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SOILS AND VEGETATION OF SEMDOE PROPOSED FOREST RESERVE BOMBWERA DIVISION, MUHEZA DISTRICT, TANGA.

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Detailed Soil Survey Report, 1997

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SUMMARY

East Usambara Catchment Forest Project (EUCFP) requested National Soil Service (NSS) to carried out soils and vegetation survey of Semdoe Forest Reserve. The objectives of the study were to give general soils distribution, assess the fertility and to describe the forest in terms of density and dominant tree species.

The study area covering an area of about 900 ha is located in Bombwera division, Muheza District. The climate within the area is characterised by bi-modal rainfall pattern with long and short rain seasons from March to May and October to December respectively.

Semdoe Forest Reserve is divided into three major physiographic units summit and upper slope, mid-slope and lower slopes. Slope gradient of the study area dominantly ranges from 10 to 45 % at an elevation that varies from between 600 to 200 m above sea level. The soils are formed from metamorphic rocks of the Usagaran system. The rocks are dominantly gneiss.

The soils in the study area are shallow to deep, well drained, clay loam to clay, dark reddish brown to dark red or red. The soils in the area are dominantly characterised by the presence of rock outcrops such that some plots are even rocky. They have variable soil reaction that vary from slightly acid to strongly or very strongly acid. The soils in the study area have very high to high levels of the organic carbon and total nitrogen that decreases with the soil depth. Available phosphorus is dominantly low. The C/N ratio generally show good quality organic matter.

The exchangeable calcium varies from high to very high while the exchangeable magnesium is generally high. Potassium levels are medium to low or very low. Cation exchange capacity (CEC) is generally medium especially in the topsoil and decreases with soil depth..

Vegetation density varies from open forest mainly for the areas which have been under human influence to dense forest. In some of the plots one or two tree species are dominant while in others there is no tree dominance. The common tree species in the area include *Scorodophloeus fischeri, Manilkara sulcata, Lecaniodiscus fraxinifolius, Markhamia lutea Cussonia zimmermanii, Pandanus rabaiensis Julbernadia magnistipulata, Combretum schumannii, Diospyros kabuyeana, Diospyros natalensis, Vincentella passargei, Fernandoa magnifica, Antiaris toxicaria, Dombeya shupangae, Stereospermum kunlhianum, Ricinodendron heudelotii, Xylopia parviflora, Milicia excelsa, Cynometra fischeri, Cynometra webberi, Dialium holtsii, Markhamia lutea, and Bombax rhodognaphalon.*

1. INTRODUCTION

This report presents the results of detailed soil and vegetation survey at a scale of 1:10,000 of Semdoe Forest Reserve (900 ha) located at Bombwera Division, Muheza District, in Tanga Region. It is found within co-ordinates 38º45'E and 38º50'E and 4º55' and 5º00'S.

The survey was carried out by the National Soil Service (NSS) at the request of East Usambara Catchment Forest Project (EUCFP) which is the project dealing with catchment forest within the region.

The objectives of the study were:
1. To give general soils distribution and assess the fertility status; and
2. To describe the survey area in terms of density and dominant tree species.

The fieldwork was carried out in May 1996 by NSS Soil Surveyors. Soil samples collected during fieldwork were analysed by the NSS Central Laboratory. Vegetation classification is based on vegetation survey conducted by a botanist from Amani botanical garden.

2 THE ENVIRONMENT

2.1 Climate

Climate is one of the most important factor that affect a type of vegetation to be found in a given locality. It determines the type of tree species to be found in the given area. However, only rainfall data is available and relevant for Semdoe Forest Reserve. Table 1 presents a summary of the rainfall data from Mlingano Agricultural Research Institute which is the nearest climatic recording station.

Table 1. Mean monthly rainfall (mm) and mean monthly temperatures (ºC) at Mlingano Agricultural Research Institute (1950 -1979)

Months	Mean monthly rainfall (mm)	Mean min. temp. (ºC)	Mean max. temp. (ºC)
Jan	60.4	21.6	32.5
Feb	32.0	21.7	33.1
Mar	98.8	21.9	33.0
Apr	192.5	21.9	30.6
May	179.0	21.7	29.2
Jun	51.1	19.5	28.2
Jul	46.5	18.6	27.6
Aug	50.7	18.4	28.1
Sep	70.3	18.8	28.6
Oct	122.6	19.7	29.8
Nov	143.4	20.7	30.7
Dec	92.7	21.6	32.1

The rainfall pattern within the study area is bi-modal with long rains locally termed as "masika" and short rains locally known as "vuli" occur from March to May and October to December respectively. The main dry months are from June to September and January to February.

The data on temperature (Table 1) are also those recorded at Mlingano Agricultural Research Institute located at Muheza District on the edge of East Usambara mountains. Air temperatures and relative humidity have small yearly variations . The coolest month is July with mean minimum temperatures of 27.6ºC and the warmest one is February with mean maximum temperatures of 33.1ºC.

2.2 Landform and Geology

Semdoe Forest Reserve covers mostly the lower part of the general landscape. Most of the parts are found at the lower slope in such a way that in some of the plots are subject to flooding as shown by the presence of mottles which shows the fluctuation of the ground water table. It follows therefore that Semdoe forest reserve occupies areas of low intensity as compared to the adjacent Kambai forest reserve. Semdoe Forest Reserve can be divided into three major physiographic units which include summit and upper slopes, mid-slopes and lower slopes. The study area is situated at an elevation below 800 m above sea level. Slope gradient is variable and dominantly ranges from 2 % to 30 %.

The East Usambara in general and Semdoe Forest Reserve in particular is characterised by Metamorphic rocks of the Usagaran system (Precambrian Basement). The rocks are dominantly gneiss with intermediate mineralogical composition. The rocks have approximately equal quantities of light minerals (quartz and feldspar) and dark minerals (pyroxene and hornblende). Locally amphibolites occur (Geological Survey of Tanzania, 1965).

2.3 Land-use and vegetation

A large part of Semdoe Forest Reserve is natural forest. The forest in the area can be categorised according to density, and the degree of human involvement. `Dense forest` include uneven aged more or less disturbed natural forest which has species composition characteristic to the original forest type and has an unbroken crown cover.

On the other hand `poorly stocked forest` or open forest are those with variety of pioneer or secondary forest species which are poorly stocked because of various natural or manmade reasons. They are forest with low density, fairly open crown cover, modest volume and dominant height less than in dense forest belonging to the same forest type. This part of the forest shows some human influence especially logging or harvesting or the area has been formerly under cultivation.

Some other parts of the forests are `highly disturbed` such that often the natural vegetation types are absent. These are forests that are regenerated from the formerly cultivated lands. Or are the forests that have formally been encroached and in some plots are forests that are found at the forest edge. In such plots very few trees are present. The area is dominated mainly by short and dense grasses.

3 STUDY APPROACH

Prior to the commencement of the fieldwork, all relevant and available sources of information were studied. These include topographical and geological maps and all other relevant literature for the study area.

A detailed soil study for the area included auger hole observations in each of the established sample plots. A total of 51 auger hole observations hole observations were made to a depth of 150 cm where possible. The augerings were described according to FAO (1977) guidelines for soil profile descriptions. Soil colours were named according to the Munsell notation (Munsell colour Charts Inc., 1973).

The augering and vegetation identification followed a grid approach, with observation sites spaced at standard intervals. The overall observation density was one observation point per 20 ha, corresponding to a nominal 450 m x 450 m grid system. In each grid square there was a 20 m x 50 m vegetation plot, in which soil samples were taken.

For vegetation identification and classification, in each of the sample plot all trees with Diameter at Breast Height (DBH) greater than 10 cm were counted followed by individual tree identification and botanical classification. Forests were categorised based on the density of the forests trees and the degree of the human involvement in the study area.

Soil samples for standard soil fertility analysis were collected from two depths 0-25 cm and 25-50 cm. The soils were then analysed according to the Internationally accepted method in use at National Soil Service (NSS). The parameters studied include texture by hydrometer, pH, total N, organic C, available P, cation exchange capacity (CEC) and Exchangeable calcium, potassium, magnesium and sodium.

4. SOILS AND VEGETATION

4.1 General soils condition.

The soils in most of the plots in the study area are deep to very deep, well drained in some plots while other plots are imperfectly drained or poorly drained. These plots are those located mainly at the lower part of the slope and in most cases are prone to flooding. The soils have range of soil texture that varies from sandy clay loam to clay, dark reddish brown to dark red or in some plot brown or dark brown or very dark brown. The soils in most plots within the study area are characterised by the presence of the surface stoniness that are made from quartz and are free from rock outcrops.

The soils in the study area indicates that the soils reaction ranges from slightly acid to medium or strongly acid. Organic carbon varies from very high or high to low or very especially in the subsoil. Total nitrogen are also high in the topsoil and decreases to low levels in the subsoil.

Available phosphorus in all plots is low while exchangeable bases vary from very high to high. Such low levels of the available phosphorus is probably due to the fact that the materials from which the soils are formed are dominantly low in phosphorus. The ability of the soil to retain and supply nutrient for plant uptake is medium especially in the topsoil and dominantly becomes low in the subsoil. Cation exchange capacity in this case generally decrease with increase is soil depth. Such low levels of the cation exchange capacity within the subsoil is due to the fact that organic matter which to large extent determine the ability of the soils to release and or retain nutrient decreases

with increase in soil depth. The level of exchangeable calcium is dominantly very high to high. It seems that the parent material from which the soils are formed is rich in calcium while poor in phosphorus. Magnesium levels are as well high while exchangeable sodium very low.

4.2 General vegetation conditions

The type of vegetation in the area is dominantly dense or open forest and mature mixed without dominance. In some plots dominance is common. In plots where disturbances due to human influence has been too high the forests are characteristically open or slightly dense. Such disturbances include former encroachment for cultivation or cutting poles as building materials or logging.

Occurrence of tree species in the study area is variable. Some of the tree species commonly occur in several plots while others are specific in some plots. Common tree species in the area include *Scorodophloeus fischeri, Manilkara sulcata, Cola usambarensis, Lecaniodiscus fraxinifolius, Markhamia lutea, Cussonia zimmermanii, Pandanus rabaiensis,* Pandanus stuhlmannii, *Julbernadia magnistipulata, Combretum schumannii, Diospyros kabuyeana, Diospyros natalensis, Diospyros mespiliformis, Vincentella passargei, Fernandoa magnifica, Dombeya shupangae, Stereospermum kunthianum, Ricinodendron heudelotii, Xylopia parviflora, Milicia excelsa, Cynometra fischeri, Cynometra webberi, Dialium holtsii, Markhamia lutea, Bombax rhodognaphalon, Dorstenia kameruniana, Newtonia paucijuga, Lonchocarpus bussei, Albizia glaberrima, Antiaris toxicaria*.

Table 2. Analytical data for plots in Semdoe proposed forest reserve.

PLOT NO.	PARTICLE SIZE ANALYSIS				pH		ORG.	TOTAL	C/N	AVAILABLE P	CEC	EXCHANGEABLE BASES			
/DEPTH	<2	2-20	20-50	50-2000	1:2.5		C	N		BRAY I		Ca	Mg	K	Na
					H20	KCl	------%------			mg/kg		----------Cmolc/100g----------			
1a	45	26	4	25	6.70	6.50	4.80	0.50	10	3.00	20.50	0.50	3.40	0.85	0.04
1b	50	18	3	25	6.50	6.00	1.30	0.10	13	1.00	16.00	0.41	1.20	0.20	0.04
2a	35	24	3	41	6.00	5.80	3.20	0.30	16	2.80	18.50	0.38	3.00	0.60	0.05
2b	38	10	4	48	5.80	5.60	0.80	0.16	11	1.50	12.10	0.10	2.50	0.30	0.02
3a	40	9	10	41	6.00	5.40	3.50	0.30	12	2.10	14.20	0.40	2.80	0.60	0.03
3b	40	12	10	38	5.50	5.50	0.65	0.08	8	1.80	11.00	0.15	2.00	0.45	0.03
4a	50	5	9	36	5.40	5.10	3.00	0.30	10	3.00	10.30	0.10	3.60	1.50	0.02
4b	52	8	8	32	5.00	4.80	1.00	0.10	10	1.50	9.00	0.10	3.10	1.00	0.02
5a	45	10	2	43	6.60	6.40	3.40	0.35	10	5.20	15.00	0.65	3.00	0.90	0.01
5b	48	8	6	38	5.50	4.50	0.95	0.10	10	2.10	13.00	0.60	2.00	0.45	0.01
6a	40	6	9	45	6.10	6.00	3.10	0.36	9	3.50	12.00	0.50	2.60	0.95	0.02
6b	50	11	10	29	5.20	5.00	1.50	0.12	13	1.80	10.00	0.25	2.40	0.50	0.02

4.3 Plot description

4.3.1 Plot 1

The plot is located on the lower part of the slope with slope gradient ranging from 5 - 10 %. The soils in the plot are deep with effective rooting depth greater than 100 cm, well drained, brown to dark brown in the topsoil to very dark greyish brown in the subsoil and sand clay to sandy clay loam with a layer of sandy cover at the top. The plot is dissected with Semdoe river and the plot is prone to flooding in some parts of the year and there is few mottles. Many rock outcrops are found along the river banks but rock outcrops in the main plot.

The soils are neutral in the topsoils and the soil reaction decreases to slightly acid in the subsoil with pH values that ranges from 6.7 to 6.5 respectively. The organic carbon are very high with levels around 4.80 % in the topsoil and decreases to low or very low (1.30 %) levels in the subsoil. Total nitrogen in the topsoil is high (0.50 %) to low in the subsoil (0.10 %). The C/N ratios indicate that the organic matter within the plot are of good quality.

Available phosphorus are low with values ranging from 3.10 mgP/kg in the topsoil to 1.20 mgP/kg in the subsoil.

Cation exchange capacity varies from medium (20.50 Cmolc/kg) in the topsoil to low levels (9.70 Cmolc/kg) in the subsoil. The exchangeable calcium are high (2.50 Cmolc/kg) in the topsoil and decreases to medium levels (1.41 Cmolc/kg) in the subsoil. The magnesium levels on the other hand are high to medium or low in the topsoil and subsoil respectively. The values are 3.40 Cmolc/kg and 1.20 Cmolc/kg respectively. Potassium is medium (0.85 Cmolc/kg) in the topsoil to low or very low (0.20 Cmolc/kg) in the subsoil. The exchangeable sodium is generally very low.

The plot occupies slightly open riverine forest, mature mixed with undergrowth species of *Olyra, Saba florida and Entanda*. However the giant *Liane and Barringtonia racemosa* occurs on the river bed. Trees species include *Khaya anthotheca, Tricalysia myrtifolia, Synsepalum msolo, Barringtonia racemoso, Suregada zanzibarense, Funtumia africana, Sapium ellipticum, Pouteriana alnifolia, Sorindeia madagascariensis, Cola usambarensis, Erythrophleum suaveolens, Pteleopsis myrtifolia, Julbernadia magnistipulata, Margaritaria discoidea and Citrus aurantium*.

4.3.2 Plot 2

The plot is located on the middle part of the slope with a straight slope gradient of about 35 %.
The soils are moderately deep with effective rooting depth of 50 cm, well drained, dark reddish brown to dark red, clay to gravely clay in the subsoil. The topsoil has surface stoniness made of quartz.

The soils in the plot varies from medium acid or slightly acid in the topsoil to dominantly medium acid in the subsoil. The levels are pH 6.0 and 5.8 respectively. Organic carbon is high (3.20 %) in the topsoil and decreases to low or very low (1.20 %) levels in the subsoil. Total nitrogen on the other hand varies from medium in the topsoil to low levels in the subsoil with values 0.30 % and 0.16 % respectively. Organic matter are of good quality.

Available phosphorus are low with values ranging from 2.80 mgP/kg in the topsoil to 1.50 mgP/kg in the subsoil.

Cation exchange capacity varies from medium (18.5 Cmolc/kg) in the topsoil to low levels (11.60 Cmolc/kg) in the subsoil. The exchangeable calcium is high (3.38 Cmolc/kg) in the topsoil and decreases to medium levels (2.10 Cmolc/kg) in the subsoil. The magnesium levels are generally high to medium in the topsoil and subsoil respectively. The levels are 3.00 Cmolc/kg and 2.50 Cmolc/kg respectively. Potassium is medium in the topsoil and subsoil with values ranges from 0.60 and 0.30 Cmolc/kg. The level of the exchangeable sodium is low or very low.

The forest under the area is slightly open of low canopy and encroached for cultivation. The undergrowth species of *Olyra and acacia* are inclusive. Tree species include *Celtis africana, Croton sylvaticus, Englerophytum natalense, Antiaris toxicaria, Trilepsium Madagascariense, Rothmannia manganjae, Zanha golungensis, Markhamia lutea, Combretum schumannii, Milletia oblata, Tricalysia myrtifolia, Lecanidiodiscus fraxinifolius, Millettia schumannii, Erythrina caffra and Albizia glaberrima,*

4.3.3 Plot 3

The plot is located on the middle part of the slope with straight slope gradient of about 30 %. The soils are deep with effective rooting depth of 100 cm, well drained, dark reddish brown to dark red, clay soils.

The soil reaction is that the soils are slightly acid in the topsoils and the soil reaction decreases and become medium acid in the subsoil with pH values that ranges from 6.2 to 5.6 respectively. The organic carbon ranges from high or very high in the topsoil to low levels in the subsoil. The values are 3.50 % and 0.65 %. Total nitrogen varies from medium in the topsoil to low in the subsoil with values 0.30 % and 0.08 % respectively. Organic matter content are of good quality.

Available phosphorus are low with values ranging from 2.10 mgP/kg in the topsoil to 1.80 mgP/kg in the subsoil.

Cation exchange capacity varies from medium (14.20 Cmolc/kg) in the topsoil to low levels (11.30 Cmolc/kg) in the subsoil. The exchangeable calcium are high both in topsoil and subsoil. The levels are 4.40 Cmolc/kg and 3.15 Cmolc/kg respectively. The magnesium levels are medium both in topsoil and subsoil. The levels are 2.80 Cmolc/kg and 2.00 Cmolc/kg respectively. Potassium is dominantly medium in both topsoil and subsoil. The levels are 0.63 Cmolc/kg and 0.45 Cmolc/kg. The level of the exchangeable sodium is generally very low.

The forest under the area is slightly dense, mature and mixed. The undergrowth species of *Olyra latifolia, Grandidiera and acacia are inclusive. Terminalia sambesiaca, Celtis phillippensis, Dialium holtizii, Diospyros natalensis, Bombax rhodognaphalon, Phialodiscus zambesiacus,Combretum stuhlmannii, Millettia oblata, Millettia stuhlmannii, Antiaris toxicaria, Albizia glaberrima and Lecaniodiscus flaxinifolius.*

4.3.4 Plot 5

The plot is located on the lower part of the slope with slope gradient 2 %. The soils are deep with effective depth 70 cm, imperfectly to poorly drained, dark reddish brown to dark yellowish brown. The plot is characterised by the presence of mottles at 30 cm from the surface that are yellowish in colour. It follows therefore that the plot is subject to flooding in some parts of the year.

Chemical characteristics of the soils is that the soils are neutral or slightly acid in the topsoils and the soil reaction decreases and become medium acid or strongly acid in the subsoil with pH values

that ranges from 6.60 to 5.50 respectively. Organic carbon is high with levels around 3.40 % in the topsoil and decreases to low or very low (0.95 %) levels in the subsoil. Total nitrogen on the other hand varies from medium in the topsoil to low in the subsoil with values 0.35 % and 0.10 % respectively. Good quality organic matter are found within the plot.

Available phosphorus are low with values ranging from 5.20 mgP/kg in the topsoil to 2.10 mgP/kg in the subsoil.

Cation exchange capacity varies from medium (15.40 Cmolc/kg) in the topsoil to low levels (10.5 Cmolc/kg) in the subsoil. The exchangeable calcium are high in both topsoil and subsoil. The levels are 4.65 Cmolc/kg in the topsoil and decreases to 3.60 Cmolc/kg in the subsoil. The magnesium levels are high to medium in the topsoil and subsoil respectively. The levels are 3.40 and 2.20 Cmolc/kg respectively. Potassium is medium (0.90 Cmolc/kg) in the topsoil and decreases to 0.45 Cmolc/kg in the subsoil. The exchangeable sodium is generally very low.

The forest is open and slightly close, mature and mixed. The undergrowth species include *Olyra latifolia, Mildbraedia fallax and some acacia*. Tree species include *Tricalysia myrtifolia, Markhamia lutea, Pterocarpus tinctorius, Dialium holtizii, Diospyros natalensis, Lecaniodiscus fraxinifolius, Antiaris toxicaria, Milicia excelsa, Fernandoa magnifica, Cola greenwayi, Xylopia parvifrora, Combretum schumannii, Synsepalum msolo*.

4.3.5 Plot 7

The plot occupies middle part of the slope with slope gradient of about 20 %. The soils are moderately deep with effective depth 60 cm, well drained, dark reddish brown to reddish brown, clay soils with a scattered rock outcrops and surface stoniness of quartz.

Chemical characteristics of the soils is that the soils are slightly acid in the topsoils and the soil reaction decreases and become medium acid or strongly acid in the subsoil with pH values that ranges from 6.10 to 5.20 respectively. The organic carbon are generally very high with levels around 3.10 % in the topsoil and decreases to low or very low (1.50 %) levels in the subsoil. Total nitrogen is medium in the topsoil (0.36 %) and decreases to low levels in the subsoil. The level in the subsoil is 0.12 %. The C/N ratios indicate that the organic matter are of good quality.

Available phosphorus are low with values ranging from 3.50 mgP/kg in the topsoil to 1.80 mgP/kg in the subsoil.

Cation exchange capacity varies from medium (12.60 Cmolc/kg) in the topsoil to low levels (10.30 Cmolc/kg) in the subsoil. The exchangeable calcium are high (3.50 Cmolc/kg) in the topsoil and decreases to 2.25 Cmolc/kg in the subsoil. The magnesium levels are high in both topsoil and subsoil. The levels are 2.60 and 2.40 Cmolc/kg respectively. Potassium is medium (0.80 Cmolc/kg) in the topsoil to low levels in the subsoil (0.30 Cmolc/kg). The level of the exchangeable sodium is generally very low.

The are a is under open forest, poorly structured with cultivation. The tree species include *Grewia qoetzeana, Lannea welwitschii and Diospyros natalense.*

4.3.6 Plot 9

The plot is located on the lower part of the slope with slope gradient of about 5 %. The soils in the plot are deep with effective rooting depth greater than 100 cm, imperfectly drained to poorly

drained, dark reddish brown to brown or dark brown, sandy clay in texture with the presence of reddish mottles.

The soils in the plot are slightly acid in the topsoils and the soil reaction decreases and become medium acid in the subsoil with pH values that ranges from 6.4 to 5.9 respectively. The organic carbon is high with levels around 3.3 % in the topsoil and decreases to low or very low (1.10 %) levels in the subsoil. Total nitrogen varies from medium in the topsoil to low in the subsoil with values 0.36 and 0.13 respectively. Based on the C/N ratios the organic matter content are of good quality implying that net mineralisation is possible.

Available phosphorus are low with values ranging from 3.10 mgP/kg in the topsoil to 1.50 mgP/kg in the subsoil.

Cation exchange capacity varies from medium (19.70 Cmolc/kg) in the topsoil to low levels (8.60 Cmolc/kg) in the subsoil. The exchangeable calcium are medium (2.10 Cmolc/kg) in the topsoil and decreases to 1.00 Cmolc/kg in the subsoil. The magnesium levels are generally high (3.60 Cmolc/kg Cmolc/kg) in the topsoil to 3.10 Cmolc/kg in the subsoil. Potassium is low in both topsoil and subsoil with values ranges from 0.15 Cmolc/kg and 0.10 Cmolc/kg. The exchangeable sodium is generally very low.

The forest under this area is dense, mature mixed with dominance of *Diospyros species*.
Trees include *Terminalia sambesiaca, Diospyros natalensis, Lannea welwitschii, Combretum schumannii, Chrysophyllum spp, Bombax rhodognaphalon, Xylopia parviflora, Dialium holtzii, Terminalia sambesiaca, Nersogodonia holstii, Drypetes usambarense, Fernandoa magnifica, Scorodophleus fischeri, Lecaniodiscus fraxinifolius, Galiniera saxifraga, Chrysophyllum sp*.

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ANNEX 1: GUIDE TO SOIL FERTILITY EVALUATION

Organic matter and total nitrogen

	very low	low	medium	high	very high
Organic matter %	< 1.0	1.00-2.0	2.10-4.20	4.30-6.0	> 6.0
Organic C %	< 0.60	0.60-1.25	1.26-2.50	2.51-3.50	> 3.50
Total N %	< 0.10	0.10-0.20	0.21-0.50	> 0.50	

C/N ratios give more information about the availability of nitrogen than total N levels only. C/N ratios indicate the quality of the organic matter:
C/N 8-13: good quality
C/N 14-20: moderate quality
C/N > 20 : poor quality

Soil reaction

Soil reaction (pH H_20) is classified as follows:

Reaction	pH
extremely acid	below 4.5
very strongly acid	4.5 to 5.0
strongly acid	5.1 to 5.5
medium acid	5.6 to 6.0
slightly acid	6.1 to 6.5
neutral	6.6 to 7.3
mildly alkaline	7.4 to 7.8
moderately alkaline	7.9 to 8.4
strongly alkaline	8.5 to 9.0
very strongly alkaline	above 9.0

Available phosphorus

	low	**medium**	**high**
Avail. P (Kurtz-Bray I) mg/kg Avail. P (Olsen) mg/kg	< 7 < 5	7-20 5-10	> 20 > 10

Available phosphorus is determined by the Kurtz-Bray I method if the pH H_20 of the soil is less than 7.0. In soils with a pH H_20 of more than 7.0 the Olsen method is used.

Exchangeable calcium

	very low	**low**	**medium**	**high**	**very high**
Ca (clayey soils rich in 2:1 clays) Cmolc/kg	< 2.0	2.0-5.0	5.1-10.0	10.1-20.0	> 20.0
Ca (loamy soils) Cmolc/kg	< 0.5	0.5-2.0	2.1-4.0	4.1- 6.0	> 6.0
Ca (kaolinitic and sandy soils) Cmolc/kg	< 0.2	0.2-0.5	0.6-2.5	2.6- 5.0	> 5.0

Exchangeable magnesium

	very low	low	medium	high	very high
Mg (clayey soils) Cmolc/kg	< 0-3	0.3-1.0	1.1-3.0	3.1-6.0	> 6.0
Mg (sandy soils Cmolc/kg	< 0.2	0.2-0.5	0.5-1.0	1.1-2.0	> 2.0

For loamy soils a classification has to be used with figures in between the two sets presented for clayey and sandy soils.
The desired saturation level of exchangeable Mg is 10 to 15 percent; for sandy and kaolinitic soils 6 to 8 percent Mg saturation is still sufficient.
Ca/Mg ratios of 2 to 4 are favourable.

Exchangeable potassium

	very low	low	medium	high	very high
K (clayey soils) Cmolc/kg	< 0.20	0.20-0.40	0.41-1.20	1.21-2.00	> 2.00
K (loamy soils) Cmolc/kg	< 0.13	0.13-0.25	0.26-0.80	0.81-1.35	> 1.35
K (sandy soils) Cmolc/kg	< 0.05	0.05-1.10	0.11-0.40	0.41-0.70	> 0.70

The desired saturation level of exchangeable K is 2 to 7 percent.
Favourable Mg/K ratios for most crops are in the range of 1 to 4.

Exchangeable sodium

	very low	low	medium	high	very high
Na (Cmolc/kg)	< 0.10	0.10-0.30	0.31-0.70	0.71-2.00	> 2.00

ANNEX 2. GUIDE TO SOIL DEPTH CLASSIFICATION

Very shallow	: < 20 cm
Shallow	: 20-40 cm
Moderately deep	: 40-80 cm
Deep	: 80-120 cm
Very deep	: > 120cm

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