ACACSENE,PILIRETI,COMBMICR
22/12/94	BARSALOGHO-PENSA	725347	1502958	C21	PINKGREY	LIGHTBLUE	1	1		1	
22/12/94	PENSA-BARSALOGHO	735739	1500437	C21	LILAGREY	WHITE	1	1		1	BOSCSENE
21/12/94	BARSALOGHO-DABLO	695333	1500932	C22	PURPLEGREY	REDGREY	1	1	PTERLUCE,GREWBICO	3	COMBMICR,GREWBICO,GUIESENE
22/12/94	BARSALOGHO-PENSA	720920	1499051	C22	REDKHAKI	REDGREY	1	1	PTERLUCE	3	PTERLUCE,COMBMICR,GUIESENE
22/12/94	BARSALOGHO-PENSA	727600	1505056	C22	REDGREY	PINKBLUE	1	1	PTERLUCE,BALAAEGY,COMBGLUT	1	COMBMICR,ACACSEYA,PILIRETI,GUIESENE
22/12/94	BARSALOGHO-PENSA	729787	1507362	C22	LIGHTBLUE	WHITE&PINK	1	1		1	BOSCSENE,COMBMICR
22/12/94	PENSA-BARSALOGHO	735751	1497700	C22	KHAKIGREY	BLUEPINK	1	1	COMBMICR	1	COMBGLUT,ACACMACR,ACACSENE,COMBMICR
21/12/94	DABLO-BARSALOGHO	696263	1503291	C31	GREEN	RED	1	3	ACACSEYA,BALAAEGY	1	
22/12/94	BARSALOGHO-PENSA	713371	1488570	C31	GREENGREY	RED	1	1	BALAAEGY,COMBGLUT	2	PILIRETI,COMBMICR,BALAAEGY
22/12/94	BARSALOGHO-PENSA	716432	1493674	C31	PINKGREY	LIGHTBLUE	1	2	BALAAEGY,XIMEAMER	3	COMBMICR,PILIRETI,GUIESENE,ZIZIMAUR
22/12/94	PENSA-BARSALOGHO	736778	1506852	C31	GREENGREY	BLUEPINKISH	1	1	ACACSENE OF ACACLAET,SCLEBIRR	1	
22/12/94	PENSA-BARSALOGHO	736605	1503351	C31	GREENGREY	GREYRED	1	1	ACACSENE OF -LAET,ACACNILO,BALAAEGY	1	ACACSENE OF -LAET
21/12/94	BARSALOGHO-DABLO	696256	1503886	C32	LIGHTGREEN	RED	1	1	SCLEBIRR,ACACSEYA	2	PILIRETI,ACACSEYA
22/12/94	BARSALOGHO-PENSA	711840	1486154	C32	GREENPURPLI	RED	2	1	ADANDIGI,BALAAEGY	1	PILIRETI,BALAAEGY
22/12/94	BARSALOGHO-PENSA	732033	1509170	C32	GREYPINK	PINKBLUE	2	1	BALAAEGY,PTERLUCE	1	COMBMICR,PILIRETI
22/12/94	BARSALOGHO-PENSA	735215	1509580	C32	GRASSGREEN	PINKBLUE	2	1	ACACSEYA,BUTEPARK	1	ZIZIMAUR,PILIRETI,ACACSEYA
22/12/94	PENSA-BARSALOGHO	736934	1509133	C32	GREYGREEN	RED	6	1	AZADINDI,BALAAEGY,ACACNILO	1	
22/12/94	BARSALOGHO-PENSA	715708	1490634	D1	PURPLEGREEI	BLUEBLACK	1	2	ANOGLEIO	1	PILIRETI,DIOSMESP
21/12/94	BARSALOGHO-DABLO	697040	1507073	D3	GREYPURPLE	GREYPINK	4	2	ADANDIGI,ANOGLEIO,ACACSEYA	2	COMBMICR,GUIESENE,ACACSEYA,BOSCSENE

ANNEX 7 CONTINUATION

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H          : coverage class of total herb layer
DOMHBSP    : dominant grass and herb species
H'         : code for crust presence
G          : code for gravel presence
G'         : code for gully presence
S          : code for stone presence
REMARKS    : additional remarks
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H	DOMHBSP	H'	G	G'	S	REMARKS
2	SCHOGRAC,ZORNGLOC,CENCBIFL	1	1	2	2	GREY CRUST, FINE GRAVEL, SOIL IS BEIGE
2	SCHOGRAC,LEPTHAST,CENCBIFL	1	1	2	2	GREY CRUST, FINE GRAVEL
2	SCHOGRAC,CENCBIFL	1	1	1	1	GREY CRUST, VERY LITTLE GRAVEL, GULLY IS 1M WIDTH, 50CM DEEP
3	SCHOGRAC,ANDRPSEU,TRIPMINI,POLYLINE	1	1	2	2	GREY CRUST, VERY LITTLE GRAVEL, BEIGE/ORANGE SOIL, FURTHER AWAY GULLIES
1	SCHOGRAC,ARISADSC	1	2	2	2	GRIJZE KORST, BEIGE GROND
2	SCHOGRAC,LEPTHAST	1	1	1	2	LITTLE CRUST, FINE GRAVEL, GULLY IS 20CM DEEP, BEIGE SOIL
1	SCHOGRAC	1	1	2	2	GREYBROWN CRUST, BROWN-ORANGE SOIL, SOME QUARTS AT SURFACE
3	ANDRPSEU,SCHOGRAC,CASSOBTU	1	2	2	2	GREY BEIGE CRUST, A LITTLE FURTHER GRAVEL (NOT HERE)
3	ANDRPSEU	1	2	2	2	CRUST IS GREY
1	SCHOGRAC,PENNPEDI	1	1	2	2	GREY CRUST, FINE GRAVEL
1	SCHOGRAC,LOUDTOGO,CASSOBTU	1	2	2	2	GREY CRUST, BEIGE SOIL
2	SCHOGRAC,LOUDTOGO	1	1	2	2	GREY CRUST, FINE GRAVEL, BEIGE SOIL
3	CASSMIMO,ERAGSPP,SETAPALL	1	2	2	2	NEXT TO DRINKING PLACE
2	SCHOGRAC,PENNPEDI,LEPTHAST	1	1	2	2	GREY CRUST, FINE GRAVEL, TREE STUMPS
2	SCHOGRAC,CASSOBTU,ERAGTREM	1	2	2	2	CRUST IS GREY
1	SCHOGRAC,CASSOBTU,LEPTHAST	2	1	2	2	FINE GRAVEL,BROWN SOIL
3	SCHOGRAC,CASSOBTU,LEPTHAST	2	1	2	2	FINE GRAVEL,BROWN-ORANGE SOIL
2	PENNPEDI,SCHOGRAC,CASSOBTU,INDITINC	1	2	2	2	CRUST IS GREY
2	SORGBICO,SCHOGRAC,PENNPEDI	1	1	2	2	GREY CRUST, VERY LITTLE GRAVEL, BEIGE SOIL
3	SORGBICO,SCHOGRAC,PENNPEDI	2	1	2	2	SOIL IS BEIGE
2	ERAGTREM,ANDRGAYA,SORGBICO,HIBISABD	2	2	2	1	BROWN SOIL
2	CASSOBTU,PENNTYPH	2	1	2	2	FINE GRAVEL, BROWN SOIL
2	ANDRGAYA,CASSOBTU,CASSMIMO,HYPERUFA	2	2	1	2	GREY CLAY
1	SCHOGRAC,ERAGTENE,ANDRPSEU,ORYZSPP	1	2	2	2	CRUST IS GREY

ANNEX 8 LIST WITH ALL SPECIES FOUND DURING THE SURVEY

GRF : growne form of species (BS=tree/shrub)
SPECCODE : four character species code
LATIN : species name in Latin
FRENCH1 : species name in French (1st option)
FRENCH2 : name in French (2nd option)
MOREE1 : species name in Moree (1st option)
MOREE2 : species name in Moree (2nd option)
PEUHL1 : species name in Peuhl (1st option)
PEUHL2 : species name in Peuhl (2nd option)
L : leguminous (1) or no leguminous (0)

GRF	SPECCODE	LATIN	FRENCH1	FRENCH2	MOREE1	MOREE2	PEUHL1	PEUHL2	L
BS	ACAC ALBI	ACACIA ALBIDA		KAD(E)	ZAAGA	ZAANGA	CA'IKI	CA'IDE	1
BS	ACAC LAET	ACACIA LAETA					PATTUKI		1
BS	ACAC MACR	ACACIA MACROSTACHYA			GIEMBAOGO	KARDEGA	CIIDI		1
BS	ACAC NILO	ACACIA NILOTICA	NEB-NEB		PEGENENGA	PIARALGA	GONAAKI		1
BS	ACAC PENN	ACACIA PENNATA			KAGENGA	KANGA	GOUMI		1
BS	ACAC SENE	ACACIA SENEGAL	GOMMIER (BLANC)	VEREK	GOMIGA	GONIMINIGA	PATTUKI		1
BS	ACAC SEYA	ACACIA SEYAL	MIMOSA EPINEUX		GOMIGA	GOPORGHO	BULBI	BULBE	1
BS	ADAN DIGI	ADANSONIA DIGITATA	BAOBAB	PAIN DE SINGE	TOAYGA	TWEGA	BOKKI	BOWDE	0
BS	ANAC OCCI	ANACARDIUM OCCIDENTALE	CASHEW						0
BS	ANNO SENE	ANNONA SENEGALENSIS	POMME CANNELLE DU SENEGAL	ANNONE	BAKIKUDIGA	BARKUDGA	BARKOUTAHE	DOKUMI	0
BS	ANOG LEIO	ANOGEISSUS LEIOCARPUS	BOULEAU D'AFRIQUE		PIEGA	SIEEGHA	KOJOLI		0
BS	AZAD INDI	AZADIRACHTA INDICA	NIM	MARGOSE	NEEM	NIM-TIGA	TIROTIYA	MIRWAHI	0
BS	BALA AEGY	BALANITES AEGYPTIACA	DATTIER DU DESSERT	DATTIER SAUVAGE	KIEGHALIGHA	TIEGALIGA	TANNI	TANNE	0
BS	BOMB COST	BOMBAX COSTATUM	KAPOKIER (A FLEURS) ROUGE		VAKA	VOAAKA	BUMBUHI	KULULI	0
BS	BORA AETH	BORASSUS AETHIOPUM	RONIER		KOANGA	KWANGA	NDUBBI	DUBBE	0
BS	BOSC ANGU	BOSCIA ANGUSTIFOLIA			KISINKINDE		DANDANEEHI		0
BS	BOSC SENE	BOSCIA SENEGALENSIS			LAMBOIGA	NABEDIGA	GIGILI	KARBASI'AL	0
BS	BUTY PARK	BUTYROSPERMUM PARKII	KARITE	ARBRE A BEURRE	TAGA	TAANGA	KAREHI		0
BS	CALO PROC	CALOTROPIS PROCERA	ARBRE A SOIE DU SENEGAL	POMME DE SODOME	PANTREPOUGA	POUTREPOUGA	MBANBAMBI	AMBE	0
BS	CAPP CORY	CAPPARIS CORYMBOSA			KALNYAKA	KUANGO			0
BS	CASS OCCI	CASSIA OCCIDENTALIS	CAFE NEGRE	FAUX KINKELIBA			UULO		1
BS	CASS SIEB	CASSIA SIEBERIANA			KOMBISAKA	KOMBRISAKA			1
BS	CITR SINE	CITRUS SINENSIS	ORANGE						0
BS	COMB ACUL	COMBRETUM ACULEATUM			KODENTABAGA	KOUGUINGA	LAONYI		0
BS	COMB GLUT	COMBRETUM GLUTINOSUM			DANDEGHA	KOAGENGA	DOOKI	DOODE	0
BS	COMB MICR	COMBRETUM MICRANTHUM	KINKELIBA		KANGA	KALNYAKA	NGUNGUMI	GUNGUME	0
BS	COMB NIGR	COMBRETUM NIGRICANS			KAREMTOUAGA		DUYKI	DUYDE	0
BS	COMM AFRI	COMMIPHORA AFRICANA	BDELLIUM D'AFRIQUE	MYRRHE AFRICAINE	JAMNUTUGA	KODINTABIAGA	BADADI	BADAKI	0
BS	CRAT ADAN	CRATEVA ADANSONII			KALEGAIN	TOHIGA	BANI	DANTAKOULAGUE	0
BS	DALB MELA	DALBERGIA MELANOXYLON	EBENIER DU SENEGAL		DAUWO SUURI	KIRDIANDAGA	DALABAN	GELHELAHI	1
BS	DICH CINE	DICHROSTACHYS CINERA	MIMOSA CLOCHETTE		SOUSOUTRI		BOURLI		1
BS	DIOS MESP	DIOSPYROS MESPILIFORMIS	EBENIER DE L'OUEST AFRICAIN	FAUX EBENIER	GAAKA	GAOKA-GANAKA	GANAAHI	NELBI	0
BS	EUCA CAMA	EUCALYPTUS CAMALDULENSIS							0
BS	EUPH BALS	EUPHORBIA BALSAMIFERA					BARNAAHI	MBADAGREEHI	0
BS	FICU PLAT	FICUS PLATYPHYLLA			KANKANGA	KEMPSAOGO	NDUNDEEHI	KOBAHI	0
BS	GARD SOKO	GARDENIA SOKOTENSIS							0
BS	GREW BICO	GREWIA BICOLOR			JUALAGA	TONLAGA	KELLI	KELLE	0
BS	GREW CISS	GREWIA CISSOIDES							0
BS	GREW FLAV	GREWIA FLAVESCENS					CIIBOOLI	YENGOOHI	0
BS	GREW MOLL	GREWIA MOLLIS			MOUDRIMOUKA	MOUNIMOUKA			0
BS	GREW TENA	GREWIA TENAX					NGURSOOHI	GURSOOJE	0
BS	GUIE SENE	GUIERA SENEGALENSIS	NGER	N'GUERE	OUILIWIGA	WILENWIGA	NGELOOKI	JAMANIHEL	0
BS	JATR CURC	JATROPHA CURCAS	POURGHERE	PIGNON D'INDE	KOUBODGA		FALFAHI		0

ANNEX 8 LIST WITH ALL SPECIES FOUND DURING THE SURVEY

GRF : occurence of species (BS=tree/shrub,EG=annual grass)
SPECCODE : four character species code
LATIN : species name in Latin
FRENCH1 : species name in French (1st option)
FRENCH2 : name in French (2nd option)

MOREE1 : species name in Moree (1st option)
MOREE2 : species name in Moree (2nd option)
PEUHL1 : species name in Peuhl (1st option)
PEUHL2 : species name in Peuhl (2nd option)
L : leguminous (1) or no leguminous (0)

GRF	SPECCODE	LATIN	FRENCH1	FRENCH2	MOREE1	MOREE2	PEUHL1	PEUHL2	L
BS	KHAY SENE	KHAYA SENEGALENSIS	CAILCEDRAT	ACAJOU DU SENEGAL	KUKA		KAHI		0
BS	LANN MICR	LANNEA MICROCARPA	RAISENIER		SABGHA	SABTOULOUGA	CABIIHI	FALFAAHI	0
BS	MAER CRAS	MAERUA CRASSIFOLIA			KESSIGA	KIESGHA	SUNDUUHI	SOG'HI	0
BS	MANG INDI	MANGIFERA INDICA					MANGOROOHI		0
BS	MITR INER	MITRAGYNA INERMIS			GILGHA	GWINGA	KOOLI	KOOLE	0
BS	PILI RETI	PILIOSTIGMA RETICULATUM			BAGANDE	BAGHANGA	MBARKELEEHI	BARKELEEJE	1
BS	PTER LUCE	PTEROCARPUS LUCENS			BOUTOUNBOU	PEMPELAGA	CAMI	CAME	1
BS	SCLE BIRR	SCLEROCARYA BIRREA	PRUNIER		BUNAMAGABU	NOABEGA	EEDI	EEDE	0
BS	TAMA INDI	TAMARINDUS INDICA	TAMARINIER		BUPUGUBU	PUAGA	NJAMMI	JAMME	1
BS	ZIZI MAUR	ZIZIPHUS MAURITIANA	JUJUBIER		BAGANDRE	MAGUNUGA	NJAABI		0
BS	ZIZI MUCR	ZIZIPHUS MUCRONATA			MUEGUNGA	MUGUNINGA	NGULUNJAABI		0
BS	ZIZI SPIN	ZIZIPHUS SPINA-CHRISTI							0
BS	???? ????	ONBEKENDE (DODE) BOOM							0
EG	ANDR PSEU	ANDROPOGON PSEUDAPRICUS			NIANTA		SIIWUKO	NIANTARE	0
EG	ARIS ADSC	ARISTIDA ADSCENSIONIS			BOUGEMOUGO	MOPOUYE	SELBO	KARAGUEHO	0
EG	ARIS FUNI	ARISTIDA FUNICULATA			KOM-BAMGOUMSAADRE		SELBO	HOUDO-KOLAGAL	0
EG	ARIS HORD	ARISTIDA HORDEACEA			BAA-ZOURE		BUTAKUREJE	LAS-FOROU	0
EG	BRAC DEFL	BRACHIARIA DEFLEXA					FOARDOUKO	PAGGURI	0
EG	BRAC DIST	BRACHIARIA DISTICHOPHYLLA			KOOLRAGA		PAGGURI	BURUDE	0
EG	BRAC LATA	BRACHIARIA LATA			KAOLA	KOUARE	PAGGA PUCCI		0
EG	CENC BIFL	CENCHRUS BIFLORUS			RAANI		HEBBERE	KEBBE	0
EG	CENC PRIE	CENCHRUS PRIEURII					HEMMBERE	KOBBE-BURU	0
EG	CHLO PILO	CHLORIS PILOSA			MONPOUYO				0
EG	CTEN ELEG	CTENIUM ELEGANS							
EG	DACT AEGY	DACTYLOCTENIUM AEGYPTIUM			WANTEGA	TARGANGA	BURUUGEL	FUTUKU	0
EG	DIGI GAYA	DIGITARIA GAYANA							0
EG	DIGI HORI	DIGITARIA HORIZONTALIS			TINTINRE				0
EG	DIHE HAGE	DIHETEROPOGON HAGERUPII							0
EG	ERAG PILO	ERAGROSTIS PILOSA					SIIWUKO	SI'UKO	0
EG	ERAG TENE	ERAGROSTIS TENELLA					LAMLAMKO		0
EG	ERAG TREM	ERAGROSTIS TREMULA			SAAGA		BURUUDI	PAGOURI-DIAU-LE	0
EG	ERAG TURG	ERAGROSTIS TURGIDA							0
EG	LOUD TOGO	LOUDETIA TOGOENSIS			SUTU	SOUDOUNGOU	SELBO	CELBI	0
EG	ORYZ SATI	ORYZA SATIVA					MAARO		0
EG	PANI LAET	PANICUM LAETUM			PINKILEGA		PAGGURI	N'GANCHIRI	0
EG	PENN PEDI	PENNISETUM PEDICELLATUM			KIMBOGO	KIIMOGO	BOGODOLLO	BOGODOLLOOJI	0
EG	PENN TYPH	PENNISETUM TYPHOIDES	PETIT MIL		CAJOUI		MOUTRI		0
EG	SCHO GRAC	SCHOENEFELDIA GRACILIS			LAOUGODO	SORPOUKA	NYOMRE	KARAGEHO	0
EG	SETA PALL	SETARIA PALLIDE-FUSCA			KOUSGA	BASORE	SAFUURE		0
EG	SORG BICO	SORGHUM BICOLOR	SORGHO BLANC	SORGHO ROUGE	KAZINGA	KARAOGA	MOJONOORI	BE-HERI	0
EG	TRIP MINI	TRIPOGON MINIMUS			SAOMBTENGA		BAHELL	MANGEL MANGURLA	0
EK	ACAN HISP	ACANTHOSPERMUM HISPIDUM			SINKAORE	SANGOANGA	LABBEL FOWRU	TOUPE-TOUBAKO	0
EK	ALYS OVAL	ALYSICARPUS OVALIFOLIUS			REMSA		BUNDIYA	SINKAARE	1

ANNEX 8 LIST WITH ALL SPECIES FOUND DURING THE SURVEY

GRF : occurence of species (EK=annual herb)
SPECCODE : four character species code
LATIN : species name in Latin
FRENCH1 : species name in French (1st option)
FRENCH2 : name in French (2nd option)
MOREE1 : species name in Moree (1st option)
MOREE2 : species name in Moree (2nd option)
PEUHL1 : species name in Peuhl (1st option)
PEUHL2 : species name in Peuhl (2nd option)
L : leguminous (1) or no leguminous (0)

GRF	SPECCODE	LATIN	FRENCH1	FRENCH2	MOREE1	MOREE2	PEUHL1	PEUHL2	L
EK	AMAR GRAE	AMARANTHUS GRAECIZANS					NYUNKUNI	LEGEY	0
EK	ARAC HYPO	ARACHIS HYPOGEA	ARACHIDE	CACAHUETE			YIRIIRE	SUNKAARU	1
EK	ASPI ANTE	ASPILIA (ANTELMA?)					GOUDOUBAL		0
EK	BLEP LINA	BLEPHARIS LINARIIFOLIA			SILNAYHGA		GIRIINGAL	GIRNGAL	0
EK	CASS MIMO	CASSIA MIMOSOIDES			TINROANGA	MARE	GAURAL	MOJI	1
EK	CHRY AMER	CHRYSANTELLUM AMERICANUM					YAADATA		0
EK	CITR LANA	CITRULLUS LANATUS	PASTEQUE SAUVAGE DOUCE						0
EK	CLEO SCAP	CLEOME SCAPOSA			YAR-KINLBO		HISSO		0
EK	COMM BENG	COMMELINA BENGHANLENSIS							0
EK	CORC OLIT	CORCHORUS OLITORIUS			VOULVAAKA		FAKO	BOULBAAKA	0
EK	CROT PODO	CROTALARIA PODOCARPA			WEND-LEBINDE-RAGA		GODARO		1
EK	CUCU MELO	CUCUMIS MELO			KIRENIGI	NO-GNABA	DENDELOL	DEENET-BALI	0
EK	CUCU METU	CUCUMIS METULIFERUS							0
EK	CYPE AMAB	CYPERUS AMABILIS					GOALL	GOHE	0
EK	CYPE DIFF	CYPERUS DIFFORMIS			SINTOUMSINGO	SANSAONGO	GOWE		0
EK	DETE NODI	DETERNANTHERA NODIFLORA			YODGA	TING-DOAGA			0
EK	FIMB EXIL	FIMBRISTYLIS EXILIS			YIBRE-ZOUGPEOGO		BAHELL	PAGOURI DJIGORI	0
EK	FIMB LITT	FIMBRISTYLIS LITTORALIS							0
EK	GYNA GYNA	GYNANDROPSIS GYNANDRA			KINLBEDO		CELLEBODO	KELBEDO	0
EK	HYGR AURI	HYGROPHILA AURICULATA							0
EK	HYPT SPIC	HYPTIS SPICIGERA			NIOUNOUNIOUGOU		BUNDUURE	NIOUNOUNIOUGOU	0
EK	INDI DIPH	INDIGOFERA DIPHYLLA					LEGAHI	WULUREHI	1
EK	INDI HIRS	INDIGOFERA HIRSUTA							1
EK	IPOM ERIO	IPOMOEA ERIOCARPA			GUINOUGITOU		LAYENDI		0
EK	IPOM HETE	IPOMOEA HETEROTRICHA			GUINOUGITOU	NIOMGA	LAYEDI-GORAEVOL		0
EK	KYLL SQUA	KYLLINGA SQUAMULATA							0
EK	LAGE SICE	LAGENARIA SICERARIA	CALEBASSE		KA-ANDE		TOUNGOUROU		0
EK	LEUC MART	LEUCAS MARTINICENSIS			ROUMROUMDI		BOUTALEL		0
EK	LUDW ABYS	LUDWIGIA ABYSSINICA							0
EK	MITR VILL	MITRACARPUS VILLOSUS					GUDDUDELL		0
EK	MOLL NUDI	MOLLUGO NUDICAULIS					SAAFAARE YAARE	CAFAAJE JAAHI	0
EK	MONE ALIA	MONECHMA (ALIARIS?)							0
EK	MONE CILI	MONECHMA CILIATUM			MOGWIIDOUGOU		BONKOTJAL		0
EK	MUKI MADE	MUKIA MADERASPATANA							0
EK	NICO TABA	NICOTIANA TABACUM	TABACCO				LEGGAL TABO	LEDDE TABA	0
EK	PAND HEUD	PANDIAKA HEUDELOTII			MONRAADO				0
EK	PAND INVO	PANDIAKA INVOLUCRATA			YOD-PELA		GIRIINGAL	KORRENDOUO	0
EK	PERI BICA	PERISTROPHE BICALYCULATA							0
EK	PHYS ANGU	PHYSALIS ANGULATA							0
EK	POLY LINE	POLYCARPAEA LINEARIFOLIA			NIOUGO-NAKILA		LABA-HOREHI		0
EK	RHYN MEMN	RHYNCHOSIA MEMNONIA							0
EK	RHYN MINI	RHYNCHOSIA MINIMA							0
EK	SCOP DULC	SCOPARIA DULCIS							0

ANNEX 8 LIST WITH ALL SPECIES FOUND DURING THE SURVEY

GRF : occurence of species (EK=annual herb,MG/MK=perannual grass/herb PP=parasite,TK=biannual herb)
SPECCODE : four character species code
LATIN : species name in Latin
FRENCH1 : species name in French (1st option)
FRENCH2 : name in French (2nd option)
MOREE1 : species name in Moree (1st option)
MOREE2 : species name in Moree (2nd option)
PEUHL1 : species name in Peuhl (1st option)
PEUHL2 : species name in Peuhl (2nd option)
L : leguminous (1) or no leguminous (0)

GRF	SPECCODE	LATIN	FRENCH1	FRENCH2	MOREE1	MOREE2	PEUHL1	PEUHL2	L
EK	SESA INDI	SESAMUM INDICUM	SESAM				NAMTIIRI LEULA		0
EK	SESB PACH	SESBANIA PACHICARPA							1
EK	SIDA STIP	SIDA STIPULATA							0
EK	STRI HERM	STRIGA HERMONTICA							0
EK	TRIP MINI	TRIPOGON MINIMUS					MANGEL MANGURLA	BAHEL	0
EK	TRIU PENT	TRIUMFETTA PENTANDRA			GOMTIGORGA	GOMTIGO-LAMDO	HABOU-DIOGNORDE		0
EK	VICO LEPT	VICOA LEPTOCLADA							0
EK	VIGN RADI	VIGNA RADIATA					NIEBE-LEOLA		1
EK	VIGN UNGU	VIGNA UNGUICULATA	NIEBE		BINGA		NYEBBE		1
EK	VOAN SUBT	VOANDZEIA SUBTERRANEA	POIS DE TERRE	POIS BAMBARA	SOUMA	SOUM-MOAGA	GIRIIJE JORDE	GUINIDIE	1
EK	ZORN GLOC	ZORNIA GLOCHIDIATA			DINGENDERE	NATOU-KOULI	DENGEERE	LENGERI	1
MG	ANDR GAYA	ANDROPOGON GAYANUS			PITOU		LANYERE	RADJARE	0
MG	CHLO GAYA	CHLORIS GAYANA			ZINNIBA	KINABODO			0
MG	CYMB SCHO	CYMBOPOGON SCHOENANTHUS					WUULUNNDE	BULUUJE	0
MG	HYPH RUFA	HYPHARHENIA RUFA							0
MG	ORYZ LONG	ORYZA LONGISTAMINATA					BURGU		0
MG	PASP SCRO	PASPALUM SCROBICULATUM			MO-FAOGO				0
MG	ROTT COCH	ROTTBOELLIA COCHINCHINENS IS							0
MK	ABUT TREN	ABUTILON (TRENOSUM?)							0
MK	CASS NIGR	CASSIA NIGRICANS			ZOMDRE-KOUHA		NIANGARI-BUBU	DJAM-GOROAARE	1
MK	CYPE ESCU	CYPERUS ESCULENTUS							0
MK	CYPE ROTU	CYPERUS ROTUNDUS					GOWAL	GOO'E	0
MK	EVOL ALSI	EVOLVULUS ALSINOIDES					LEMREHI		0
MK	HIBI ASPE	HIBISCUS ASPER			BITO		POLLEH		0
MK	INDI TINC	INDIGOFERA TINCTORIA			KARDEGA				1
MK	LAGG OLOP	LAGGERA OLOPTERA							0
MK	LEPT HAST	LEPTADENIA HASTATA			LELOUNGO	LELINGO	NDULOOHI	LELINGOO	0
MK	NELS CANE	NELSONIA CANESCENS							0
MK	PERG DAEM	PERGULARIA DAEMIA			ALKA-FOUSSI				0
MK	PUPA LAPP	PUPALIA LAPPACEA			NYONGTABODO	GNIAMKI	NYAKABERE	NYAKABAL	0
MK	SIDA ALBA	SIDA ALBA			SAAWARE				0
MK	SOLA AETH	SOLANUM AETHIOPICUM	AUBERGINE						0
MK	SOLA INCA	SOLANUM INCANUM					GITE NGAARI		0
MK	TEPH BRAC	TEPHROSIA BRACTEOLATA			NINTUNDEGAGDE		GORDA		1
MK	TEPH NIOR	TEPHROSIA (NIORA?)							1
PP	TAPI OPHI	TAPINANTHUS (OPHIOIDES?)							0
TK	ACHY ASPE	ACHYRANTHES ASPERA			BAG-YOBELA		M'BAGGA	KOBBE-DJAULE	0
TK	BLUM AURI	BLUMEA AURITA							0
TK	BORR RADI	BORRERIA RADIATA			YOD-NIOMGA		GUDDEL	DUBURRI	0
TK	BORR STAC	BORRERIA STACHYDEA			YOD-SABLAGA				0
TK	CASS OBTU	CASSIA OBTUSIFOLIA	CASSE PUANTE		SYOUGEDO		UULO	UULOROOWOL	1
TK	CORC TRID	CORCHORUS TRIDENS			VOULVAAK-RAAGA		FAKO	BOULBAAKA-GOORO	0
TK	CROT RETU	CROTALARIA RETUSA	ARACHIDE DE BROUSSE		WEND-TOLEBINDE		YATA-NSNGUEHI		1

ANNEX 8 LIST WITH ALL SPECIES FOUND DURING THE SURVEY

GRF : occurence of species (TK=biannual herb,ZG/ZK=unkown name grass/herb)
SPECCODE : four character species code
LATIN : species name in Latin
FRENCH1 : species name in French (1st option)
FRENCH2 : name in French (2nd option)

MOREE1 : species name in Moree (1st option)
MOREE2 : species name in Moree (2nd option)
PEUHL1 : species name in Peuhl (1st option)
PEUHL2 : species name in Peuhl (2nd option)
L : leguminous (1) or no leguminous (0)

GRF	SPECCODE	LATIN	FRENCH1	FRENCH2	MOREE1	MOREE2	PEUHL1	PEUHL2	L
TK	EUPH HIRT	EUPHORBIA HIRTA	MALNOMMEE	JEAN ROBERT	WALBISSOUM		KOSAHI	INDAMBOUGALI	0
TK	HIBI CANN	HIBISCUS CANNABINUS	KENAF				POLLI		0
TK	HIBI ESCU	HIBISCUS ESCULENTUS	GOMBO	KETMIE COMESTIBLE			LAHAJE		0
TK	HIBI SABD	HIBISCUS SABDARIFFA	OSEILLE				FOLLERE	LAMMUDE	0
TK	MELO CORC	MELOCHIA CORCHORIFOLIA			KAFERMANA				0
TK	PHYL PENT	PHYLLANTHUS PENTANDRUS			SALGOMDE		GAURIHI		0
TK	PORT GRAN	PORTULACA GRANDIFLORA							0
TK	SESB SESB	SESBANIA SESBAN			MOIGA				1
TK	STYL MUCR	STYLOSANTHES MUCRONATA							1
TK	TEPH PURP	TEPHROSIA PURPUREA							1
TK	WALT INDI	WALTHERIA INDICA					KOPPETEEKI	POPPETEKI	0
TK	WISS AMPL	WISSADULA AMPLISSIMA							0
ZG	PENN ????	PENNISETUM SPP							0
ZG	SPOR ????	SPOROBOLUS SPP							0
ZG	???? ????	ONBEKEND GRAS							0
ZK	ABUT ????	ABUTILON SPP							0
ZK	BIDE ????	BIDENS SPP							0
ZK	CISS ????	CISSUS SPP							0
ZK	CROT ????	CROTALARIA SPP							1
ZK	HYGR ????	HYGROPHILA SPP							0
ZK	INDI ????	INDIGOFERA SPP							1
ZK	IPOM ????	IPOMOEA SPP							0
ZK	KOHA ????	KOHAUTIA SPP							0
ZK	NOTH ????	NOTHOSAERVA SPP							0
ZK	ORTH ????	ORTHOSIPHON SPP							0
ZK	TEPH ????	TEPHROSIA SPP							1
ZK	???? ????	ONBEKEND KRUID							0
ZK	???? ????	FAMILLE DES ASTERACEAE							0

ANNEX 9 ADAPTED CONDENSED FORMAT FILE

Condensed format file of ninety nine homogeneous vegetation samples T
(I5, 9(I5,F 3. 0)) 9

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    1   32 4   35 3   37 3   40 3   51 3   52 4   54 3   66 3   74 3
    1   86 2   90 3   93 3   99 2  105 3  125 3  129 2  154 3  162 4
    1  174 1  187 7  204 1  213 4
    2   31 3   32 3   35 2   40 3   52 3   54 3   57 3   68 1   90 3
    2   93 3   99 3  105 3  106 1  129 1  176 2  187 1  206 1  211 1
    3   31 6   32 5   54 1   57 3   74 4  176 4  186 4  187 6  189 1
    3  197 4  206 5
    4   31 5   32 1   33 1   40 5   48 4   52 1   54 3   57 4   79 3
    4   93 3  125 1  187 4  197 1  206 4
    5   31 4   32 3   33 4   40 5   47 3   49 4   54 4   57 3   64 3
    5   71 1   93 3  105 2  112 3  118 2  125 1  129 1  141 1  176 1
    5  186 4  187 4  197 1  205 4  206 5  212 1
    6   31 6   52 4   74 3   90 3  111 3  118 1  129 3  162 1  183 1
    6  184 1  186 1  187 5  197 1  205 1  206 5
    7   31 4   32 2   52 2   54 2   74 4   90 3   93 1  118 1  125 2
    7  187 1
    8    2 1   27 1   32 3   40 3   46 3   52 3   54 6   74 4  118 4
    8  122 1  131 2  153 1  184 1  187 2
    9   31 5   32 3   49 3   52 4   54 4   57 3   90 3   93 3  162 1
    9  184 4  185 1  206 1
   10    5 1   31 4   32 3   38 3   40 4   54 4   90 3   93 3  118 4
   10  131 1  186 4  187 4  213 4
   11   31 3   40 5   49 4   54 1   57 3   74 3   90 2  187 4  206 1
   11  212 1
   12   15 4   16 4   31 3   52 3   54 3   57 3   74 3   83 1  118 3
   12  141 1  175 1  176 1  184 5  187 4  197 1  211 4
   13   31 6   40 3   49 4   52 4   54 4  161 1  184 1  185 1  186 1
   13  188 4
   14   31 7   32 2   40 3   47 1   49 3   52 2   54 4   57 3   64 3
   14   70 1   74 1   85 1   90 3   93 3  105 1  106 2  111 3  118 3
   14  130 2  132 1  176 1  206 1  212 1
   15    5 4   27 5   28 4   31 9   32 3   33 4   41 3   46 3   49 3
   15   52 3   54 5   55 3   57 3   64 1   74 3   86 2  105 3  112 3
   15  113 3  114 1  118 1  122 1  131 1  141 1  161 1  165 4  168 1
   15  172 4  176 4  186 4  187 1  205 4  206 1  212 2
   16    5 4    6 4    9 5   16 4   27 5   31 7   32 3   37 2   41 2
   16   46 3   49 3   52 3   54 7   57 4   64 1  105 4  122 3  126 1
   16  127 3  161 5  166 3  176 4  183 3  186 5  198 1  205 6  206 3
   16  211 5
   17    3 1    9 4   13 1   16 4   20 1   31 6   32 3   47 3   52 3
   17   54 4   57 3   70 1   90 3   93 3  105 3  106 3  118 4  129 3
   17  131 2  133 2  141 3  163 4  176 4  178 1  183 1  186 4  187 1
   17  198 1  205 5  206 4  212 1  215 1
   18    3 4    4 4    9 4   16 1   19 1   31 7   33 3   46 4   49 3
   18   52 3   54 3   57 3   64 1  105 3  106 3  111 3  122 1  125 3
   18  131 1  140 3  141 3  146 1  176 2  182 1  183 1  184 1  186 5
   18  191 1  195 4  198 4  206 4  211 4  212 1
   19    3 1    9 4   15 1   31 4   32 3   38 3   39 3   47 3   49 4
   19   52 4   54 4   59 1   86 2  114 1  118 1  129 3  131 4  141 3
   19  161 4  165 1  176 1  184 4  185 1  203 2  205 4  206 1
   20    3 4   16 1   21 4   27 4   31 4   32 3   52 3   54 4   55 1
   20   57 3   60 1   83 3   90 1  105 3  122 3  129 3  141 2  161 1
   20  165 1  176 1  186 4  205 1  206 2  214 1
   21    3 1   10 5   16 4   27 1   29 1   32 3   35 3   39 3   52 3
   21   54 4   55 3   58 3   62 3   80 1  105 3  118 3  122 3  127 3
   21  131 4  132 3  161 1  167 1  172 4  173 2  186 4  187 1  200 1
   21  217 1
   22   31 8   32 3   54 3   63 3   90 3   93 3  111 3  118 3  129 3
   22  154 3  166 1  172 1  206 1  208 1  212 1
   23    3 4    5 4   16 4   21 1   27 4   31 6   46 3   49 5   52 7
   23   54 4   55 3   59 3   70 1   95 1  106 3  122 3  127 3  129 3
   23  131 3  163 1  165 1  186 4  187 1  205 5  206 4  212 1  214 1
   24   11 1   15 4   31 6   32 1   39 3   41 1   49 4   52 5   54 3
   24   57 3   89 1   90 1  105 4  127 1  166 1  172 4  176 1  180 4
   24  186 4  187 1  189 1  205 6  206 1
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25	31 3	32 3	37 3	41 1	47 1	49 3	51 2	52 3	54 4
25	74 2	176 1	187 3	205 1	206 4				
26	31 3	49 3	52 3	54 5	187 1	206 3			
27	23 1	32 3	35 3	37 3	46 4	47 2	54 3	58 2	60 3
27	80 1	110 1	111 1	118 1	129 3	132 3	133 1	173 1	176 1
27	211 1								
28	32 5	35 3	37 3	41 3	42 1	47 3	51 3	54 7	60 3
28	74 1	85 1	86 1	93 1	105 3	112 1	118 1	129 3	131 3
28	132 1	138 1	176 2	187 1	212 2	213 1			
29	31 3	32 4	33 2	35 4	37 3	47 3	49 3	54 6	105 3
29	118 3	120 1	122 1	141 2	163 1	172 1	173 1	212 1	
30	10 1	32 3	37 2	46 1	54 7	86 1	132 1	140 1	141 1
30	159 1	160 1	172 1	173 1	207 1	208 3			
31	2 4	32 3	52 3	54 8	59 3	106 2	118 3	122 3	131 6
31	160 1								
32	2 4	32 5	47 3	54 5	64 3	105 3	118 1	176 1	
33	32 4	35 3	37 2	38 2	41 2	46 3	47 1	54 4	68 1
33	105 3	131 1	176 1	207 1					
34	31 3	32 5	54 7	80 3	111 4	118 3	122 3	129 2	131 3
34	140 1	146 1	165 1	178 1	217 1				
35	32 4	37 3	54 4	68 1	70 1	80 3	111 3	114 1	129 1
35	165 1	166 1							
36	10 1	32 3	54 6	59 1	165 4	166 1			
37	37 3	47 3	53 5	54 3	68 3	103 3	106 2	129 3	131 3
37	163 1	172 1	173 2						
38	10 1	47 3	54 7	105 3	118 3	131 4	144 3	164 1	175 1
39	5 4	32 4	38 3	54 4	131 3	153 1			
40	32 4	35 3	47 3	54 4	59 3	118 1			
41	10 1	32 1	35 3	37 2	46 2	54 3	208 1		
42	10 1	32 3	37 3	47 3	54 4	57 3	70 1	93 3	118 1
42	132 3								
43	32 3	37 4	38 2	46 3	47 3	49 2	54 5	105 1	116 1
43	118 4	124 4	129 3	141 3	144 1	179 1	187 1		
44	31 3	32 3	41 3	46 3	47 3	52 3	54 4	67 1	86 2
44	114 1	132 1	141 1	176 4	206 4				
45	10 4	31 3	32 3	46 3	52 3	54 7	59 1	68 1	70 1
45	132 1	156 1	165 1	166 4	168 4	172 1	212 4		
46	10 4	31 3	32 3	46 3	52 4	54 4	57 3	60 3	64 1
46	80 1	91 1	93 1	98 1	106 3	121 1	122 2	125 2	127 3
46	131 2	168 1	172 1	173 1	176 4	183 2	187 1	206 1	212 6
47	6 1	10 4	32 4	41 3	46 3	47 2	52 3	53 3	54 6
47	55 3	62 2	64 3	78 1	83 1	86 1	91 2	93 3	104 3
47	107 3	116 1	118 4	121 1	122 1	126 1	127 3	129 3	165 4
47	166 1	172 4	173 4	176 1	183 1	212 4			
48	32 3	37 5	41 3	46 3	47 1	52 3	54 4	60 1	86 1
48	105 1	114 1	176 4						
49	30 4	31 4	32 1	46 3	52 4	54 5	57 3	60 1	91 2
49	105 3	106 1	118 4	125 3	131 3	132 1	165 1	168 1	176 1
49	212 1	217 1	218 1						
50	7 4	9 4	31 6	36 3	45 5	49 5	52 3	54 4	64 3
50	68 3	78 1	87 3	106 4	113 3	116 3	122 3	128 3	129 4
50	146 1	161 4	167 4	172 4	176 1	183 1	184 4	185 1	186 1
50	187 1	205 4	206 5	211 4	212 4	213 1			
51	4 1	6 1	10 4	39 3	41 3	46 5	52 3	54 5	58 3
51	59 3	105 3	118 1	131 3	163 1	168 2	172 1	173 3	
52	4 1	6 1	10 4	32 4	52 4	54 4	105 3	118 3	129 3
52	131 3	172 1	173 1	208 1	211 1	212 4			
53	15 1	22 4	37 1	39 3	40 3	44 3	47 3	52 3	54 3
53	59 3	105 3	118 4	121 3	129 1	132 3	141 3	179 4	186 4
53	194 4	195 1							
54	37 3	39 6	46 3	47 2	52 3	54 3	60 3	81 2	86 1
54	91 2	105 3	114 2	116 1	118 3	122 3	127 3	129 3	131 2
54	132 3	137 3	141 1	152 1	173 1	176 1	186 4	187 4	206 2
54	211 4	212 4							
55	37 3	52 4	83 2	118 3	121 3	141 2	152 1	187 4	
56	12 4	19 5	22 4	28 4	31 4	47 3	52 5	54 6	59 4
56	69 3	105 5	106 4	118 1	122 3	129 3	154 5	158 4	167 4
56	168 4	192 4	193 4	206 1	212 5	216 1			
57	9 4	26 4	32 5	49 3	52 6	105 3	106 4	108 5	111 3
57	125 3	146 3	184 1	185 4	186 1	205 4	206 5	211 1	212 4
58	31 6	32 4	52 4	54 6	59 4	68 3	81 2	91 1	105 3
58	106 4	110 1	122 3	127 2	129 3	132 3	133 2	154 3	167 4
58	168 4	172 1	173 1	181 1	183 1	196 1	202 1	206 4	212 4
58	216 4	217 4							
59	7 4	9 4	31 3	42 3	46 3	47 4	49 3	52 3	54 4
59	55 2	60 1	64 3	70 2	106 3	109 3	113 4	122 2	129 4
59	132 5	141 2	167 4	168 4	170 1	172 4	173 1	176 4	206 1
59	212 4								
60	31 3	32 3	46 4	52 3	54 2	55 4	58 3	59 3	89 2
60	106 3	116 3	122 3	131 1	133 1	161 1	182 1	186 1	187 4
60	192 1	206 4	211 1	212 4					
61	6 6	31 3	32 3	34 2	52 3	54 6	105 3	111 3	122 1
61	129 3	132 3	141 1	167 4	168 4	176 2	212 1	217 1	
62	6 4	28 4	31 5	32 3	106 6	108 5	165 1	166 1	
63	4 1	6 4	10 4	21 4	31 4	32 3	52 5	54 4	59 3
63	80 3	106 6	111 4	118 3	125 3	131 4	133 3	141 3	154 3
63	167 1	172 1	206 1	208 1	211 1	212 1	216 4	217 1	
64	6 4	9 5	25 5	27 1	77 3	84 3	109 3	176 1	186 4
64	187 1	199 1	201 1	222 4	223 4	224 1			
65	14 4	22 4	28 4	29 4	31 4	52 4	54 7	85 3	106 3
65	118 2	141 3	186 4	205 5	206 4	212 5			
66	28 4	31 4	52 2	54 4	56 4	61 7	106 3	118 1	131 3
66	141 3	178 1	212 4	219 1					
67	22 4	28 4	39 3	46 3	47 3	51 4	52 3	54 8	55 2
67	59 3	71 7	72 2	74 2	82 3	85 3	105 4	113 3	118 4
67	129 2	132 1	140 2	141 3	144 2	179 2	211 4	212 1	
68	3 1	9 5	12 1	15 4	29 4	31 3	35 3	39 3	46 3
68	52 7	54 4	58 1	59 3	62 3	105 3	122 3	127 3	129 3
68	131 4	146 3	162 1	186 4	187 1	198 1			
69	3 4	5 4	6 4	9 5	10 1	20 1	28 4	29 4	39 3
69	52 2	58 1	62 3	89 1	94 1	118 3	122 3	131 3	133 1
69	141 1	142 3	150 1	161 1	176 1	182 1	183 1	189 1	190 1
69	198 1	206 1	214 1						
70	22 5	52 4	54 4	56 7	78 7	100 4	106 5	136 5	211 4
70	212 4								
71	29 4	31 3	32 4	41 3	46 4	47 3	52 6	54 4	56 5
71	59 6	62 3	83 3	91 3	100 3	102 3	106 4	122 3	127 4
71	132 1	136 4	146 1	167 1	183 1	198 1	217 4		
72	31 4	32 3	47 5	52 3	53 3	54 3	56 4	61 4	83 3
72	100 3	103 3	106 3	132 3	136 3	141 3	167 1	172 4	178 1
72	211 1	212 4							
73	11 4	47 3	52 4	53 4	54 3	56 8	78 3	81 1	83 3
73	122 2	132 2	135 3	136 3					
74	10 5	26 4	31 4	47 4	52 3	54 3	59 3	61 5	65 2
74	69 2	78 3	81 2	83 2	106 3	122 3	127 3	132 2	136 1
74	165 4	172 4	183 1	206 1	212 4				
75	31 4	32 3	47 4	52 3	53 4	54 3	55 3	56 4	59 3
75	64 3	69 2	83 2	89 3	93 1	97 2	100 1	103 4	105 2
75	118 4	122 2	129 3	132 3	133 1	136 1	141 1	176 4	186 4
75	206 4	212 2							
76	19 4	31 3	32 3	42 3	47 1	48 1	52 4	54 5	55 3
76	56 5	59 5	62 4	68 3	78 3	81 3	83 3	89 2	93 1
76	97 2	98 3	100 3	102 3	105 2	106 4	122 3	128 1	129 3
76	132 3	133 3	136 3	141 1	176 2	212 5			
77	1 4	26 4	37 1	41 3	47 3	52 4	54 2	56 4	58 3
77	68 3	78 3	81 3	83 3	85 3	93 1	98 1	103 3	104 3
77	106 4	118 3	132 3	135 3	136 2	171 1	211 1	212 4	215 1
78	26 4	41 3	43 3	46 3	47 3	53 3	56 5	58 1	59 3
78	68 3	76 1	78 3	80 1	81 3	83 3	85 4	88 3	93 1
78	101 1	116 2	118 3	121 2	127 2	129 2	132 3	136 3	141 1
78	151 1	164 2	190 1	212 3					
79	23 1	46 3	47 3	52 4	53 3	55 1	56 5	58 3	59 3
79	60 3	68 3	78 1	83 3	91 1	93 3	100 3	106 3	118 1
79	122 3	129 1	132 3	136 3	143 3	176 1	206 2	208 1	211 4
79	212 5								
80	18 1	39 3	41 3	46 3	47 3	52 3	53 3	54 3	56 5
80	59 3	64 1	68 3	69 3	81 1	83 3	85 1	93 3	103 3
80	106 3	118 3	129 2	131 3	132 2	136 3	147 3	217 1	
81	10 1	47 3	52 3	53 3	56 4	59 3	68 3	87 3	93 3
81	97 3	106 4	129 3	145 3	178 1	206 4	212 4		
82	6 1	31 4	32 1	34 2	47 1	54 4	56 4	68 3	85 1
82	93 3	97 3	105 2	111 1	118 1	129 3	132 3	136 2	164 1
82	167 1	168 4	176 1	212 4	217 1				
83	6 1	13 1	26 4	35 5	52 3	53 3	54 5	59 3	68 3
83	70 1	80 2	83 3	98 1	111 4	122 3	131 5	132 3	146 3
83	152 1	157 1	177 1	208 1					
84	7 4	24 4	45 3	46 3	52 4	55 3	56 4	58 3	59 3
84	68 3	78 4	81 3	84 3	87 3	106 3	113 3	122 3	132 3
84	135 3	136 3	139 3	146 3					
85	12 4	53 3	54 3	56 4	59 3	62 3	67 3	68 3	81 3

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85   86 1    93 3    97 4   100 3   116 1   122 3   131 3   132 3   135 2
85  136 3   139 3   164 1
86   14 4    47 3    52 4    59 3   106 6   131 3   140 2   184 1   205 4
86  206 1   211 4   212 6
87    4 4    10 4    35 3    46 3    52 3    56 5    58 3    59 1    62 3
87   68 4    73 3    81 4    83 3   102 1   106 3   113 3   131 3   132 3
87  133 1   136 3   139 3   173 2   186 1   217 1
88   17 4    29 4    35 3    42 2    45 3    52 4    55 3    56 4    58 1
88   59 3    62 3    68 3    78 1    83 3    91 1    93 3   106 4   115 1
88  118 3   122 3   127 3   131 3   132 3   155 3   169 1   192 1   212 4
89   26 1    45 1    47 1    56 5    58 1    59 3    62 3    78 3    81 1
89   97 3   106 4   122 1   131 1   132 3   134 1   136 1   138 1   212 4
90   47 1    58 1    59 1    78 1    81 2   123 6   132 1   212 1
91   56 5    68 1    81 1    91 1   100 1   118 1   122 1   129 1   131 2
91  136 3   167 1   168 1   212 1   217 1
92    4 1     9 4    19 1    28 4    29 4    47 3    52 5    55 3    56 3
92   59 3    62 3    78 3    80 1    85 3   102 3   106 5   116 1   122 3
92  127 3   131 3   136 2   141 1   187 1   192 1   196 1   206 1   211 4
92  212 4   225 1
93   19 4    26 4    56 3    62 5    64 3    68 4    73 5    78 5    84 3
93  115 1   127 3   131 1   132 3   139 3   146 3   193 1   211 1   212 1
94    9 4    19 5    25 5    31 4    50 7    52 4    64 3    73 3    75 6
94  100 3   106 3   131 3   132 3   139 3   146 4   209 4   211 4
95    4 4    25 4    36 1    46 3    51 3    62 3    64 3    73 3    75 3
95   84 3    96 3   108 4   122 3   131 4   132 3   146 2   164 1   209 4
95  210 4
96    8 1    24 7    25 5    36 3    46 3    62 2    73 3    78 3    84 3
96   92 3   108 4   115 1   117 3   118 4   119 4   128 4   132 1   146 4
96  148 4   149 5   221 1
97   24 5    36 5    72 3    77 3    78 3    81 3    84 3   118 6   126 1
97  149 7   220 4
98   25 6    73 3   108 4   118 1
99   25 6
 0
ACACALBIACACLAETACACMACRACACNILOACACSENEACACSEYAADANDIGIANACOCCIANOGLEIOBALAAEGY
BOMBCOSTBUTYPARKCALOPROCCASSSIEBCOMBGLUTCOMBMICRDIOSMESPEUCACAMAFICUPLATGREWBICO
GUIESENELANNMICRMAERCRASMANGINDIMITRINERPILIRETIPTERLUCESCLEBIRRTAMAINDIZIZIMUCR
ANDRPSEUARISADSCARISFUNIARISHORDBRACDISTBRACLATACENCBIFLCENCPRIECHLOPILOCTENELEG
DACTAEGYDIGIGAYADIGIHORIDIHEHAGEERAGPILOERAGTENEERAGTREMERAGTURGLOUDTOGOORYZSATI
PANILAETPENNPEDIPENNTYPHSCHOGRACSETAPALLSORGBICOTRIPMINIACANHISPALYSOVALAMARGRAE
ARACHYPOASPIANTEBLEPLINACASSMIMOCHRYAMERCLEOSCAPCOMMBENGCORCOLITCROTPODOCUCUMELO
CYPEAMABCYPEDIFFDETENODIFIMBEXILFIMBLITTGYNAGYNAHYGRAURIHYPTSPICINDIDIPHINDIHIRS
IPOMERIOKYLLSQUALEUCMARTLUDWABYSMITRVILLMOLLNUDIMONECILINICOTABAPANDHEUDPANDINVO
PERIBICAPHYSANGUPOLYLINERHYNMEMNRHYNMINISCOPDULCSESAINDISESBPACHSIDASTIPSTRIHERM
TRIUPENTVICOLEPTVIGNUNGUVOANSUBTZORNGLOCANDRGAYACHLOGAYACYMBSCHOORYZLONGABUTTREN
CASSNIGRCYPEESCUCYPEROTUEVOLALSIHIBIASPEINDITINCLAGGOLOPLEPTHASTNELSCANEPERGDAEM
PUPALAPPSIDAALBASOLAAETHSOLAINCATEPHBRACTAPIOPHIACHYASPEBLUMAURIBORRRADIBORRSTAC
CASSOBTUCORCTRIDCROTRETUEUPHHIRTHIBICANNHIBISABDPHYLPENTPORTGRANSESBSESBSTYLMUCR
WALTINDIWISSAMPLSPOR????ABUT????HYGR????IPOM????KOHA????NOTH????CITRSINEDALBMELA
LAGESICECUCUMETUCOMMAFRIINDI????ROTTCOCHCITRLANAPENN????ACACALB2ACACLAE2ACACLAE3
ACACMAC2ACACMAC3ACACNIL2ACACNIL3ACACSEN2ACACSEN3ACACSEY2ACACSEY3ADANDIG3ANOGLEI3
AZADIND2BALAAEG2BALAAEG3BOSCANG3BOSCSEN2BOSCSEN3CALOPRO2CALOPRO3CASSOCC3CASSSIE2
CASSSIE3COMBACU2COMBACU3COMBGLU2COMBGLU3COMBMIC2COMBMIC3COMBNIG2COMBNIG3DICHCIN2
DICHCIN3DIOSMES2DIOSMES3EUPHBAL3FICUPLA2FICUPLA3GARDSOK3GREWBIC2GREWBIC3GREWCIS3
GREWFLA2GREWFLA3GREWMOL3GREWTEN3GUIESEN2GUIESEN3MAERCRA2MAERCRA3MITRINE2MITRINE3
PILIRET2PILIRET3PTERLUC2PTERLUC3SCLEBIR2ZIZIMAU2ZIZIMAU3ZIZIMUC2ZIZISPI3CITRSIN2
CITRSIN3ACACPEN2DALBMEL2DALBMEL3ANNOSEN3
B1 510 1B2 21312B1 412 1B1 312 2C2 412 3B1 413 6B1 213 7B1 417 4B2 417 8B2 320 5
B1 324 3B2 327 3C2 3 2 5C2 416 3C2 5 8 1C3 6 8 2C2 516 1C2 516 4C2 422 1C2 322 2
C3 418 3A1 519 1C2 622 3C3 527 2C2 2 2 2C2 2 2 1C2 21310C2 414 1C2 415 1C2 317 1
C2 617 5C2 317 7C2 318 4A2 519 2C2 219 4C2 319 8C2 220 1C2 420 2C2 220 6B2 221 2
C2 221 3B2 223 1C2 324 2C3 2 5 1C3 5 6 2C2 41311C2 41314C2 223 2C2 326 4D  612 9
C3 518 6C2 321 1C2 411 1B2 413 5B1 217 3D  610 3C3 625 3C3 612 7D  51210C3 313 9
C3 425 2A1 626 1C2 626 2C2 416 2D  4 2 6C3 4 3 3C2 511 3D  519 5D  526 3C3 5 3 1
C2 510 2C2 4 4 2C3 5 5 2C3 4 6 4C2 512 4C3 512 6C3 313 2C2 413 4C3 413 8C3 318 1
C3 321 4C3 325 1A2 419 3D  419 6C3 220 4C3 427 1C3 320 7C3 31315D  31317D  31318
C2 219 9D  524 4D  624 1D  6 3 2D  318 5D  520 8D  519 7D  318 7D  318 2
```


ANNEX 10 FINAL TWINSPAN TABLE

```
CND FILE NUMBER              111 111222 1111222 22233333333344444 326 4444455555 55556566666666 777778887777788888889999 9999 99
                    123456789012 345456 6789031 78901235678980123 422 4567912345 67890013456789 567890120123434567890123 4567 89

LEGEND CODE         BBBBCBBBBBBB CECCCC CEECCCC CCCCCCCCCCCCCBCBC AAA CCCCCCCCBB CCCDCDCCEDCDDD CCCCCCCCCCCCCCDCCCCCCCCD DDDD DD
                    122122112212 2 2322 3  2223 22222221122222222     3323232221 33333332 13311 233233333333331333333233 2222 22
                        2        2 2211 2  2222 1212212  2211 1 1     12222222   222 1 22  2    22222222222222 22222222

TRACK NUMBER        111111111222  1 2    112221 11111111122222222 112   11212111 121111221  112 11111122 1   11222111122  121 11
                    032223377047 268722 8662228 34577789900031134 996 5633681137 05223256623196 223338153045699070333944 3809 88
PLOT NUMBER          1                          1                        11         1                             111
                    121236748533 531221 2141233 01115744812622312 211 1214461153 33709922263353 462481411222436417578941 2587 72
Main group 2
  Association of Fimbristylis exilis and Gardenia sokotensis
    66 CLEOS CAP    3----------- ------ ------- ----------------- --- ---------- -------------- ------------------------ ---- --
    99 SIDAS TIP    23---------- ------ ------- ----------------- --- ---------- -------------- ------------------------ ---- --
   162 ACACM AC3    4----1--1--- ------ ------- ----------------- --- ---------- ------------1- ------------------------ ---- --
   197 GARDS OK3    --4111-----1 ------ ------- ----------------- --- ---------- -------------- ------------------------ ---- --
    40 CTENE LEG    33-55--3-45- 33---- ------- ----------------- --- -------3-- -------------- ------------------------ ---- --
   125 TEPHB RAC    3--11-2----- ------ --3---- ----------------- --- --2-3----- -3-----3------ ------------------------ ---- --
    74 FIMBE XIL    3-4--344--33 -13-2- ------- -1--------------- --- ---------- -----------2-- ------------------------ ---- --
    90 PANDI NVO    33---33-332- -3-1-- -3--1-- ----------------- -3- ---------- -------------- ------------------------ ---- --
    33 ARISF UNI    ---14------- --4--- --3---- --2-------------- --- ---------- -------------- ------------------------ ---- --
    93 POLYL INE    33-33-1-33-- -3---- -3----- -1-------------3- -3- --13------ -------------- 11113333-------3--3----- ---- --
   187 COMBM IC3    71644512-444 --1131 -1---11 -1--------------1 --- --1-----44 ----41--1---1- ----------------------1- ---- --
  Association of Fimbristylis exilis and Loudetia togoensis
    57 TRIPM INI    -3343---3-33 -333-- 433-3-- ---------------3- --- --3-3----- -------------- ------------------------ ---- --
   213 PTERL UC2    4-------4--- ------ ------- -1--------------- --- ---------- -----1-------- ------------------------ ---- --
   206 GUIES EN3    -15455--1-1- -11143 344124- ----------------- -1- 4-1-----2- 154145-1-4---1 4---2-4-----1---1-----1- ---- --
    49 LOUDT OGO    ----4---3-4- 433433 3-34-5- --3-------------2 --- ---------- -3-3-5-------- ------------------------ ---- --
   184 COMBG LU2    -----1-14--5 1----- --14--- ----------------- --- ---------- -1---4-------- ----------------1------- ---- --
    15 COMBG LUT    -----------4 ---4-- ---1--- ----------------- --- -------1-- ------------4- ------------------------ ---- --
Main group 3
  Association of Pterocarpus lucens and Acacia macrostachya
    31 ANDRP SEU    -365464-5433 679633 767446- --3-------------- 385 333-4----- 4-633634-44-3- 43-----4-34-4----------- 4--- --
   186 COMBM IC2    --4-41---4-- 1-44-- 545-444 ----------------- --- -------44- -1--11--44--4- 4----------------1------ ---- --
   205 GUIES EN2    ----41------ --461- 65-415- ----------------- --- ---------- -4---4---5---- ----------------4------- ---- --
    16 COMBM ICR    -----------4 ------ 441-144 ----------------- --- ---------- -------------- ------------------------ ---- --
    27 PTERL UCE    -------1---- --5--- 5---441 ----------------- --- ---------- --------1----- ------------------------ ---- --
   161 ACACM AC2    ------------ 1-1--- 5--41-1 ----------------- --- ---------- ----14-------1 ------------------------ ---- --
   198 GREWB IC2    ------------ ------ 114---- ----------------- --- ---------- ------------11 ---------1-------------- ---- --
     3 ACACM ACR    ------------ ------ -141441 ----------------- --- ---------- ------------14 ------------------------ ---- --
    21 GUIES ENE    ------------ ------ ----41- ----------------- --- ---------- -------4------ ------------------------ ---- --
   214 PTERL UC3    ------------ ------ ----11- ----------------- --- ---------- -------------1 ------------------------ ---- --
     5 ACACS ENE    ---------1-- --4--- 4----4- -----------4----- --- ---------- -------------4 ------------------------ ---- --
   183 COMBA CU3    -----1------ ------ 311---- ----------------- --- --21------ --1--1-------1 ---------1--1----------- ---- --
    41 DACTA EGY    ------------ --311- 2------ -3----2-----3---- --- 3--3-3---- -------------- --33-3---3-------------- ---- --
Main group 4
  Association of Cenchrus bifloris and Brachiaria distichophylla
    32 ARISA DSC    43513-2333-- -2313- 33-33-3 354335443--434133 533 33341-4--- -54-3-33------ 33-----1-43------------- ---- --
    54 SCHOG RAC    33134-264413 445345 7434444 37678544637444345 73- 474655433- 6-642464-7484- 352--3-4443335-3-------- ---- --
   176 BOSCS EN3    -24-1------1 -1411- 44211-- 12---11-----4---- --- 4-411---1- ---4-12-1----1 42--1--1---------------- ---- --
    35 BRACD IST    32---------- ------ ------3 334---3------33-- --- ---------- ------------3- --------------5---33---- ---- --
    37 CENCB IFL    3----------- ----3- 2------ 3332--23-3--5-234 --- -------133 -------------- --1--------------------- ---- --
    38 CENCP RIE    ---------3-- ------ ---3--- ------2----3----2 --- ---------- -------------- ------------------------ ---- --
   159 ACACL AE2    ------------ ------ ------- ---1------------- --- ---------- -------------- ------------------------ ---- --
   160 ACACL AE3    ------------ ------ ------- ---11------------ --- ---------- -------------- ------------------------ ---- --
     2 ACACL AET    -------1---- ------ ------- ----44----------- --- ---------- -------------- ------------------------ ---- --
Main group 1
  Association of Cassia nigricans and Blepharis linariifolia
   111 CASSN IGR    -----3------ -3---- --3---- 1------3--------- 43- ---------- -3----34------ -------1-----4---------- ---- --
   166 ACACS EN3    ------------ ---1-- 3------ -------11-------- -11 -4-1------ -------------- ------------------------ ---- --
   165 ACACS EN2    ------------ --4--- ---111- -------14-------- 1-1 -1-41----- -------------- ------------4----------- ---- --
    63 BLEPL INA    ------------ ------ ------- ----------------- -3- ---------- -------------- ------------------------ ---- --
Main group 5
  Association of Pupalia lappacea and Balanites aegyptiaca
    46 ERAGT ENE    -------3---- --3--- 3-4--3- 4--1--3-----3-2-3 --- 333335--3- ---34------33- ---333---4----3--3------ -33- --
    86 MOLLN UDI    2----------- --2--- ---2--- -1-1--------1---- --- 2--1----1- -------------- ---------------1-------- ---- --
   172 BALAA EG2    ------------ --44-- ------4 --11-----1------- -1- -114-11--- --14-4-1------ ----------4-4----------- ---- --
   173 BALAA EG3    ------------ ------ ------2 1-11-----2------- --- --14-31-1- --11---------- -----------------2------ ---- --
    10 BALAA EGY    ------------ ------ ------5 ---1----1-1---11- --- -444-44--- -------4-----1 ------1-----5----4------ ---- --
    60 AMARG RAE    ------------ ------ ----1-- 33----------1---- --- --3-1---3- ---1---------- ----3------------------- ---- --
   121 PUPAL APP    ------------ ------ ------- ----------------- --- --11---3-3 -------------- ---2-------------------- ---- --
Main group 6
  Association of Andropogon gayanus and Anogeissus leiocarpus
    52 PENNP EDI    43-1-4234--3 423533 3334373 ----3-------3---- --- 3343434334 56433335-42372 344-433-4634334-434---5- 4--- --
```

106	ANDRG AYA	-1---------- -2---- -33--3- ----2----2------- --6 --3-1----- 444334-6-33--- -44-334-543-3-3-6344--5- 3--- --
118	LEPTH AST	----2114-4-3 -31--- -4-1--3 113-31----3--1-14 33- ---4413433 1------3-214-3 4-3313-1---------3--1-- --46 1-
105	ZORNG LOC	33--2------- -134-- 433-3-3 -33--33---3--1--1 --- ----33333- 533---3----43- 22-----2---------------- ---- --
141	WALTI NDI	----1------1 --1--- -3332-- --21-----------3 --- 1------312 ---2--13-333-1 11-1------3-----------1- ---- --
9	ANOGL EIO	------------ ------ 5444--- ---------------- --- ---------- -4-4-4--5---55 ----------------------4- 4--- --
168	ACACS EY3	------------ --1--- ------- ---------------- --- -41-12---- 4-44--4------- -----------4----------1- ---- --
39	CHLOP ILO	------------ ---3-- ---3--3 ---------------- --- -----3-36- ------------333 -----3------------------ ---- --
6	ACACS EYA	------------ ------ 4------ ---------------- --4 ---1-11--- ------644----4 --------1-----1--------- ---- --
167	ACACS EY2	------------ ------ ------1 ---------------- --- ---------- 4-44-441------ --------1-11---------1-- ---- --
28	SCLEB IRR	------------ --4--- ------- ---------------- --4 ---------- 4--------444-4 ----------------------4- ---- --
22	LANNM ICR	------------ ------ ------- ---------------- --- -------4-- 4--------4-4-- ---------5-------------- ---- --
7	ADAND IGI	------------ ------ ------- ---------------- --- ---------- ----4-4------- ------------------4----- ---- --
113	CYPER OTU	------------ --3--- ------- ---------------- --- ---------- ----4-3-----3-- ---------------3-3------ ---- --
116	INDIT INC	------------ ------ ------- ---------------1 --- ---1----1- ----33-------- ---2--------1------1---- ---- --
133	CROTR ETU	------------ ------ -2----- 1--------------- --- ---------- ---2-1--3-----1 13-------------1-------- ---- --
4	ACACN ILO	------------ ------ --4---- ---------------- --- -----11--- -----------1-- ---------------4----1--- -4-- --
154	INDI? ???	3----------- ------ ------- ---------------- -3- ---------- 5-3----3------ ------------------------ ---- --
71	CYPEA MAB	----1------- ------ ------- ---------------- --- ---------- ---------7---- ------------------------ ---- --
192	DIOSM ES2	------------ ------ ------- ---------------- --- ---------- 4---1--------- -----------------1---1-- ---- --

Main group 7

Association of *Leucas martinicensis* and *Corchorus olitorius*

129	BORRR ADI	21--13------ ------ -3-333- 33-----1-3------3 23- ---3--313- 3-34-43----23- 33-21233-------------1-- ---- --
47	ERAGT REM	----3------- --1--1- -3-3--- 233--31---33-13-33 --- 3--2---32- 3--4--------3-- 41333331-3534---3--11-3- ---- --
212	PILIR ET3	----1-----1- -12--- -11--1- -21-------------- -1- -4641-4-4- 54444411-541-- 25435-444-4-4---6-441141 ---- --
131	CASSO BTU	-------2-1-- --1--- -214-34 -3--6-1--343----- 3-- --2-333-2- ----1--4--3-43 -----3-------5-33331-231 34-- --
55	SETAP ALL	------------ --3--- ----133 ---------------- --- ---3------ -----24------2-- 33--1---------3---3---3- ---- --
122	SIDAA LBA	-------1---- --1--- 3-1-333 --1-3----------- 3-- --21----3- 3-32331-----33 23--3----3-23333--31-13- -3-- --
211	PILIR ET2	-1---------4 ------ 5-4---- 1--------------- --- -------1-4- -1--14-1----4-- --1--4---4-1------4----41 4--- --
127	ACHYA SPE	------------ ---1-- 3---33- ---------------- --- --33----3- --2-----------3- --2-----4--3-----3---33 ---- --
59	ALYSO VAL	------------ ------ --1-3-- ----3---1----3--- --- -1---3--3-- 4-4-3--3---33- 35-3333---6---333331331-3- ---- --
64	CASSM IMO	----3------- -31--- 1-1---- ------3---------- --- ---13----- ----3--3------ 3----1---------------------3 33-- --
132	CORCT RID	------------ -1---- ------3 31-1----------3- --- 11--1--33- --35--3----1-- 333332-3-1322333-3331--3 331- --
58	ACANH ISP	------------ ------ ------3 2--------------- --- -----3---- ------3------11 --313-----------3--3111--- ---- --
91	PERIB ICA	------------ ------ ------- ---------------- --- ----122---2-- --1---------- ---------1-----3---------1--1-- ---- --
68	CORCO LIT	-1---------- ------ ------- ------11-3------ --- -1-------- --3--3-------- -3333333-----333-43--1-4 ---- --
56	SORGB ICO	------------ ------ ------- ---------------- --- ---------- ----------4-- 454555447548--44-545-533 ---- --
136	HIBIS ABD	------------ ------ ------- ---------------- --- ---------- -------------- 132333-254331-33-3-1-32- ---- --
81	IPOME RIO	------------ ------ ------- ---------------- --- --------2- --2----------- -333-1-----12-33-4-121-- ---3 --
83	LEUCM ART	-----------1 ------ ----3-- ---------------- --- ---1-----2 -------------- 233333---33323----33----- ---- --
53	PENNT YPH	------------ ------ ------- -----------5------ --- ---3------ -------------- 4--3333---34-3-3-------- ---- --
97	SESAI NDI	------------ ------ ------- ---------------- --- ---------- -------------- 22----33-------4---3---- ---- --
26	PILIR ETI	------------ ------ ------- ---------------- --- ---------- --4----------- ---44-----------44-----1---4 ---- --
104	VOANS UBT	------------ ------ ------- ---------------- --- ---3------ -------------- --3--------------------- ---- --
12	BUTYP ARK	------------ ------ ------- ---------------- --- ---------- 4-----------1- ----------------4------- ---- --
217	ZIZIM AU3	------------ ------ ------1 ---------------- 1-- ----1----- --4---11------ -----1-1-4--------1---1-- ---- --
29	TAMAI NDI	------------ ------ ------1 ---------------- --- ---------- ---------4--44 ---------4-------4---4-- ---- --
85	MITRV ILL	------------ --1--- ------- -1-------------- --- ---------- --------3-3-- --34-1-1-----------3-- ---- --
1	ACACA LBI	------------ ------ ------- ---------------- --- ---------- -------------- ---4-------------------- ---- --
11	BOMBC OST	------------ ---1-- ------- ---------------- --- ---------- -------------- ----------4------------- ---- --
17	DIOSM ESP	------------ ------ ------- ---------------- --- ---------- -------------- -----------------4------ ---- --
123	SOLAA ETH	------------ ------ ------- ---------------- --- ---------- -------------- ---------------------6-- ---- --
103	VIGNU NGU	------------ ------ ------- -----3---------- --- ---------- -------------- 4--3--3-----3----------- ---- --

Main group 8

Association of *Mitragyna inermis* and *Bractea lata*

100	STRIH ERM	------------ ------ ------- ---------------- --- ---------- -------------- 13--3---433----3-----1-- 3--- --
19	FICUP LAT	------------ ------ --1---- ---------------- --- ---------- 5------------- -4--------------------14 5--- --
78	HYPTS PIC	------------ ------ ------- ---------------- --- ---1------ -----1-------- -3331---7---33-4---131-35 --33 --
62	ASPIA NTE	------------ ------ ------3 ---------------- --- ---2------ ------------33 -4------3-----3-333--35 -32- --
146	IPOM? ???	------------ ------ --1---- ---------------- 1-- ---------- -3---1------3- ---------1---33--------3 424- --
139	SESBS ESB	------------ ------ ------- ---------------- --- ---------- -------------- ----------------33-3-----3 3--- --
84	LUDWA BYS	------------ ------ ------- ---------------- --- ---------- --------3----- ----------3-------3 -333 --
24	MANGI NDI	------------ ------ ------- ---------------- --- ---------- -------------- --------------4---------- --75 --
36	BRACL ATA	------------ ------ ------- ---------------- --- ---------- -----3-------- ------------------------ -135 --
50	ORYZS ATI	------------ ------ ------- ---------------- --- ---------- -------------- ------------------------ 7--- --
75	FIMBL ITT	------------ ------ ------- ---------------- --- ---------- -------------- ------------------------ 63-- --
209	MITRI NE2	------------ ------ ------- ---------------- --- ---------- -------------- ------------------------ 44-- --
51	PANIL AET	3----------- ----2- ------- -3-------------- --- ---------- ----------4-- ------------------------ -3-- --
96	SCOPD ULC	------------ ------ ------- ---------------- --- ---------- -------------- ------------------------ -3-- --
210	MITRI NE3	------------ ------ ------- ---------------- --- ---------- -------------- ------------------------ -4-- --
92	PHYSA NGU	------------ ------ ------- ---------------- --- ---------- -------------- ------------------------ --3- --
117	LAGGO LOP	------------ ------ ------- ---------------- --- ---------- -------------- ------------------------ --3- --
119	NELSC ANE	------------ ------ ------- ---------------- --- ---------- -------------- ------------------------ --4- --
148	NOTH? ???	------------ ------ ------- ---------------- --- ---------- -------------- ------------------------ --4- --
149	CITRS INE	------------ ------ ------- ---------------- --- ---------- -------------- ------------------------ --57 --
220	CITRS IN2	------------ ------ ------- ---------------- --- ---------- -------------- ------------------------ ---4 --
221	CITRS IN3	------------ ------ ------- ---------------- --- ---------- -------------- ------------------------ --1- --

Association of *Mitragyna inermis* and *Deternanthera nodiflora*

108	CYMBS CHO	------------ ------ ------- ---------------- --5 ---------- -5------------ ------------------------ -44- 4-
25	MITRI NER	------------ ------ ------- ---------------- --- ---------- --------5----- ------------------------ 545- 66
73	DETEN ODI	------------ ------ ------- ---------------- --- ---------- -------------- ------------------3-----5 333- 3-
8	ANACO CCI	------------ ------ ------- ---------------- --- ---------- -------------- ------------------------ --1- --

Rare species

79	INDID IPH	---3-------- ------ ------- ---------------- --- ---------- -------------- ------------------------ ---- --
95	RHYNM INI	------------ ------ -----1- ---------------- --- ---------- -------------- ------------------------ ---- --

112	CYPEE SCU	----3------- --3--- ------- -1-------------- --- ---------- -------------- ------------------------ ---- --
130	BORRS TAC	------------ -2---- ------- ---------------- --- ---------- -------------- ------------------------ ---- --
174	BOSCA NG3	1----------- ------ ------- ---------------- --- ---------- -------------- ------------------------ ---- --
180	CASSS IE2	------------ ---4-- ------- ---------------- --- ---------- -------------- ------------------------ ---- --
185	COMBG LU3	--------1--- 1----- ---1--- ---------------- --- ---------- -4---1-------- ------------------------ ---- --
188	COMBN IG2	------------ 4----- ------- ---------------- --- ---------- -------------- ------------------------ ---- --
191	DICHC IN3	------------ ------ --1---- ---------------- --- ---------- -------------- ------------------------ ---- --
199	GREWB IC3	------------ ------ ------- ---------------- --- ---------- -------------- ------------------------ ---- --
201	GREWF LA2	------------ ------ ------- ---------------- --- ---------- ---------1---- ------------------------ ---- --
203	GREWM OL3	------------ ------ ---2--- ---------------- --- ---------- ---------1---- ------------------------ ---- --
204	GREWT EN3	1----------- ------ ------- ---------------- --- ---------- -------------- ------------------------ ---- --
222	ACACP EN2	------------ ------ ------- ---------------- --- ---------- ---------4---- ------------------------ ---- --
223	DALBM EL2	------------ ------ ------- ---------------- --- ---------- ---------4---- ------------------------ ---- --
224	DALBM EL3	------------ ------ ------- ---------------- --- ---------- ---------1---- ------------------------ ---- --
20	GREWB ICO	------------ ------ -1----- ---------------- --- ---------- -------------1 ------------------------ ---- --
109	ORYZL ONG	------------ ------ ------- ---------------- --- ---------- ---3----3----- ------------------------ ---- --
163	ACACN IL2	------------ ------ -4---1- --1------1------ --- -----1---- -------------- ------------------------ ---- --
175	BOSCS EN2	-----------1 ------ ------- ----------1----- --- ---------- -------------- ------------------------ ---- --
189	COMBN IG3	--1--------- ---1-- ------- ---------------- --- ---------- -------------1 ------------------------ ---- --
70	CUCUM ELO	------------ -1---- -1---1- -------1-------1- --- -1-------- ---2---------- ---------------1-------- ---- --
80	INDIH IRS	------------ ------ ------1 1------3-------- 3-- --1------- -------3------ ---1---------2--------1- ---- --
126	TAPIO PHI	------------ ------ 1------ ---------------- --- ---1------ -------------- ------------------------ ---1 --
152	CUCUM ETU	------------ ------ ------- ---------------- --- --------11 -------------- ---------------1-------- ---- --
208	MAERC RA3	------------ ------ ------- ---3---------1-- -1- ------1--- -------1------ ----1---------1--------- ---- --
114	EVOLA LSI	------------ --1--- ---1--- -------1----1--- --- 1--------2- -------------- ------------------------ ---- --
140	STYLM UCR	------------ ------ --3---- ---1------------ 1-- ---------- -----------2-- ----------------2------- ---- --
182	COMBA CU2	------------ ------ --1---- ---------------- --- ---------- ----1--------1 ------------------------ ---- --
48	ERAGT URG	---4-------- ------ ------- ---------------- --- ---------- -------------- -1---------------------- ---- --
195	FICUP LA2	------------ ------ --4---- ---------------- --- --------1-- -------------- ------------------------ ---- --
14	CASSS IEB	------------ ------ ------- ---------------- --- ---------- ---------4---- ----------------4------- ---- --
30	ZIZIM UCR	------------ ------ ------- ---------------- --- ----4----- -------------- ------------------------ ---- --
44	DIHEH AGE	------------ ------ ------- ---------------- --- -------3-- -------------- ------------------------ ---- --
82	KYLLS QUA	------------ ------ ------- ---------------- --- ---------- -----------3-- ------------------------ ---- --
94	RHYNM EMN	------------ ------ ------- ---------------- --- ---------- -------------1 ------------------------ ---- --
107	CHLOG AYA	------------ ------ ------- ---------------- --- ---3------ -------------- ------------------------ ---- --
110	ABUTT REN	------------ ------ ------- 1--------------- --- ---------- --1----------- ------------------------ ---- --
120	PERGD AEM	------------ ------ ------- --1------------- --- ---------- -------------- ------------------------ ---- --
124	SOLAI NCA	------------ ------ ------- ---------------4 --- ---------- -------------- ------------------------ ---- --
137	PHYLP ENT	------------ ------ ------- ---------------- --- --------3- -------------- ------------------------ ---- --
142	WISSA MPL	------------ ------ ------- ---------------- --- ---------- -------------3 ------------------------ ---- --
144	ABUT? ???	------------ ------ ------- ----------3-----1 --- ---------- -----------2-- ------------------------ ---- --
150	DALBM ELA	------------ ------ ------- ---------------- --- ---------- -------------1 ------------------------ ---- --
153	COMMA FRI	-------1---- ------ ------- -----------1---- --- ---------- -------------- ------------------------ ---- --
156	CITRL ANA	------------ ------ ------- ---------------- --- -1-------- -------------- ------------------------ ---- --
158	ACACA LB2	------------ ------ ------- ---------------- --- ---------- 4------------- ------------------------ ---- --
170	ANOGL EI3	------------ ------ ------- ---------------- --- ---------- ---1---------- ------------------------ ---- --
179	CASSO CC3	------------ ------ ------- ---------------1 --- -------4-- -----------2-- ------------------------ ---- --
181	CASSS IE3	------------ ------ ------- ---------------- --- ---------- --1----------- ------------------------ ---- --
193	DIOSM ES3	------------ ------ ------- ---------------- --- ---------- 4------------- ---------------------1-- ---- --
194	EUPHB AL3	------------ ------ ------- ---------------- --- -------4-- -------------- ------------------------ ---- --
200	GREWC IS3	------------ ------ ------1 ---------------- --- ---------- -------------- ------------------------ ---- --
202	GREWF LA3	------------ ------ ------- ---------------- --- ---------- --1----------- ------------------------ ---- --
207	MAERC RA2	------------ ------ ------- ---1--1--------- --- ---------- -------------- ------------------------ ---- --
216	ZIZIM AU2	------------ ------ ------- ---------------- --- ---------- 1-4----4------ ------------------------ ---- --
218	ZIZIM UC2	------------ ------ ------- ---------------- --- ----1----- -------------- ------------------------ ---- --
219	ZIZIS PI3	------------ ------ ------- ---------------- --- ---------- ----------1--- ------------------------ ---- --
72	CYPED IFF	------------ ------ ------- ---------------- --- ---------- -----------2-- ------------------------ ---- --
77	HYGRA URI	------------ ------ ------- ---------------- --- ---------- --------3----- ------------------------ ---3 --
128	BLUMA URI	------------ ------ ------- ---------------- --- ---------- -----3-------- ------------------------ ---3 --
215	SCLEB IR2	------------ ------ -1----- ---------------- --- ---------- -------------- -1---------------------- --4- --
23	MAERC RAS	------------ ------ ------- 1--------------- --- ---------- -------------- --1--------------------- ---- --
42	DIGIG AYA	------------ ------ ------- -1-------------- --- ---------- -------------- ----1------------------- ---- --
138	PORTG RAN	------------ ------ ------- -1-------------- --- ---------- ---3---------- -3--------------2------- ---- --
190	DICHC IN2	------------ ------ ------- ---------------- --- ---------- -------------1 ----------------1------- ---- --
34	ARISH ORD	------------ ------ ------- ---------------- --- ---------- ------2------- ---1-------------------- ---- --
178	CALOP RO3	------------ ------ -1----- ---------------- 1-- ---------- ----------1--- -------2---------------- ---- --
61	ARACH YPO	------------ ------ ------- ---------------- --- ---------- ----------7--- ------1---1------------- ---- --
69	CROTP ODO	------------ ------ ------- ---------------- --- ---------- 3------------- -----------4-5---------- ---- --
89	PANDH EUD	------------ ---1-- ------- ---------------- --- ---------- ----2--------1 2----3------2----------- ---- --
98	SESBP ACH	------------ ------ ------- ---------------- --- --1------- -------------- 32---------------------- ---- --
196	FICUP LA3	------------ ------ ------- ---------------- --- ---------- --1----------- -31---------1----------- ---- --
13	CALOP ROC	------------ ------ -1----- ---------------- --- ---------- -------------- ---------------------1-- ---- --
45	ERAGP ILO	------------ ------ ------- ---------------- --- ---------- -------------- -------------1---------- ---- --
87	MONEC ILI	------------ ------ ------- ---------------- --- ---------- -----5-------- ---------------3---31---- ---- --
115	HIBIA SPE	------------ ------ ------- ---------------- --- ---------- -----3-------- ------3-------3--------- ---- --
67	COMMB ENG	------------ ------ ------- ---------------- --- 1--------- -------------- ----------------1----1 --1- --
18	EUCAC AMA	------------ ------ ------- ---------------- --- ---------- -------------- ---------------3-------- ---- --
43	DIGIH ORI	------------ ------ ------- ---------------- --- ---------- -------------- -----1------------------ ---- --
65	CHRYA MER	------------ ------ ------- ---------------- --- ---------- -------------- ---3-------------------- ---- --
76	GYNAG YNA	------------ ------ ------- ---------------- --- ---------- -------------- ------------2----------- ---- --
88	NICOT ABA	------------ ------ ------- ---------------- --- ---------- -------------- ---1-------------------- ---- --
101	TRIUP ENT	------------ ------ ------- ---------------- --- ---------- -------------- ---3-------------------- ---- --
102	VICOL EPT	------------ ------ ------- ---------------- --- ---------- -------------- ---1-------------------- ---- --
134	EUPHH IRT	------------ ------ ------- ---------------- --- ---------- -------------- -3-------3-------1----3- ---- --
		------------ ------ ------- ---------------- --- ---------- -------------- ----------------1------- ---- --

```
135 HIBIC ANN  ------------ ------ ------- ----------------- --- ---------- -------------- --3--------3--32-------- ---- --
143 SPOR? ???  ------------ ------ ------- ----------------- --- ---------- -------------- ----3------------------- ---- --
145 HYGR? ???  ------------ ------ ------- ----------------- --- ---------- -------------- ------3----------------- ---- --
147 KOHA? ???  ------------ ------ ------- ----------------- --- ---------- -------------- -----3------------------ ---- --
151 LAGES ICE  ------------ ------ ------- ----------------- --- ---------- -------------- ---1-------------------- ---- --
155 ROTTC OCH  ------------ ------ ------- ----------------- --- ---------- -------------- ------------------3----- ---- --
157 PENN? ???  ------------ ------ ------- ----------------- --- ---------- -------------- -------------1---------- ---- --
164 ACACN IL3  ------------ ------ ------- ----------1------ --- ---------- -------------- ---2---1-------1-------- -1-- --
169 ADAND IG3  ------------ ------ ------- ----------------- --- ---------- -------------- ------------------1----- ---- --
171 AZADI ND2  ------------ ------ ------- ----------------- --- ---------- -------------- --1--------------------- ---- --
177 CALOP RO2  ------------ ------ ------- ----------------- --- ---------- -------------- -------------1---------- ---- --
225 ANNOS EN3  ------------ ------ ------- ----------------- --- ---------- -------------- ----------------------1- ---- --

               000000000000 000000 0000000 00000000000000000 000 0000000000 00000000000000 000000000000000000000000 0000 11
               000000000000 000000 0000000 00000000000000000 000 0000000000 00000000000000 111111111111111101111111 1111
               000000010000 000000 0000001 11111111111111111 101 1111111111 10111011011111 000000000000000010000000 0111
               111111101111 111111 1111110 00000000000000000 011 0000000000 11111111011111 000000000000000010000001 1
               000000000000 101101 1111111 00000000000000000 000 0000011111 01000100 00011 000100000000001110111111
               001111111111 010010 0000000 00000000000010000 000 1111100111 01000100 111   110011110000000001001101

Number of species:

               211121111111 12321  2332222 12111 11 1  1  11 11  112321122  21222312111223 232322121221222212 21 121 1121
               281445042306 034346 8236478 94750831629626706 458 4673175098 48982376553640 937186630503322124788498 7911 41
```

ANNEX 11 SYNOPTIC TABLE OF ALL DISTINGUISHED VEGETATION TYPES

In this table the frequency percentages of each species per cluster are given

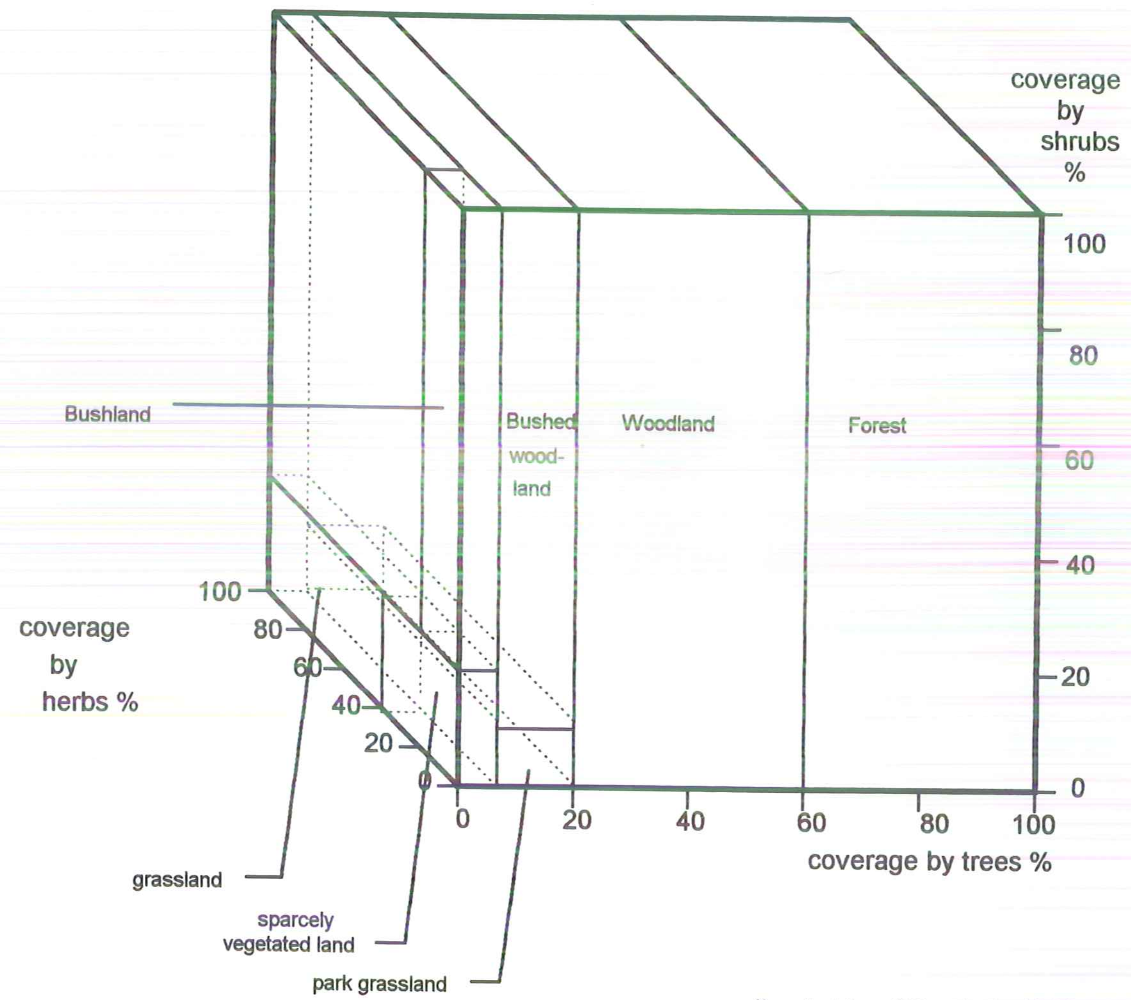
Main group:	2	2	3	4	1	5	6	7	8	8
Veg. type:	2A	2B	3	4	1	5	6	7	8A	8B
Nr.relevés:	12	6	7	17	3	10	14	24	4	2
Aver.nr.spec.:	14.9	18.3	28.3	11.8	12.3	20.0	22.9	21.6	17.0	2.5
Stand.error:	4.3	9.4	3.0	4.9	3.1	7.3	6.1	6.7	3.7	1.5
DIFFERENTIATING WOODY SPECIES										
GARD SOK3	41	0	0	0	0	0	0	0	0	0
ACAC MAC3	25	0	0	0	0	0	7	0	0	0
COMB MIC2	33	50	85	0	0	20	42	8	0	0
COMB MIC3	91	66	42	11	0	30	28	4	0	0
ACAC MAC2	0	33	57	0	0	0	21	0	0	0
PTER LUCE	8	16	57	0	0	0	7	0	0	0
PTER LUC2	16	0	0	5	0	0	7	0	0	0
ACAC MACR	0	0	85	0	0	0	14	0	0	0
COMB MICR	8	0	85	0	0	0	0	0	0	0
PTER LUC3	0	0	28	0	0	0	7	0	0	0
MANG INDI	0	0	0	0	0	0	0	4	50	0
CITR SINE	0	0	0	0	0	0	0	0	50	0
CITR SIN2	0	0	0	0	0	0	0	0	25	0
CITR SIN3	0	0	0	0	0	0	0	0	25	0
MITR INE2	0	0	0	0	0	0	0	0	50	0
MITR INE3	0	0	0	0	0	0	0	0	25	0
MITR INER	0	0	0	0	0	0	7	0	75	100
DIFFERENTIATING GRASS AND HERB SPECIES										
FIMB EXIL	58	50	0	5	0	0	7	0	0	0
TRIP MINI	58	50	57	5	0	20	0	0	0	0
LOUD TOGO	25	100	57	11	0	0	21	0	0	0
CENC BIFL	8	16	14	64	0	30	0	4	0	0
CASS NIGR	8	16	14	11	66	0	21	8	0	0
SCHO GRAC	91	100	100	100	66	89	78	50	0	0
ANDR PSEU	83	100	85	5	100	40	71	25	25	0
BLEP LINA	0	0	0	0	33	0	0	0	0	0
PUPA LAPP	0	0	0	0	0	40	0	4	0	0
LEUC MART	8	0	14	0	0	20	0	54	0	0
CORC OLIT	8	0	0	17	0	10	14	58	0	0
SORG BICO	0	0	0	0	0	0	7	83	0	0
HIBI SABD	0	0	0	0	0	0	0	75	0	0
IPOM ????	0	0	14	0	33	0	21	16	75	0
HYPT SPIC	0	0	0	0	0	10	7	54	50	0
BRAC LATA	0	0	0	0	0	0	7	0	75	0
FIMB LITT	0	0	0	0	0	0	0	0	50	0
LUDW ABYS	0	0	0	0	0	0	7	8	75	0
DETE NODI	0	0	0	0	0	0	0	8	75	50
CONSTANT WOODY SPECIES										
BOSC SEN2	8	0	0	5	0	0	0	0	0	0
GUIE SEN2	16	50	71	0	0	0	21	4	0	0
BOSC SEN3	33	66	71	29	0	50	35	16	0	0
GUIE SEN3	58	83	85	0	33	30	64	25	0	0
PILI RET3	16	33	42	11	33	60	78	70	0	0
ACAC SEN3	0	16	14	11	66	20	0	0	0	0
ACAC SEN2	0	16	42	11	66	30	0	4	0	0
ACAC SENE	8	16	28	5	0	0	7	0	0	0
BALA AEG2	0	33	14	17	33	50	28	8	0	0
BALA AEG3	0	0	14	23	0	50	14	4	0	0

BALA AEGY	0	0	14	29	0	50	14	12	0	0
GUIE SENE	0	0	28	0	0	0	7	0	0	0
PILI RETI	0	0	0	0	0	0	7	25	0	0
PILI RET2	16	0	28	5	0	20	35	29	25	0
ANOG LEIO	0	0	57	0	0	0	42	4	25	0
CONSTANT GRASS AND HERB SPECIES										
CTEN ELEG	58	33	0	0	0	10	0	0	0	0
PAND INVO	58	33	28	0	33	0	0	0	0	0
POLY LINE	58	16	14	11	33	20	0	41	0	0
ZORN GLOC	25	50	71	41	0	50	42	12	0	0
WALT INDI	16	16	57	17	0	40	50	20	0	0
DACT AEGY	0	50	14	17	0	30	0	16	0	0
ERAG TREM	8	33	28	64	0	40	21	66	0	0
ARIS ADSC	75	66	71	88	100	60	35	20	0	0
BORR RADI	33	0	57	29	66	40	50	33	0	0
ALYS OVAL	0	0	28	17	0	30	42	70	0	0
CASS OBTU	16	16	71	35	33	50	35	41	50	0
PENN PEDI	66	100	100	11	0	100	92	70	25	0
LEPT HAST	50	33	42	52	66	69	42	33	50	50
ANDR GAYA	8	16	42	11	33	20	64	62	25	0
SIDA ALBA	8	16	71	11	33	30	57	54	25	0
CASS MIMO	8	33	28	5	0	20	14	12	50	0
ERAG TENE	8	16	42	35	0	69	28	25	50	0
CORC TRID	0	16	14	23	0	50	28	79	75	0
ASPI ANTE	0	0	14	0	0	10	14	33	50	0
IPOM ERIO	0	0	0	0	0	10	7	50	25	0
CYMB SCHO	0	0	0	0	33	0	7	0	50	50
REMAINING SPECIES										
TEPH BRAC	33	0	14	0	0	20	14	0	0	0
ACAC SEY2	0	0	14	0	0	0	42	16	0	0
ACAC SEYA	0	0	14	0	33	30	28	8	0	0
ACAC SEY3	0	16	0	0	0	40	28	8	0	0
SCLE BIRR	0	16	0	0	33	0	35	4	0	0
ACAC NIL2	0	0	28	11	0	10	0	0	0	0
CUCU MELO	0	16	28	11	0	10	7	4	0	0
PANI LAET	8	16	0	5	0	0	7	0	25	0
MITR VILL	0	16	0	5	0	0	14	20	0	0
INDI ????	8	0	0	0	33	0	21	0	0	0
ACHY ASPE	0	16	42	0	0	30	14	25	0	0
SETA PALL	0	16	42	0	0	10	21	25	0	0
MOLL NUDI	8	16	14	17	0	30	0	4	0	0
CROT RETU	0	0	14	5	0	0	28	12	0	0
CALO PRO3	0	0	14	0	33	0	7	8	0	0
GREW BIC2	0	0	42	0	0	0	14	4	0	0
TAPI OPHI	0	0	14	0	0	10	0	0	25	0
CLEO SCAP	8	0	0	0	0	0	0	0	0	0
INDI DIPH	8	0	0	0	0	0	0	0	0	0
AMAR GRAE	0	0	14	17	0	30	7	4	0	0
CYPE ROTU	0	16	0	0	0	0	21	8	0	0
CHLO PILO	0	16	28	0	0	30	21	4	0	0
SIDA STIP	16	0	0	0	0	0	0	0	0	0
BRAC DIST	16	0	14	35	0	0	7	12	0	0
STYL MUCR	0	0	14	5	33	0	7	4	0	0
PENN TYPH	0	0	0	5	0	10	0	37	0	0
PERI BICA	0	0	0	0	0	40	7	16	0	0
INDI HIRS	0	0	14	11	33	10	7	12	0	0
ACAN HISP	0	0	14	5	0	10	21	33	0	0
STRI HERM	0	0	0	0	0	0	0	33	25	0
SESB SESB	0	0	0	0	0	0	0	16	25	0
SESA INDI	0	0	0	0	0	0	0	25	0	0
ORYZ SATI	0	0	0	0	0	0	0	0	25	0
CYPE DIFF	0	0	0	0	0	0	7	0	25	0

HYGR AURI	0	0	0	0	0	0	7	0	25	0
PHYS ANGU	0	0	0	0	0	0	0	0	25	0
SCOP DULC	0	0	0	0	0	0	0	0	25	0
HIBI ASPE	0	0	0	0	0	0	0	8	25	0
LAGG OLOP	0	0	0	0	0	0	0	0	25	0
NELS CANE	0	0	0	0	0	0	0	0	25	0
BLUM AURI	0	0	0	0	0	0	7	4	25	0
NOTH ????	0	0	0	0	0	0	0	0	25	0
BOSC ANG3	8	0	0	0	0	0	0	0	0	0
GREW TEN3	8	0	0	0	0	0	0	0	0	0
BORR STAC	0	16	0	0	0	0	0	0	0	0
CASS SIE2	0	16	0	0	0	0	0	0	0	0
COMB NIG2	0	16	0	0	0	0	0	0	0	0
CYPE ESCU	8	16	0	5	0	0	0	0	0	0
COMM AFRI	8	0	0	5	0	0	0	0	0	0
ARIS FUNI	16	16	14	5	0	0	0	0	0	0
ACAC LAET	8	0	0	11	0	0	0	0	0	0
COMB NIG3	8	16	0	0	0	0	7	0	0	0
COMB GLU2	33	16	28	0	0	0	14	4	0	0
CENC PRIE	8	0	14	17	0	0	0	0	0	0
COMB GLUT	8	16	14	0	0	10	7	0	0	0
CYPE AMAB	8	0	0	0	0	0	7	0	0	0
COMB GLU3	8	16	14	0	0	0	14	0	0	0
PERG DAEM	0	0	0	5	0	0	0	0	0	0
SOLA INCA	0	0	0	5	0	0	0	0	0	0
ACACL AE2	0	0	0	5	0	0	0	0	0	0
ACACL AE3	0	0	0	11	0	0	0	0	0	0
MAERC RA2	0	0	0	11	0	0	0	0	0	0
RHYNM INI	0	0	14	0	0	0	0	0	0	0
DICHC IN3	0	0	14	0	0	0	0	0	0	0
GREWC IS3	0	0	14	0	0	0	0	0	0	0
GREWM OL3	0	0	14	0	0	0	0	0	0	0
EVOLA LSI	0	16	14	11	0	20	0	0	0	0
BOMBC OST	0	16	0	0	0	0	0	4	0	0
ERAGT URG	8	0	0	0	0	0	0	4	0	0
FICUP LA2	0	0	14	0	0	10	0	0	0	0
FICUP LAT	0	0	14	0	0	0	7	12	25	0
MAERC RA3	0	0	0	11	33	10	7	8	0	0
LANNM ICR	0	0	0	0	0	10	21	4	0	0
ZIZIM AU2	0	0	0	0	0	0	21	0	0	0
ZIZIM AU3	0	0	14	0	33	10	21	20	0	0
TAMAI NDI	0	0	14	0	0	0	21	12	0	0
ACACN ILO	0	0	14	0	0	20	7	8	25	0
COMBA CU3	8	0	42	0	0	20	21	8	0	0
ACACN IL3	0	0	0	5	0	0	0	12	25	0
ANACO CCI	0	0	0	0	0	0	0	0	25	0
GREWB ICO	0	0	14	0	0	0	7	0	0	0
ABUT? ???	0	0	0	11	0	0	7	0	0	0
COMBA CU2	0	0	14	0	0	0	14	0	0	0
ABUTT REN	0	0	0	5	0	0	7	0	0	0
CASSO CC3	0	0	0	5	0	10	7	0	0	0
ZIZIM UCR	0	0	0	0	0	10	0	0	0	0
DIHEH AGE	0	0	0	0	0	10	0	0	0	0
CHLOG AYA	0	0	0	0	0	10	0	0	0	0
PHYLP ENT	0	0	0	0	0	10	0	0	0	0
CITRL ANA	0	0	0	0	0	10	0	0	0	0
EUPHB AL3	0	0	0	0	0	10	0	0	0	0
ZIZIM UC2	0	0	0	0	0	10	0	0	0	0
CALOP ROC	0	0	14	0	0	0	0	4	0	0
SCLEB IR2	0	0	14	0	0	0	0	4	0	0
PANDH EUD	0	16	0	0	0	0	14	8	0	0
CUCUM ETU	0	0	0	0	0	20	0	4	0	0

KYLLS QUA	0	0	0	0	0	0	7	0	0	0
RHYNM EMN	0	0	0	0	0	0	7	0	0	0
ORYZL ONG	0	0	0	0	0	0	14	0	0	0
WISSA MPL	0	0	0	0	0	0	7	0	0	0
DALBM ELA	0	0	0	0	0	0	7	0	0	0
ACACA LB2	0	0	0	0	0	0	7	0	0	0
ANOGL EI3	0	0	0	0	0	0	7	0	0	0
CASSS IE3	0	0	0	0	0	0	7	0	0	0
GREWB IC3	0	0	0	0	0	0	7	0	0	0
GREWF LA2	0	0	0	0	0	0	7	0	0	0
GREWF LA3	0	0	0	0	0	0	7	0	0	0
ZIZIS PI3	0	0	0	0	0	0	7	0	0	0
ACACP EN2	0	0	0	0	0	0	7	0	0	0
DALBM EL2	0	0	0	0	0	0	7	0	0	0
DALBM EL3	0	0	0	0	0	0	7	0	0	0
INDIT INC	0	0	0	5	0	20	14	12	0	0
MAERC RAS	0	0	0	5	0	0	0	4	0	0
PORTG RAN	0	0	0	5	0	0	0	4	0	0
COMMB ENG	0	0	0	0	0	10	0	4	0	0
VOANS UBT	0	0	0	0	0	10	0	4	0	0
ADAND IGI	0	0	0	0	0	0	14	4	0	0
BUTYP ARK	0	0	0	0	0	0	14	4	0	0
DIGIG AYA	0	0	0	5	0	0	7	8	0	0
CASSS IEB	0	0	0	0	0	0	7	4	0	0
ARISH ORD	0	0	0	0	0	0	7	4	0	0
DICHC IN2	0	0	0	0	0	0	7	4	0	0
DIOSM ES2	0	0	0	0	0	0	14	8	0	0
DIOSM ES3	0	0	0	0	0	0	7	4	0	0
FICUP LA3	0	0	0	0	0	0	7	4	0	0
SESBP ACH	0	0	0	0	0	10	0	12	0	0
ARACH YPO	0	0	0	0	0	0	7	8	0	0
MONEC ILI	0	0	0	0	0	0	7	8	0	0
VIGNU NGU	0	0	0	5	0	0	0	16	0	0
ERAGP ILO	0	0	0	0	0	0	7	12	0	0
CROTP ODO	0	0	0	0	0	0	7	12	0	0
ACACA LBI	0	0	0	0	0	0	0	4	0	0
DIOSM ESP	0	0	0	0	0	0	0	4	0	0
EUCAC AMA	0	0	0	0	0	0	0	4	0	0
DIGIH ORI	0	0	0	0	0	0	0	4	0	0
CHRYA MER	0	0	0	0	0	0	0	4	0	0
GYNAG YNA	0	0	0	0	0	0	0	4	0	0
NICOT ABA	0	0	0	0	0	0	0	4	0	0
TRIUP ENT	0	0	0	0	0	0	0	4	0	0
VICOL EPT	0	0	0	0	0	0	0	16	0	0
SOLAA ETH	0	0	0	0	0	0	0	4	0	0
EUPHH IRT	0	0	0	0	0	0	0	4	0	0
HIBIC ANN	0	0	0	0	0	0	0	16	0	0
SPOR? ???	0	0	0	0	0	0	0	4	0	0
HYGR? ???	0	0	0	0	0	0	0	4	0	0
KOHA? ???	0	0	0	0	0	0	0	4	0	0
LAGES ICE	0	0	0	0	0	0	0	4	0	0
ROTTC OCH	0	0	0	0	0	0	0	4	0	0
PENN? ???	0	0	0	0	0	0	0	4	0	0
ADAND IG3	0	0	0	0	0	0	0	4	0	0
AZADI ND2	0	0	0	0	0	0	0	4	0	0
CALOP RO2	0	0	0	0	0	0	0	4	0	0
ANNOS EN3	0	0	0	0	0	0	0	4	0	0

ANNEX 12 KEY TO THE VEGETATION STRUCTURE



according to Van Gils *et al.*, 1985