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SOTER

PROCEDURES MANUAL FOR SMALL-SCALE MAP AND DATABASE COMPILATION

FOR DISCUSSION

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ISRIC

INTERNATIONAL SOIL REFERENCE AND INFORMATION CENTRE

PREFACE

This new version of the manual is a complete revision as far as the structure and the mapping approach is concerned. It is still meant as a base for discussion and its contents is far from final. Improvements are still possible and will certainly be nedeed when SOTER will start using GIS technology. Also the developments of applications of the database will certainly require changes.

This manual is a result of a common effort of many people. Firstly, the group of experts that conceived the idea of SOTER should be mentioned, in particular the experts that participated in the 1986 'International workshop on the structure of a digital international soil resource map annex database' (ISRIC, 1986).

Secondly, the actual compilation of the first draft of the manual was executed by Dr. Jack Shields and Dr. Dick Coote of the Canadian Land Resource Research Centre, Ottawa. After testing their methodology in the field, in Latin America (LASOTER pilot area in Argentina, Brazil and Uruguay), in the USA and Canada (NASOTER pilot area) and in Central Brazil (BRASOTER pilot area) changes became imperative.

Moreover, the first use of the database during the benchmark testing for the selection of a Geographic Information System for SOTER also did show some shortcomings and suggested possible improvements in the database. With the development of some applications imperfections in the definitions and descriptions of attributes became apparent.

The manual consists of two parts. The first part is dealing with the terrain and soil characteristics while the second part gives information on the climatic data needed by SOTER. In each part definitions and descriptions of the attributes to be coded are given while in the first part also an explanation of the mapping approach is provided.

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PART I SOILS & TERRAIN

1 INTRODUCTION

As can be deducted from the SOTER project proposal there are several objectives for this manual:

a) define a universal legend for a digital soils and terrain database for a scale of 1:1,000,000
b) develop a methodology that should be scale-independent and transferable to national surveys or databases (technology transfer).

Universal legend

So far the universal legend has been defined. Attribute data in two pilot areas have been collected and coded, together with the mapping of the soils and terrain units. The time has come now to test the database in several applications in order to assess the usefulness of the database. Possible applications are soil erosion assessment, crop suitability, irrigation suitablity, forest productivity, agro-ecological zonation, soil fertility assessment, risk of droughtiness, global change, etc.

Methodology

Basic in the approach presented in this manual are the three levels of entry for terrain and soils information. They should be on patterns of landforms (geomorphic units), materials (surface lithology) and soils. These entries form the basis for the separation of homogenous areas in the terrain. Soil classification is not used in the methodology.

Thus terrain units are mapping units delineated on a specific set of these criteria. Subdivisions of the mapping units based on non-mappable information form the terrain-soil components. They encompass attribute data that does not possess a more precise location than that it is situated somewhere in the mapping unit: viz. a part of a soil complex.

The methodology as presented here is meant to be scale-independent. There are however, some remarks to be made. At small scales (up to 1:250,000) the structure as presented in this manual can be maintained. With increasing scales, e.g. from 1:1,000,000 to 1:100,000 or 1:50,000, it is expected that the highest level in the hierarchy will subsequently disappear and that only single terrain-soil entities will form the mapping units. This does not mean that the terrain unit information will be left out. It will be part of the information of the single mapping unit.

Moreover, the degree of detail in the attributes will make it necessary to introduce additional attributes at larger scales.

In order to be truly scale-independent it is necessary to develop a hierarchy of terms for the attibutes to be used at the various scales. Examples are given in this manual for land use, vegetation and lithology for which at each level a scale related set of classes exists.

No such hierarchy could be given for hydrology and physiography at the higher levels of the database. At the lower levels of the database a hierarchy of terms is not required for soils.

The transferability of the methology as described in the first two versions of the manual has been tested in two pilot areas. It appeared possible to apply it successfully. It is suggested to apply the adapted methodology at the usual scale of 1:1 million as well as at greater scales in a new pilot area.

2 GENERAL SOTER CONCEPTS

2.1 Geometry and attributes

In every discipline involved with mapping of spacial phenomena, two types of data can be distinguished:

1. Location ('geometry') of the item; represented by a point, a line or an area
2. Characteristics of the item ('attributes').

Also in SOTER these two forms are present. Soils and terrain information has a geometric component which indicates the location as well as an attribute part that describes the non-spatial characteristics. The geometry is stored in one part of the database while the attribute data are stored in separate attribute files. A unique label attached to both the geometric and the attribute data forms the link to connect these two groups of information (see Figure 1).

The overall system that stores and handles the locational and attribute database is called a Geographic Information System. This manual limits itself to the attribute part of the database, in particular the structure of the attribute database and the definitions of the attributes.

2.2 Mapping approach

The basic concept in mapping for SOTER is the physiographic approach. Land is subdivided according to general landforms. The delineated map areas are called terrain units. The precise location of the terrain units and information on their characteristics are stored in the database, more accurately in the geometric part and in the attribute part of the database respectively.

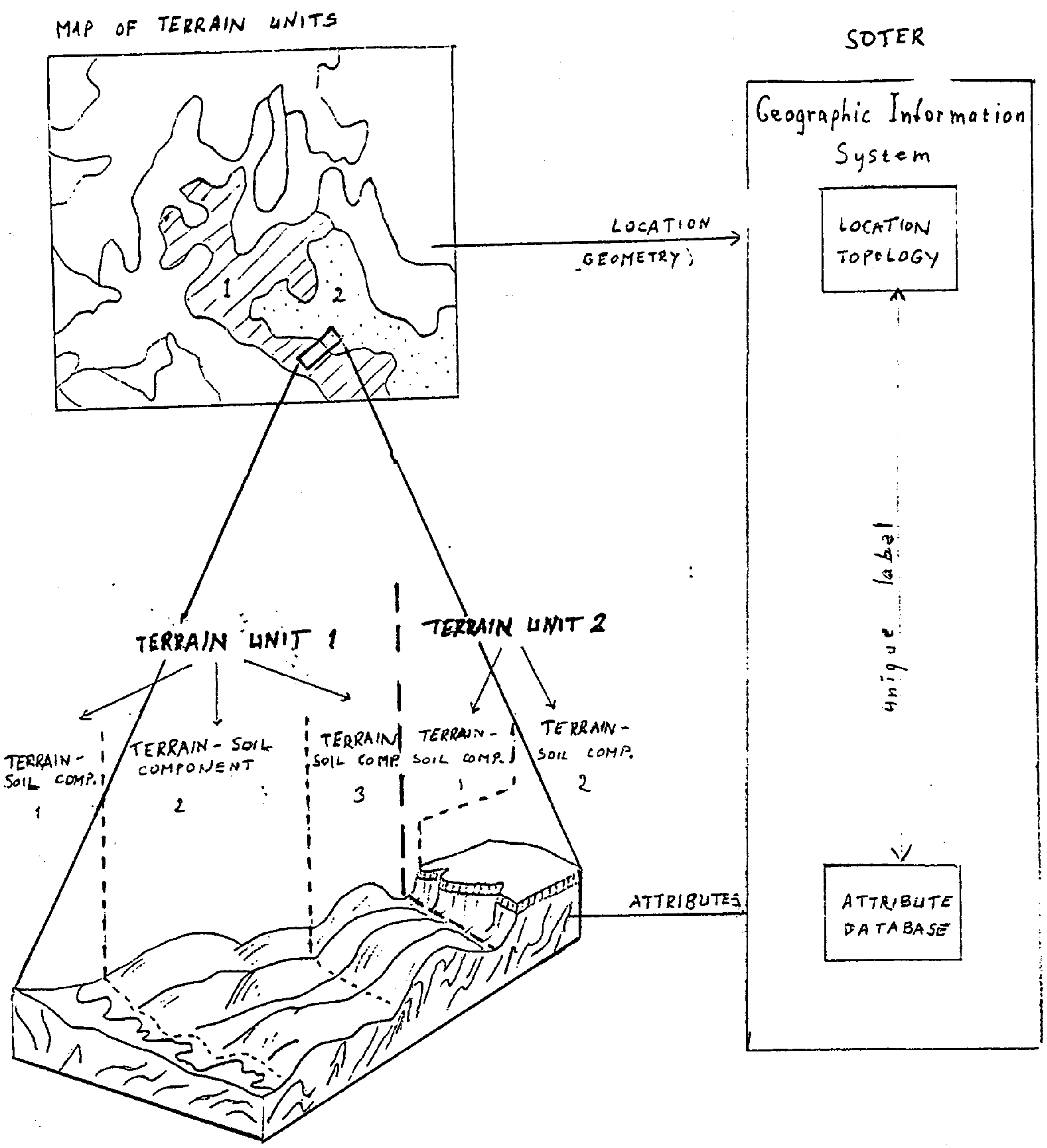

Figure 1.Terrain units and terrain-soil components.

For most of the terrain units more detailed information is available. However, this information cannot be precisely located on the map due to its scale (viz. complexes in conventional mapping). In other words more attribute data are available but no extra geometric data can be added. In order to store this information the mapping units are subdivided into terrain-soil components, which do not have a precise location on the map (but certainly in the field). Nevertheless, their physiographic position and proportion within the unit are stored. They possess more detailed information about their characteristics than the terrain units but their exact location cannot be recorded. Only their relative part within a mappable unit (terrain unit) is known.

The above sketched approach makes it possible to collect and store more information than would be possible if the geometric component for all attributes would be determined. It has certainly a disadvantage: location of attributes belonging to a subdivision of the terrain units, such as those belonging to terrain soil components, cannot be located more precisely than those of the terrain unit. It should be considered a compromise between the resolution of the small-scale map and the available information.

The SOTER approach is meant to be scale independent. Nevertheless, changes will be necessary when scales become larger. With increasing scales attributes from the terrain-soil component will become mappable and will consequently move to the terrain unit level. Moreover, greater scales will certainly lead to more detailed attributes and increasingly more attributes.

3 LEGEND CONCEPTS AND DEFINITIONS

3.1 Terrain unit

A terrain unit is an area of the earth surface with a distinctive, often repetitive pattern of landform and relief, slope, parent material and soil. It consists of one or more enclosed map delineations or polygons (see Figure 1), in other words it can be mapped.

Each terrain unit is assigned an identifying code that is required to be unique for the world. This code should also form the base for codes used at different scales.

The permitted minimum size of the mapping unit should be about 0.25 cm^2, corresponding with an area of 25 km^2 at the 1:1,000,000 scale. This is conventionally considered as the smallest area that can be cartographically presented.

3.2 Terrain-soil component

A terrain-soil component is defined as a segment of the overall landscape of a terrain unit with comparable topographic (surface form and slope gradient) and soil patterns with the provision that the smallest component occupies more than 20% of the terrain unit. This implies a maximum of 4 components per terrain unit.

Parts of the terrain unit which occupy less than 20% of it cannot be allocated separately. They should be joined with neighbouring components.
The sum of the percentages of the terrain-soil components as indicated in the attribute file should always be 100.

For each terrain-soil component, one soil is characterized. The map compiler must indicate which terrain-soil component applies to what proportion of the terrain unit. The terrain-soil component is subdivided into three parts:

1. a site, in which the site characteristics are described (e.g. meso-relief, micro-relief, slope position and gradient, surface drainage, rock outcrops and stoniness, flooding),

2. a generalized soil profile which gives information on the overall properties of the soil like e.g. internal drainage, rootable depth and infiltration, and

3. the layers of the generalized profile which treat soil properties for each individual soil layer.

The generalized profile is derived from one or more actual soil profiles with similar chacteristics representative for the terrain-soil component, and can therefore be considered a synthetic profile. This is in contrast with data from actual soil profiles that apply to a point location.

A separate file contains the references to the profiles which have been used for the compilation of the generalized profile. The original data of the reference pedons are not part of the central SOTER database.

Pedogenetic master horizons of the profile and layers which have an impact on the use of the soil are described. They are derived from the FAO-Unesco's Soil map of the world (1974 and 1989).
Each profile may have a maximum of 4 layers in a continuum:

- 2 layers to about 50 cm, or 1 if the topsoil is very homogeneous
- 2 layers from about 50 cm

Numeric layer data are stored in a format that allows for statistical processing. The average value, standard deviation and number of observations are stored.

In the absence of analytical data, an estimate by a qualified expert is acceptable and is referred to as an 'expert estimate'. For expert estimates, the standard deviation is absent and the number of observations is zero. When an attribute is non applicable, the number of observations is entered as -1.

For non-numeric layer data the dominant quality is stored in the attribute file.

4 ATTRIBUTE CODING

The attributes of the entities presented in the previous chapter are presented in Figure 2.

TERRAIN

1 terrain unit ID
2 year
3 regional landform
4 elevation
5 relief intensity
6 general lithology
7 permanent water surface
8 vegetation

TERRAIN-SOIL COMPONENT

1 terrain unit ID
2 site ID
3 profile ID
4 proportion of unit

SITE

1 site ID
2 surface form
3 micro-relief
4 length of slope
5 position in terrain
6 slope gradient, median (50%)
7 slope gradient, low (10%)
8 slope gradient, high (90%)
9 parent material
10 texture group of parent material
11 frequency of flooding
12 area of flooding
13 duration of flooding
14 high ground water
15 low ground water
16 conductivity of ground water
17 surface drainage
18 surface rockiness, %coverage
19 surface stoniness, %coverage
20 size of stones
21 depth to parent rock

PROFILE

1 profile ID
2 internal drainage
3 infiltration
4 rootable depth
5 soil development
6 decomposition

LAYER

1 profile ID
2 layer number
3 lower depth
4 abruptness of boundary
5 moist colour
6 dry colour
7 structure form
8 structure size
9 structure grade
10 stickiness
11 plasticity
12 consistence moist
13 consistence dry
14 biological activity
15 diagnostic horizon
16 diagnostic property
17 clay mineralogy
18 carbon content
19 nitrogen content
20 P-Olsen
21 P-retention
22 CEC soil
23 AEC
24 exchangeable Ca
25 exchangeable Mg
26 exchangeable K
27 exchangeable Na
28 exchangeable Al
29 exchangeable Mn
30 pH-H_2O
31 pH-KCl
32 EC_e
33 $CaCO_3$
34 gypsum
35 coarse fragments, vol%
36 coarse fragments, size
37 texture class
38 total sand%
39 very fine sand%
40 silt%
41 clay%
42 soil porosity%
43 SM% field capacity
44 SM% wilting point
45 bulk density
46 sat. hydraulic conductivity
47 Fe-dithionite
48 Al-dithionite
49 Fe-oxalate
50 Al-oxalate

REFPEDON

1 profile ID
2 reference pedon
3 parent
4 location
5 laboratory
6 year

Figure 2. Attribute lists for soils and terrain files.

4.1 Terrain unit

unit_id

The unit_id of the terrain unit must be unique for the world. It should also suit use at different scales. Proposed is a code based on the Universal Transverse Mercator grid system (UTM).
The UTM system divides the globe into grids of 6° longitude and 8° latitude; these so-called quadrilaterals are subdivided in square cells of 100x100 km. Within these cells a position is coded by combining the easting and northing to the lower left corner (both in northern and southern hemispheres).

At a scale of 1:1,000,000 1 cm represents 10 km, thus the UTM code should be accurate up to 10 km. Within 1 cm^2, a sequence number from 1 to 9 will suffice to identify all possible terrain units.
Example code: 3PWN34/1

It is necessary to use a certain coding convention; it is proposed for a given terrain unit, to use the UTM code for its left lower or southwestern part, followed by a sequence number.
It must be noted that the major purpose of using the UTM code is not to exactly locate a unit, but to have a coding system that allows independent or non-coordinated coding of units throughout the world, and to have unique identifiers for them.

year

The year in which the original terrain data were collected.

regional landform

Landforms are described by their physiography (form) in contrast to their genetic origin or processes causing their shape.
Landforms are determined by their dominant slopes and the relief intensity, which is defined as the median difference between high and low per unit length (m/km).

Major landforms:

M	Mountains	slopes more than 30%, relief intensity larger than 300 m/km. In general with a restricted summit area and steep sides, irregular shape and considerable bare rock surface, or very thin soil cover. Major scarps are the relatively steep and straight cliff-like slopes of considerable linear extent separating surfaces such as plateaus lying at different levels.
H	Hills	slopes more than 30%, relief intensity between 100 and 300 m/km. Natural elevations rising prominently above the

		surrounding plain having a recognizably denser pattern of generally higher knolls or crest lines with an irregular or chaotic surface form composed of upper surface convexity and lower concavity.
U	Uplands	slopes between 8 and 30%; for steeper slopes the relief intensity must be less than 100 m/km, for slopes between 2 and 8% the relief intensity must be larger than 20 m/km. Flat to gently sloping areas are found between major rivers which are deeply incised.
P	Plain	slopes up to 8%, relief intensity less than 20 m/km; incissions must be less than 20 m deep. Flat to gently undulating areas which have few or no prominent irregularities.

Miscellaneous landforms:

T	Tableland	special type of plain. Plateau, bounded on at least one side by an abrupt escarpment, or may be terminated by mountains.
D	Depression	Basins surrounded by mountains, hills or table lands.
V	Valley	Elongated incised landform, serving as a drainage way. If mappable, the composing parts such as uplands, hills and floodplain, should be delineated separately.

elevation

Median or dominant elevation, m.

relief intensity

The relief intensity is the difference between highest and lowest per unit length, m/km.

lithology

Generalized description of the consolidated or unconsolidated surficial materials which occupy most of the terrain unit (Holmes, 19##). Major differentiating criteria are genesis and mineralogical composition.
For a description of the hierarchy of terms, see ANNEX 1. The lithology should be specified to at least the group level.

vegetation

Generalized description of the physiognomy of the vegetation (Unesco, 1975). A hierarchical classification of the vegetation to apply at the terrain unit and terrain-soil component is given in ANNEX 2.
Vegetation should be specified at least on the formation subclass level.

permanent water surface

Area of terrain unit that is a permanent water body, i.e. more than 10 months/year. When a water body is large enough, it should be delineated on the map.
The area is expressed as a percentage of the terrain unit area.

4.2 Terrain-soil component

The terrain-soil component links a site description and a generalized profile to a terrain unit.

unit_id

The unit_id of the terrain unit.

site_id

Identification code for the site of the terrain-soil component. The site_id code is equal to the unit_id code together with an extra sequence number. Thus, the first terrain-soil component of unit 3PWN34/1 is coded as 3PWN34/1-1.
When a site description has already been coded, the user can enter the code of the referenced site.

profile_id

Code for generalized profile: this code is equal to the terrain-soil component code or when refering to an already described profile, identical to that profile_id.
Example: 3PWN34/1-1

proportion

Proportion that the terrain-soil component occupies of the terrain unit, %. The sum of all terrain-soil components should be 100%. If a terrain-soil component is too small to be coded, it should be included within an adjacent component.

4.3 Site

site ID

Identification code of the site.

surface form

The local surface form or meso-relief (FAO, 1977; Soil Survey Staff, 1951) is determined by the general slope class:

L level	Slopes 2% or less. A flat or very gently sloping, unidirectional surface with a generally constant slope not broken by marked elevations and depressions.
U undulating	Slopes 3 - 8%. A very regular sequence of gentle slopes that extends from rounded, sometimes confined concavities to broad rounded convexities producing a wavelike pattern of low local relief. Slope length is generally less than 0.8 km.
R rolling	Slopes 9 - 30%. A very regular sequence of moderate slopes extending from rounded, sometimes confined concave depressions to broad, rounded convexities producing a wavelike pattern of moderate relief.
S steep	Slopes > 30%. Erosional slopes on both consolidated and unconsolidated materials.

Miscellaneous forms:

T terraced	Scarp face and the horizontal or gently sloping surface above it. Slopes 2% or less.
S sloping	Uniform long slope of more than 2%.
D dissected	A dense pattern of gullies more than 5 m deep.
H hummocky	A very complex sequence of slopes extending from somewhat rounded depressions or kettles of various sizes to irregular conical knolls or knobs. There is a general lack of concordance between knolls or depressions. Slopes are generally between 4 and 70%.
R ridged	A long, narrow elevation of the surface, usually sharp crested with steep sides. The ridges may be parallel, subparallel or intersecting.

micro-relief

The micro-relief is the small-scale differences in the surface form (FAO, 1986).

M mounded	A pattern including distinct mounds of varying relief rising above a planar surface. The mounds must occupy at least 40% of the area. Examples are termite and ant mounds.
G gilgai	A microrelief pattern consisting of enclosed micro-basins and micro-knolls less than 60 cm in nearly level areas or of micro-valleys and micro-ridges that run with the slope. The pattern occurs on clay soils with high coefficients of expansion and contraction with changes in moisture.
G gullies	A well developed pattern of frequent, active gullies (more than 30 cm deep) providing external drainage for the area.
R rills	A well developed pattern of frequent, active rills (less than 30 cm deep) providing external drainage for the area.
D depositions	Overwash and overblow deposits, forming slight elevations above the original surface (micro-dunes, etc.)
P frost polygons	Polygonal ridges, consisting of coarser material (mostly stones) than the inner part, slightly rising above the surface.

dominant length of slope

Estimated median length of slopes, m.

position in terrain

The position of the soils within the terrain unit is relative:

H	high	upper part of terrain unit
M	medium	medium positions of terrain unit
L	low	lower part of terrain unit
A	all	all positions within terrain unit

slope gradient, median

Median slope gradient (50% value), %

slope gradient, low

Lower slope gradient (10% value); 10% of the area has a slope equal to or lower than this gradient.

slope gradient, high

Upper slope gradient (90% value); only 10% of the area has a slope higher than this gradient.

parent material

Generalized description of the consolidated or unconsolidated surficial materials which occupy most of the terrain-soil component (Holmes, 19##; Strahler, 1969). These materials include the kinds of rockmass from which parent material is derived and other unconsolidated mineral or organic deposits.
A complete listing of the codes of lithology is given in ANNEX 1. Describe the parent material at least up to the type level.

texture group of parent material

Texture group of particles < 2mm of the parent material or the material at 2 m if the soil is deeply developed (Proc. Manual, 1989).

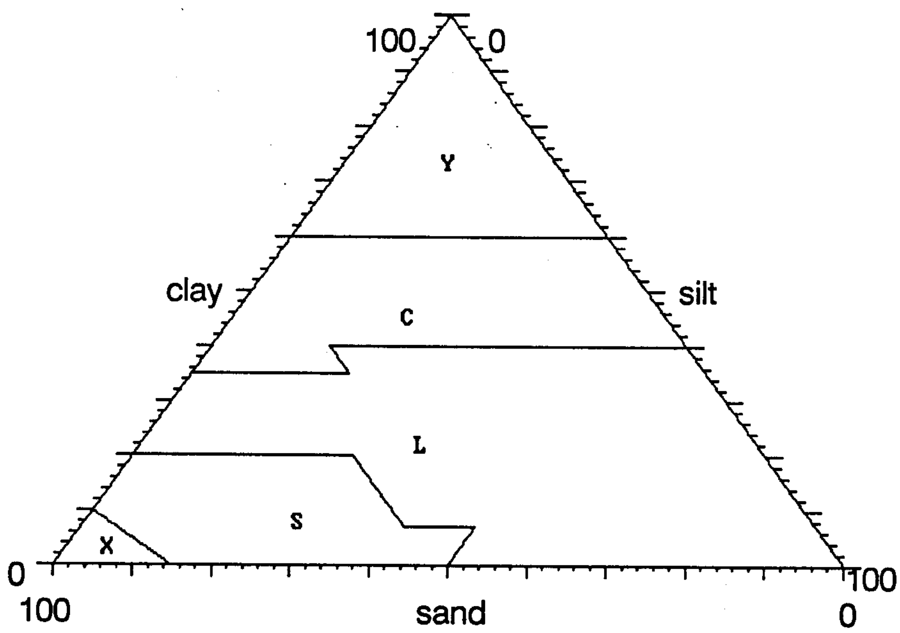

Figure 3.Texture groups of parent material.

Y very clayey	More than 60% clay
C clayey	Sandy clay, silty clay and clay texture classes (see Figure 3) up to 60% clay
L loamy	Loam, sandy clay loam, clay loam, silt, silt loam, and silty clay loam texture classes
S sandy	Loamy sand, and sandy loam texture classes
X extremely sandy	Sand texture classes

frequency of flooding

The frequency of flooding, periods/year.
E.g.: 0.2 = one period of flooding in five years

area of flooding

The area of the terrain-soil component that is flooded less than 10 months per year; when flooding is more than 10 months/year, it is a permanent water body.
Percentage of total site area, %

duration of flooding

The median duration of flooding, days/period.

depth to ground water, high

Mean highest ground water level, cm.

depth to ground water, low

Mean lowest ground water level, cm.

conductivity of ground water

Electrical conductivity of the ground water, mS/m.

surface drainage

Surface drainage (Cochrane et.al., 1985; van Waveren, 1987).

P	ponding	Water ponds at the surface, and the soil is waterlogged for periods of a month or more

S	slow	Water drains slowly; the soil does not remain waterlogged for a period less than a month
M	medium	Water drains at a medium rate; the soil is not waterlogged for more than 48 hours
R	rapid	Excess water drains rapidly, even during periods of prolonged rainfall
V	very rapid	Excess water drains very rapidly; the soil cannot ensure adequate topsoil moisture for seed germination

rockiness

Rock outcrops, % coverage or exposure.

stoniness

Stoniness at surface, % coverage.

size of stones

Size of dominant stones, cm.

depth to parent rock

Depth to parent rock, m.

4.4 Generalized profile

Generalized profiles are generated from several reference pedons that are considered representative for a soil component.
In the ideal case, all data are corrected for the method of analysis used.

profile_id

Code for generalized profile.

internal drainage

Internal drainage (FAO, 1977).

X	excessive	Water is removed from the soil very rapidly in relation to supply. Excess water flows downward very rapidly if underlying material is pervious. There may be very rapid subsurface flow during heavy rainfall provided there is a steep gradient. Water source is precipitation.
R	rapid	Water is removed rapidly. Excess water flows downward if underlying material is pervious. Subsurface flow may occur on steep gradients during heavy rainfall. Water source is precipitation.
W	well	Water is removed from the soil readily. Excess water flows downward readily into underlying pervious material or laterally as subsurface flow. These soils commonly retain optimum amounts of moisture for plant growth after rains or addition of irrigation water.
I	imperfect	Water is removed from the soil sufficiently slowly in relation to supply to keep the soil wet for a significant part of the growing season. Excess water moves slowly downward if precipitation is the major supply. If subsurface water or ground water, or both, is the main source, the flow rate may vary but the soil remains wet for a significant part of the growing season.
P	poor	Water is removed so slowly in relation to supply that the soil remains wet for a comparatively large part of the time the soil is not frozen. Excess water is evident in the soil for a large part of the time. Subsurface flow or ground water flow, or both, in addition to precipitation are the main water sources; there may also be a perched water table.
V	very poor	Water is removed from the soil so slowly that the water table remains at or on the surface for the greater part of the time the soil is not frozen. Ground water flow and subsurface flow are the major water sources. Precipitation is less important except where there is a perched water table.

rootable depth

Depth to which root growth is not restricted by any physical or chemical characteristics, such as an impenetrable or toxic layer, cm.

soil development

The soil development (ISSS comm. V, 1988) that is responsible for the present soil.

AD	andic	Weathering of volcanic material resulting in the formation of amorphous alumino-silicates
AN	anthric	Pronounced human influence
CA	calcic	Accumulation of calcium carbonate
CB	cambic	Weathering in situ leading to a change in colour, texture or consistence without important translocations
CH	chernic	Surface accumulation of saturated organic matter
FA	ferralic	Residual accumulation of sesquioxides as a result of strong weathering
FL	fluvic	Absence of distinct attributes due to soil formation, but with sedimentary stratification
GL	gleyic	Reduction as a result of groundwater influence
GY	gypsic	Acculation of gypsum
HA	halic	Accumulation of soluble salts
HI	histic	Thick surface accumulation of non or only partial decomposed organic materials associated with waterlogging
LI	lixic	Illuvial accumulation of low activity clay
LU	luvic	Illuvial accumulation of high activity clay
MO	modic	Surface accumulation of desaturated organic matter
NI	nitic	Accumulation of clay (illuvial and/or residual) in the presence of low activity clays
PO	podzic	Illuvial accumulation of amorphous compounds of organic matter, often with iron and/or aluminium
PR	primic	Absence of distinct attributes due to soil formation, non-stratified
SO	sodic	Accumulation of sodium (and magnesium) leading to dispersed soil material
ST	stagnic	Reduction as a result of surface or subsurface waterlogging

VE	vertic	Churning of soil material as a result of swelling and shrinking

infiltration

Infiltration or percolation, cm/hr.

degree of decomposition

Degree of decomposition of organic matter/litter (Soil Survey Staff, 1975).

F	fibric	Weakly decomposed organic soil materials, fiber content >2/3 of volume
H	hemic	organic soil material that has a degree of decomposition that is intermediate between fibric and humic (fiber content between 1/6 and 2/3 of volume)
S	sapric	organic soil material has a high degree of decomposition; fiber content < 1/6th of volume.

4.5 Layer of generalized profile

profile_id

Code for generalized profile.

layer number

Sequence number for layer of generalized profile. Up to 4 layers are allowed.

lower depth of layer

Lower depth of layer, cm.

abruptness of boundary

Abruptness of layer boundary to underlying layer (FAO, 1973; FAO, 1977).

A	abrupt	less than 2 cm
C	clear	2 to 5 cm
G	gradual	5 to 12 cm
D	diffuse	12 cm or more

colour, moist

Munsell hue, chroma and value for moist soil.

colour, dry

Munsell hue, chroma and value for dry soil.

form of structure

Form or type of structure (FAO, 1977; Soil Survey Staff, 1951).

P platy	Particles arranged around a plane, generally horizontal
R prismatic	Prisms without rounded upper ends
C columnar	Prisms with rounded caps
A angular blocky	Bounded by plains intersecting at largely sharp angles
S subangular blocky	Mixed rounded and plane faces with vertices mostly rounded
G granular	Spheroidal or polyhedral, relatively non-porous
B crumb	Spheroidal or polyhedral, porous
M massive	No structure; massive
N single grain	No structure; individual grains
W wedge-shaped	Structure in horizons with intersecting slickensides, as in Vertisols.

size of structure elements

Table 1. Size classes for structure types. In mm's. (Soil Survey Staff, 1951).

	platy	prismatic	columnar	ang.blk	sub.blk	granular	crumb
V very fine	<1	<10	<10	<5	<5	<1	<1
F fine	1-2	10-20	10-20	5-10	5-10	1-2	1-2
M medium	2-5	20-50	20-50	10-20	10-20	2-5	2-5
C coarse	5-10	50-100	50-100	20-50	20-50	5-10	
X very coarse	>10	>100	>100	>50	>50	>10	

grade of structure elements

Grade of structure elements (FAO, 1977).

N structureless	No observable aggregation or no orderly arrangement of natural lines of weakness
W weak	Poorly formed indistinct peds, barely observable in place
M moderate	Well-formed distinct peds, moderately durable and evident, but not distinct in undisturbed soil
S strong	Durable peds that are quite evident in undisplaced soil, adhere weakly to one another, withstand displacement, and become separated when soil is disturbed

stickiness

Degree of adhesion of wet soil to other objects. Determined by pressing the wet soil material between thumb and forefinger (FAO, 1977).

0 non-sticky	After release of pressure no soil material adheres to fingers
1 slightly sticky	Soil material adheres to one finger but comes off the other easily
2 sticky	Soil material adheres to both thumb and finger, stretches somewhat
3 very sticky	Soil material strongly adheres to both thumb and finger

plasticity

Capability of molding wet soil by hand. Determined by rolling the soil material between thumb and forefinger (FAO, 1977).

0 non-plastic	No wire is formable by rolling the material between hands
1 slightly plastic	A wire formable (< 1 cm) but soil mass is easily deformable
2 plastic	A wire is formable (> 1 cm) and moderate pressure is needed to deform the soil mass
3 very plastic	A wire is formable (> 1 cm) and much pressure is needed to deform the soil mass

consistence moist

(FAO, 1977).

0 loose	Soil material is non-coherent
1 very friable	Aggregates crush under very gentle pressure, but cohere when pressed together
2 friable	Gentle pressure is required to crush aggregates
3 firm	Moderate thumb and forefinger pressure is required to crush aggregates
4 very firm	Aggregates crush under strong pressure, barely crushable between thumb and forefinger
5 extremely firm	Aggregates cannot be crushed by thumb and forefinger pressure

consistence dry

(FAO, 1977).

0 loose	Soil material is non-coherent
1 soft	Aggregate easily breaks to single grain or powder under very slight pressure. Very weakly coherent and friable
2 slightly hard	Gentle pressure is required to crunch the material; weakly resistant to pressure.

3 hard — Aggregates barely breakable between thumb and forefinger; moderately resistant to pressure

4 very hard — Aggregates are barely breakable in the hands; very resistant to pressure.

5 extremely hard — Aggregates cannot be broken with both hands. Extremely resistant to pressure

biological activity

Biological activity (FAO, 1977).

Table 2. Biological activity classes.

No. of roots per 100 cm2	Size class of roots/biopores (mm)			
	Very fine < 1	Fine 1 - 2	Medium 2 - 5	Coarse > 5
< 1	None	None	None	None
1 - 10	Few	Few	Few	Few
10 - 50	Few	Few	Common	Common
50 - 200	Common	Common	Many	Many
> 200	Many	Many	Many	-

The code for the largest activity must be entered in the database.

N None
F Few
C Common
M Many

diagnostic horizon

Descriptions are taken from the Revised Legend of the FAO/Unesco Soil Map of the World (1989). See it for more precise definitions.

HI histic — A horizon which is more than 25 cm but less than 40 cm thick. It can be more than 40 cm but less than 60 cm thick if it consists of 75 percent or more, by volume, of sphagnum fibres or has a bulk density when moist of less than 0.1 kg.dm^{-3}. A surface layer less than 25 cm thick qualifies as a histic horizon if, after having been mixed to a depth of 25 cm, it has 16% or more organic carbon and the mineral fraction contains more than 60% clay, or 8% or more organic carbon for intermediate contents of clay.

MO mollic

A horizon with the following properties for the upper 18 cm:
1) the soil structure is sufficiently strong that the horizon is not both massive and hard or very hard when dry. Very coarse prisms larger than 30 cm in diameter are included in the meaning of massive if there is no secondary structure within the prisms.
2) the chroma is less than 3.5 when moist, the value darker than 3.5 when moist and 5.5 when dry; the colour value is at least one unit darker than that of the C (both moist and dry). If a C horizon is not present, comparison should be made with the horizon immediately underlying the A horizon. If there is more than 40% finely divided lime, the limits of the colour value dry are waived; the colour value moist should then be 5 or less.
3) the base saturation is 50% or more
4) the organic carbon content is at least 0.6% throughout the thickness of mixed soil, as specified below. It is at least 2.5% when the colour requirements are waived because of finely divided lime. The upper limit of organic carbon content of the mollic horizon is the lower limit of the histic horizon.
5) the thickness is 10 cm or more if resting directly on hard rock, a petrocalcic/petrogypsic horizon or a duripan. The thickness must be at least 18 cm and more than 1/3 of the thickness of the solum where the solum is less than 75 cm thick, and must be more than 25 cm where the solum is more than 75 cm thick. The measurement of the thickness of a mollic horizon includes transitional horizons in which the characteristics of the horizon are dominant.

FI fimic

A man made surface layer 50 cm or more thick which has been produced by long continued manuring with earthy mixtures. If a fimic horizon meets the requirements of the mollic or umbric horizon, it is distinguished from it by an acid-extractable P_2O_5 content which is higher than 250 mg/kg soil by 1 percent citric acid. Examples are the plaggen epipedon and the anthropic epipedon of Soil Taxonomy.

UM umbric

Comparable to mollic in colour, organic carbon and phosphorus content, consistency, structure and thickness. However, the base saturation is less than 50%.

OC ochric

The horizon is too light in colour, has too high a chroma, too little organic carbon, or is too thin to be a mollic or umbric, or is both hard and massive when dry. Finely stratified materials do not qualify as an ochric horizon, e.g. surface layers of fresh alluvial deposits.

AR argic

A subsurface horizon which has a distinctly higher clay content than the overlying horizon. This difference may be due to an illuvial accumulation of clay, or to a destruction of clay in the surface horizon, or to a selective surface erosion of clay, or to biological activity or to a combination of two or more of these different processes. Sedimentation of surface materials, which are coarser than the subsurface horizon, may enhance a pedogenic textural differentiation. However, a mere lithological discontinuity, such as may occur in alluvial deposits, does not qualify as an argic horizon. When an argic horizon is formed by clay alluviation, clay skins may occur on ped surfaces, in fissures, in pores, and in channels.
The texture must be sandy loam or finer with at least 8% clay.

NA natric

An argic horizon with
1) a columnar or prismatic structure in some part of the horizon, or a blocky structure with tongues of an eluvial horizon in which there are uncoated silt or sand grains extending more than 2.5 cm into the horizon, and
2) an exchangeable sodium percentage of more than 15% within the upper 40 cm of the horizon; or more exchangeable magnesium plus sodium than calcium plus exchange acidity within the upper 40 cm of the horizon if the saturation with exchangeable sodium is more than 15% in some subhorizon within 200 cm of the surface.

CB cambic

An altered horizon lacking properties that meet the requirements of an argic, natric or spodic horizon; lacking the dark colours, organic matter content and structure of the histic horizon, or the mollic and umbric horizons.
The texture is sandy loam or finer, with at least 8% of clay; the thickness is at least 15 cm with the lower depth at least 25 cm below the surface; soil structure is at least moderately developed or rock structure is absent in at least half the volume of the horizon; the CEC is more than 160 mmol(+)/kg clay, or the content of weatherable minerals in the 0.050 to 0.200 mm fraction is 10% or more; the horizon shows alteration in a) stronger chroma, redder hue, or higher clay content than the underlying horizon, or b) evidence of removal of carbonates, or c) if carbonates are absent in the parent material and in the dust that falls on the soil, the required evidence of alteration is satisfied by the presence of soil structure and the absence of rock structure in more than 50% of the horizon; shows no cementation, induration or brittle consistence when moist.

SP spodic

A spodic horizon meets one of the following requirements below a depth of 12.5 cm:
1) a subhorizon more than 2.5 cm thick that is continuously cemented by a combination of organic matter with iron or aluminium or with both

2) a sandy or coarse-loamy texture with distinct dark pellets of coarse silt size or larger or with sand grains covered with cracked coatings which consist of organic matter and aluminium with or without iron.
3) one or more subhorizons in which a) if there is 0.1% or more extractable iron, the ratio of iron plus Al extractable by pyrophosphate at pH 10 to clay% is 0.2 or more, or if there is less than 0.1% extractable iron, the ratio of Al plus organic carbon to clay is 0.2 or more; and b) the sum of pyrophosphate-extractable Fe+Al is half or more of the sum of dithionite-citrate extractable Fe+Al; and c) the thickness is such that the index of accumulation of amorphous material in the subhorizons that meet the preceding requirements is 65 or more. This index is calculated by subtracting half the clay% from CEC at pH 8.2 mmol/kg clay and multiplying the remainder by the thickness of the subhorizon in centimeters. The results of all subhorizons are then added.

FA ferralic

The ferralic horizon has a texture that is sandy loam or finer with at least 8% of clay; is at least 30 cm thick; has a CEC equal to or less than 160 mmol/kg clay or has an effective CEC equal to or less than 120 mmol/kg clay (sum of NH_4OAc exchangeable bases plus 1M KCl-exchangeable acidity); has less than 10% weatherable minerals in the 0.050 to 0.200 mm fraction; has less than 10% water-dispersible clay; has a silt-clay ratio which is 0.2 or less; does not have andic properties; has less than 5% by volume showing rock structure.

CA calcic

A horizon of accumulation of calcium carbonate. The horizon is enriched with secondary calcium carbonate over a thickness of 15 cm or more, has a calcium carbonate content of 15% or more and at least 5% greater than that of a deeper horizon. The latter requirement is expressed by volume if the secondary carbonates in the calcic horizon occur as pendants on pebbles, or as concretions or soft powdery forms. If such a calcic horizon rests on very calcareous materials (40% or more calcium carbonate equivalent), the percentage of carbonates need not decrease with depth.

PC petrocalcic

A continuous cemented or indurated calcic horizon, cemented by calcium carbonate and in places by calcium and some magnesium carbonate. Accessory silica may be present. The petrocalcic horizon is continuously cemented to the extent that dry fragments do not slake in water and roots cannot enter. It is massive or platy, extremely hard when dry so that it cannot be penetrated by spade or auger, and very firm to extremely firm when moist. Noncapillary pores are filled; hydraulic conductivity is moderately slow to very slow. It is usually thicker than 10 cm.

GY gypsic

The gypsic horizon is enriched with secondary calcium sulphate ($CaSO_4.2H_2O$), is 10 cm or more thick, has at least 5% more gypsum than the underlying horizon, and the product of the thickness (cm) and the percent of gypsum is 150 or more.

PG petrogypsic

A gypsic horizon that is so cemented with gypsum that dry fragments do not slake in water and roots cannot enter. The gypsum content usually exceeds 60%.

SU sulphuric

The sulphuric horizon forms as a result of artificial drainage and oxidation of mineral or organic materials which are rich in sulphides. It is at least 15 cm thick and characterized by a pH-H_2O less than 3.5 and generally has jarosite mottles with a hue of 2.5Y or more and a chroma of 6 or more.

AL albic

Clay and free iron oxides have been removed, or the oxides have been segragated to the extent that the colour of the horizon is determined by the colour of the primary sand and silt particles rather than by coatings of these particles. An albic horizon has a colour value moist of 4 or more, or a value dry of 5 or more, or both. If the value dry is 7 or more, or the value moist is 6 or more, the chroma is 3 or less. If the value dry is 5 or 6, or the value moist 4 or 5, the chroma is closer to 2 than to 3. If the parent materials have a hue of 5YR or redder, a chroma moist of 3 is permitted in the albic horizon where the chroma is due to the colour of uncoated silt or sand grains.

diagnostic properties

Diagnostic properties (FAO, 1989).

TC abrupt textural change

A clay increase between two layers, which takes place over a distance of less than 5 cm, where the lower layer shows a clay content of twice the clay content of the overlying layer if the latter has more than 20% clay, or an increase of 20% or more if the latter has 20% clay or more.

AD andic properties

Soil materials which meet one or more of the following requirements:
1) acid oxalate extractable Al plus 1/2 acid oxalate extractable Fe is 2.0% or more in the fine earth fraction; bulk density of the fine earth fraction, measured in the field moist state, is 0.9 kg/dm^3 or less; phosphate retention is more than 85%.
2) more than 60% by volume of the whole soil is volcani-clastic material coarser than 2 mm; acid oxalate extractable Al plus 1/2 acid oxalate extractable Fe is 0.40% or more in the fine earth fraction.

3) the 0.02 to 2.0 mm fraction is at least 30% of the fine earth fraction and meets one of the following: a) if the fine earth fraction has acid oxalate extractable Al plus 1/2 acid oxalate extractable Fe of 0.40% or less, there is at least 30% volcanic glass in the 0.02 to 2.0 mm fraction; or b) if the fine earth fraction has acid oxalate extractable Al plus 1/2 acid oxalate extractable Fe of 2.0% or more, there is at least 5% volcanic glass in the 0.02 to 2.0 mm fraction; or c) if the fine earth fraction has acid oxalate extractable Al plus 1/2 acid oxalate extractable Fe of between 0.40 and 2.0%, there is a proportional content of volcanic glass in the 0.02 to 2.0 mm fraction between 30 and 5%.

CO calcareous

Soil material which shows strong effervescence with 10% HCl in most of the fine earth or which contains more than 2% calcium carbonate equivalent.

CA calcaric

Soils which are calcareous throughout the depth between 20 and 50 cm.

RO continuous hard rock

The underlying material is sufficiently coherent and hard when moist to make hand digging with a spade impractable. The material is continuous except for a few cracks produced in place without significant displacement of the pieces and horizontally distant to an average of 10 cm or more. The material considered here does not include subsurface horizons such as a duripan, a petrocalcic or a petrogypsic horizon or a petroferric phase.

FA ferralic properties

The term 'ferralic properties' is used in connection with Cambisols and Arenosols which have a CEC of less than 240 mmol(+)/kg clay or less than 40 mmol(+)/kg soil in at least one subhorizon of the cambic horizon or the horizon immediately underlying the A horizon.

FI ferric properties

Many coarse mottles with hues redder than 7.5YR or chromas more than 5 or both; discrete nodules, up to 2 cm in diameter, the exteriors of the nodules being enriched and weakly cemented or indurated with Fe and having redder hues or stronger chromas than the interiors (Luvisols, Alisols, Lixisols and Acrisols).

FL fluvic properties

Fluviatile, marine and lacustrine sediments, which receive fresh materials at regular intervals, and which, unless empoldered, have one or both of the following properties: 1) an organic carbon content that decreases irregularly with depth or that remains above 0.20% to a depth of 125 cm. Thin strata of sand may have less organic carbon if the finer sediments below, exclusive of buried horizons, meet the requirement; 2) stratification in at least 25% of the soil within 125 cm of the surface.

GE geric properties

Soil materials which have either: 1) 15 mmol(+)/kg or less of exchangeable bases (Ca, Mg, K, Na) plus unbuffered 1M KCl extractable Al and a pH (1M KCl) of 5.0 or more; or 2) a delta pH (pH KCl minus pH H_2O) of +0.1 or more.

GL gleyic and stagnic properties

Soil materials which are saturated with water at some period of the year, or throughout the year, in most years, and which show evidence of reduction processes or of reduction and segregation of iron (see FAO/UNESCO Soil Map of the World).

GY gypsiferous

Soil material which contains 5% or more gypsum.

IN interfingering

Penetrations of an albic horizon into an underlying argic or natric horizon along ped faces, primarily vertical faces. The penetrations are not wide enough to constitute tonguing, but form continuous skeletans (ped coatings of clean silt or sand, more than 1 mm thick on the vertical ped faces).

NI nitic properties

Soil material that has 30% or more clay, has a moderately strong angular blocky structure which falls easily apart into flat edged ('polyhedric' or 'nutty') elements which show shiny ped faces that are either thin clay coatings or pressure faces. This soil structure is apparently associated with the presence of significant amounts of active iron oxides and is indicative of a high effective moisture storage and favourable phosphate sorption - desorption properties.

OR organic soil materials

Organic soil materials are: 1) saturated with water for long periods or are artificially drained and, excluding live roots, a) have 18% or more organic carbon if the mineral fraction is 60% or more clay, b) have 12% or more organic carbon if the mineral fraction has no clay, or c) have a proportional content of organic carbon between 12 and 18% if the clay content of the mineral fraction is less than 60%; or 2) never saturated with water for more than a few days and have 20% or more organic carbon.

PE permafrost

Permafrost is a layer in which the temperature is perennially at or below 0°C.

PL plinthite

Plinthite is an iron-rich, humus-poor mixture of clay with quartz and other diluents. It commonly occurs as red mottles, usually in platy, polygonal or reticulate patterns, and changes irreversibly to a hardpan or to irregular aggregates on exposure to repeated wetting and drying. In a moist soil, plinthite is usually firm but it can be cut with a spade. When irreversibly hardened the mnaterial is no longer considered plinthite. Such hardened material is shown as a petroferric or a skeletic phase.

SA salic properties

The electric conductivity of the saturation extract is more than 15 dS/m within 30 cm of the surface, or more than 4 dS/m within 30 cm of the surface if the pH-H_2O exceeds 8.5.

SI slickensides

Slickensides are polished and grooved surfaces that are produced by one mass sliding past another. Some of them occur at the base of a lsip surface where a mass of soil moves downward on a relatively steep slope. Slickensides are very common in swelling clays in which there are marked seasonal changes in moisture content.

SM smeary consistence

Thixotropic soil material; it changes under pressure or by rubbing from a plastic solid into a liquefied stage and back to the solid condition. In the liquefied stage the material skids or smears between the fingers (Andosols).

SO sodic properties

The exchangeable sodium percentage is 15% or more, or exchangeable sodium plus magnesium is 50% or more.

SL soft powdery lime

Translocated authigenic lime, soft enough to be cut readily with finger nail, precipitated in place from the soil solution rather than inherited from a soil parent material. It should be present in a significant accumulation (coatings on pores or structural faces).

HU strongly humic

Soil material with an organic carbon content of more than 14 g/kg fine earth as a weighted average over a depth of 100 cm from the surface. This calculation assumes a bulk density of 1.5 kg/dm^3.

SU sulphidic materials

Sulphidic materials are waterlogged mineral or organic soil materials containing 0.75% or more sulphur (dry weight), mostly in the form of sulphides, having less than three times as much calcium carbonate equivalent as sulphur, and having a pH above 3.5. Sulphidic materials accumulate in a soil that is permanently saturated and having a pH above 3.5, generally with brackish water. If the soil is drained the sulphides oxidize to form sulphuric acid. The pH, which is normally near neutrality before drainage, drops below 3.5. At this point these materials become a sulphuric horizon. Sulphidic material differs from the sulphuric horizon in its reduced condition, its pH and the absence of jarosite mottles with a hue of 2.5Y or more or a chroma of 6 or more.

TO tonguing

An albic horizon penetrates an argic horizon along ped surfaces, if peds are present. Tongues must have greater depth than width, have horizontal dimensions of 5 mm or more in fine textured argic horizons (clay, silty clay and sandy clay), 10 mm or more in moderately fine textured argic horizons, and 15 mm or more in medium or coarser textured argic horizons (silt loams, loams and sandy loams), and must occupy more than 15% of the mas of the upper part of the argic horizon.

VE vertic properties

In connection with clayey soils which at some period in most years show one or more of the following: cracks, slickensides, wedge-shaped or parallelepiped structural aggregates, that are not in a combination, or are not sufficiently expressed, for the soils to qualify as Vertisols.

WM weatherable minerals

Minerals included are those that are unstable in a humid climate relative to other minerals, such as quartz and 1:1 lattice clays, and that, when weathering occurs, liberate plant nutrients and iron or aluminium. They include: 1) clay minerals: all 2:1 lattice clays except aluminium-interlayered chlorite. Sepiolite, talc and glauconite are also included in the meaning of this group of weatherable clay minerals, although they are not always of clay size. 2) silt- and sand-size minerals: feldspars, feldspathoids, ferromagnesian minerals, glasses, micas, and zeolites.

clay mineralogy

Dominant minerals in the clay fraction:

AL allophane

CH chloritic

IL illitic

KA kaolinitic

MO montmorillonitic

SE sesquioxidic

VE vermiculitic

carbon content

Content of organic carbon in the fine earth, g/kg.

nitrogen content

g/kg

P-Olsen

mg/kg

P-retention

Phosphate retention of fine earth, mg/kg

CEC soil

mmol(+)/kg

AEC soil

mmol(+)/kg

exchangeable Ca

mmol(+)/kg

exchangeable Mg

mmol(+)/kg

exchangeable K

mmol(+)/kg

exchangeable Na

mmol(+)/kg

exchangeable Al

mmol(+)/kg

exchangeable Mn

mmol(+)/kg

pH-H2O

pH is determined in the supernatant suspension of a 1:2.5 soil-water mixture

pH-KCl

pH is determined in the supernatant suspension of a 1:2.5 soil-1 m KCl mixture

electrical conductivity

Electrical conductivity of saturation extract, mS/m.

calciumcarbonate

Content of $CaCO_3$, g/kg

gypsum

Content of $CaSO_4.2H_2O$, g/kg

Volume of coarse fragments

Estimated volume % of coarse fragments in soil matrix.

Size of coarse fragments

Size of dominant coarse fragments. When the estimate is based on the classes gravel (0.2 - 7.5 cm), stones (7.5 to 25 cm) and boulders (> 25 cm) enter the average class value.
Dimension: cm.

texture class

Texture class of the fine earth (Soil Survey Staff, 1951).

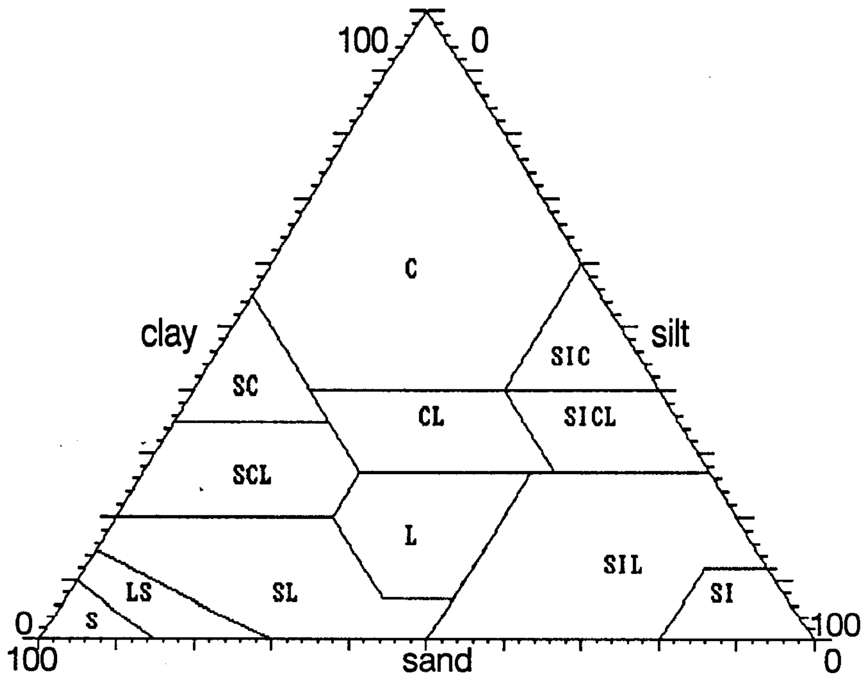

Figure 4. Texture classes of fine earth.

S	sand
LS	loamy sand
SL	sandy loam
SIL	silty loam
SI	silt
L	loam
SCL	sandy clay loam
CL	clay loam
SICL	silty clay loam
SC	sandy clay
SIC	silty clay
C	clay

sand (total)

Volume % of particles 0.050 - 2.0 mm in the fine earth.

very fine sand

Volume % of particles 0.050 - 0.100 mm in the fine earth.

silt

Volume % of particles 0.002 - 0.050 mm in the fine earth.

clay

Volume % of particles < 0.002 mm in the fine earth.

porosity

Total porosity, volume %.

available water at field capacity

Volume % of soil moisture at field capacity.

available water at wilting point

Volume % of soil moisture at wilting point.

bulk density

kg/dm^3, or g/cm^3

saturated hydraulic conductivity

cm/hr

Fe, dithionite extractable

Dithionite extraction.

Al, dithionite extractable

Fe, acid oxalate extractable

Extraction with a solution of ammonium oxalate at pH 3.

Al, acid oxalate extractable

4.6 Reference pedons

This file links the generalized profiles to the pedons used for their generation, and to other reference pedons that are considered similar.

profile_id

Code for generalized profile.

reference pedon

Code for reference pedon that is similar to generalized profile.

parent

Is the reference pedon used for the generalized profile? Y/N.

location

Location code for the reference pedon. Contains both the latitude and the longitude in degrees and minutes; e.g. 50N34-140E57

laboratory

Identification code for the laboratory that analyzed the reference pedon.

year

The year in which the reference pedon was sampled and analyzed.

PART II LAND USE

5 INTRODUCTION TO LAND USE

An objective of SOTER is to provide international, regional and national decision-makers with information essential for development, management and conservation of environmental resources.

In contrast to landform, land use is considered a dynamic entity, of which it is desired to assess its changes with time. Therefore, it is stored in a separate file in order to enable addition of new records when land use has changed in time.

SOTER does not digitize new land use boundaries of the landscape. Land use is described for each terrain unit and its terrain-soil components.

At present, land use is described in a hierarchy of terms. No additional attributes are used to differentiate within those land use groups or systems. Therefore, the structure of the land use files is very simple; it contains the key of the terrain or terrain-soil component file together with a term to classify the land use, and the year of observation.

5.1 Land use group

terrain unit ID

land use group

year

land use group

At terrain unit level, the land use group can be determined. For definitions of the various classes, see ANNEX 3.

5.2 Land use system

terrain unit ID

site ID

profile ID

year

land use system

At terrain-soil component level, at least the land use system must be given. For land use system codes see ANNEX 3.

6 INTRODUCTION TO CLIMATE

The SOTER climate files are intended for multiple applications of the World Soils and Terrain Database. Climatic data form an inseparable part of the basic inventory of natural resources for any land evaluation. The climatic data as described in the paragraphs below are thought to provide a sufficient base for any application of the SOTER database.

Data from point observations are extracted from meteorological data sets and consist of two major groupings: (1) station particulars and (2) climatic data. These two groups are also found in the structure of the climatic database:

- Climate station file.
  This file is a listing of the climatic stations with their local name, the exact location coordinates of the station and altitude.

- Climate attribute file.
  This file contains the numeric values of various climate elements per climatic station. The values are given as mean annual and monthly, averaged over a specific number of years, or they can be given as actual values for a number of years. The format of the file indicates in which way the values are reported.

More detailed studies at a larger scale may require data for shorter periods, such as weeks or days. For SOTER, monthly or decadal data are considered sufficient.

7 ATTRIBUTE LISTS AND CODING

The following files are used to store the climate, monthly data and decadal data:

STATION	MONTHLY DATA	DECADE DATA
1 country code	1 station code	1 station code
2 station code	2 kind of data	2 kind of data
3 station name	3 start of period	3 start of period
4 altitude	4 end of period	4 end of period
	5 years of record	5 years of record
	6 January	6 January, 1-10
	7 February	7 January, 11-20
	etc.	etc.
	17 December	41 December, 21-31
	18 annual	42 annual

Descriptive attribute have character codes to distinguish them from numeric attributes. Dimensions for numeric attributes are as SI-units.

7.1 Climate station

Country code

Maximally three characters. Codes are taken from the list of country codes (FAO, 1985). A full list of codes is presented as ANNEX 4.

Station code

Unique code for climate station. The code reflects the location of the station and is composed of both latitude and longitude coordinates.
The latitude and longitude are specified up to minutes: the first two or three digits indicate degrees, then a character for the hemisphere, and the following two digits indicate the minutes.
An example code is 50N43-160W57 for 50°43' North - 160°57' West.

Station name

Name is abbreviated to 12 characters. Give name under which climate station is known locally. Stations are usually named after the nearest village or city.

Altitude

Altitude above or below (negative) sea level, m.

7.2 Climate attributes

Station code

The station code (see previous paragraph).

Source

Source of information for each separate kind of data is coded (2 digits). It can refer to a combination of publications used for a certain kind of data. Codes are to be explained in a separate file.

Kind of data

A code for the kind of climatic element recorded. The unit of measure is included with the kind of data.

RTOT	precipitation totals (mm)
RDAY	number of rainy days; days with at least 1 mm of precipitation per day
RMAX	maximum 24-hour rainfall (mm)
RREL	rainfall reliability; the amount of rainfall exceeded in 3 out of 4 years (mm)
TMIN	mean minimum temperature during a 24 hour period (°C)
TMAX	mean maximum temperature during a 24 hour period (°C)
TAVG	mean 24-hour temperature (°C)
RADI	total radiation ($MJ.m^{-2}.day^{-1}$)
SUNH	hours of bright sunshine per day (hr)
CLOU	degree of cloudiness during daylight period (octas)
HMIN	minimum relative humidity during 24 hour period (%)
HMAX	maximum relative humidity during 24 hour period (%)
HAVG	mean 24 hour relative humidity (%)
WAVG	mean 24 hour wind velocity at 2 m (m/s)
WDAY	wind velocity at 2 m during day time (m/s)
WNIG	wind velocity at 2 m during night time (m/s)
PETP	potential evapotranspiration, Penmann (mm)
PETH	potential evapotranspiration, Hargreaves (mm)
PETT	potential evapotranspiration, Thornthwaite (mm)
EPAN	evaporation, class A pan (mm)
ECOL	evaporation, Colorado pan (mm)
EPIC	evaporation, Piche (mm)

Start observation period

The start of the observation period; the first year of record.

End observation period

The end of the observation period; the last year of record.

Years of record

The total number of years with actual recording values, used to calculate mean values. By default the difference between end and start of observation plus one. If data for one or more years within the observation period are lacking, total years should be corrected accordingly.

Monthly/decadal values

Actual values of climatic elements per month or per decade; monthly and decadal data are stored in separate files.

Annual value

The annual values of the climatic element.

GLOSSARY

GIS

mapping unit	a set of areas (see polygon) drawn on a map to represent a well-defined feature or set of features. Mapping units are described by the map legend.
polygon	an irregular, delineated area on a map

RDBMS

primary key	attribute or combination of attributes that uniquely identify a record in a table/file
RDBMS	relational database management system. Data are stored in tables

SOTER

generalized profile	a synthetic profile, derived from multiple profile point data, with variation of data
site description	description of characteristics of the location(s) of a generalized profile inside a terrain unit; e.g. surface properties, ground water.
terrain unit	physiographic unit that is mappable at the current map scale

LITERATURE

Baumgardner, M.F. and Oldeman, L.R., 1986 (eds). Proceedings of an international workshop on the structure of a digital international soil resources map annex database. ISSS, Wageningen.

Cochrane, T.T., de Castro, N.F. and Netto, J.M., 1981. An explanatory manual for CIAT's computerized land resource study of tropical America. CIAT, Cali.

Cochrane, T.T., Sanchez, L.G., de Azevedo, L.G., Porras, J.H., and Garves, C.L., 1985. Land in tropical America. CIAT, Cali.

Day, J.H. (ed), 1983. The Canada soil information system (CanSIS), Manual for describing soils in the field. Agriculture Canada, Research Branch, Ottawa.

FAO-Unesco, 1974. Soil map of the world. Vol 1, legend. Unesco, Paris.

FAO, 1977. Guidelines for the description of soils. FAO, Rome.

-, 1986. Guidelines for the coding of soil data. Proposals for an international soil data bank, reprint 1977. FAO, Rome.

FAO, 1988. Soil map of the world, Revised legend. World Soil Resources Report 60, FAO, Rome.

Holmes, 1968. Physical geology.

ISSS, 1988. International Reference Base Group.

Kenya Soil Survey Staff, 1987. Soil survey manual. Kenya Soil Survey, Nairobi.

Meijerink, A.M.J. and Valenzuela, C.R., 1987. ILWIS: Integrated Land and Watershed Management System. Methodology, terrain soil module, input. Publication M2, 2nd version. ITC, Enschede.

National Bureau of Soil Survey and Land Use Planning, 1987. Field manual for soil mapping of India and of different states. Nagpur.

Peters. W.L. (ed), 1989. Proceedings of the second regional workshop on a global soils and terrain digital database and global assessment of soil degradation. ISSS, Wageningen.

Remmelzwaal, A., 1989. Classification of land and land use, first approach. FAO, Rome (unpublished).

Ruthenberg, H., 1980. Farming systems in the tropics. Third edition. Clarendon, Oxford.

Shields, J.A. and Coote, D.R., 1989. SOTER Procedures manual for small-scale map and database compilation. Working paper and preprint 88/2, ISRIC, Wageningen.

Soil Conservation Service, 1979. Pedon coding system for the national cooperative soil survey. US Dept. of Agric., Washington D.C.

Soil Conservation Service, 1981. Soil survey manual: revised chapter 4. US Dept. of Agric., Washington D.C.

Soil Conservation Service, 1986. National soils handbook, 1986 amendment. Glossary of landform and geologic terms. US Dept. of Agric., Washington D.C.

Soil Survey Staff, 1951. Soil survey manual. U.S. Dept. of Agric. Handbook No. 18. Government Printer, Washington D.C.

- , 1975. Soil taxonomy. U.S. Dept. of Agric. Handbook No. 438, Government Printer, Washington D.C.

Strahler, A.N., 1969. Physical geology. Wiley and Sons, New York.

Touber, L., Smaling, E.M.A., Andriesse, W. and Hakkeling, R.T., 1989. Inventory and evaluation of tropical forest land. Guidelines for a common methodology. Tropenbos Foundation, Ede.

Weg, R.F. van de, 1987 (ed). Proceedings of the second international workshop on a global soils and terrain digital database. SOTER Report 2. ISSS, Wageningen.

Waveren, E.J. van, 1987. Guidelines for the description and coding of soil data. Technical paper 14, ISRIC, Wageningen.

ANNEX 1. HIERARCHY OF LITHOLOGY

Hierarchical levels to describe lithology are major class, group, and type (after Holmes, 1968; Strahler, 1969; Soil Conservation Service, 1986).

major class	group	type
I igneous rocks	IA acid igneous	IA1 granite IA2 grano-diorite IA3 quartz-diorite IA4 rhyolite
	II intermediate igneous	II1 andesite, trachyte, phonolite II2 diorite-syenite
	IB basic igneous	IB1 gabbro IB2 basalt IB3 dolerite
	IU ultrabasic igneous	IU1 peridotite IU2 pyroxenite IU3 ilmenite, magnetite, ironstone, serpentine
M metamorphic rocks	MA acid metamorphic	MA1 quartzite MA2 gneiss, migmatite
	MB basic metamorphic	MB1 slate, phyllite (pelitic rocks) MB2 schist MB3 gneiss rich in ferro-magnesian minerals MB4 metamorphic limestone (marble)
S sedimentary rocks	SC clastic sediments	SC1 conglomerate, breccia SC2 sandstone, greywacke, arkose SC3 siltstone, mudstone, claystone SC4 shale
	SO organic	SO1 limestone, other carbonate rocks SO2 marl and other mixtures SO3 coals, bitumen & related rocks
	SE evaporites	SE1 anhydrite, gypsum SE2 halite
U unconsolidated materials	UF fluvial UC colluvial UE eolian UG glacial UL lacustrine UM marine UP pyroclastic UO organic (peat, etc.)	Lithology groups UA to UP are subdivided on the texture group of the material. ..1 sandy ..2 silty ..3 loamy ..4 clayey ..5 mixed, including > 35% coarse fragments

I igneous rocks

Formed by solidification from a molten or partially molten state; major varieties include intrusive (plutonic) and extrusive (volcanic) rocks.

IA acid igneous rocks

Any igneous rock predominantly consisting of light-coloured materials, having low specific gravity and having more than 65% silica.

IA1 granite

Coarse-grained intrusive rock, composed essentially of a mixture of quartz, potassium feldspar, and mica.

IA2 grano-diorite

IA3 quartz-diorite

IA4 rhyolite

The lava (extrusive) that is similar in composition to granite.

II intermediate igneous rocks

II1 andesite, trachyte, phonolyte

Light-gray or pink on freshly broken surfaces. Andesite is extrusive.

II2 diorite-syenite

Intrusive rocks.

IB basic igneous rocks

Any igneous rock having a relatively low silica content, sometimes delimited arbitrarily as less than 54%. They are relatively rich in Fe-Mg minerals such as pyroxenes (augite), hornblend.

IB1 gabbro

IB2 basalt

Extrusive, dense black rock.

IB3 dolerite

IU ultrabasic igneous

Igneous rock, very rich in Fe-Mg minerals.

IU1 peridotite

IU2 pyroxenite

IU3 ilmenite, magnetite, ironstone, serpentine

M metamorphic rocks

Rock of any origin altered in mineralogical and/or chemical composition, or structure by heat, pressure and movement at depth in the earth's crust. Nearly all metamorphic rocks are crystalline.
Subdivided on mineralogy (acid, basic).

MA acid metamorph

Metamorphic rocks from acid environment.

MA1 quartzite

MA2 gneiss, migmatite

MB basic metamorph

Metamorphic rocks from basic environment.

MB1 slate, phyllite

MB2 schist

MB3 gneiss rich in ferro-magnesian minerals

E.g. hornblende gneiss

MB4 metamorphic limestone (marble)

S Sedimentary rocks

A consolidated deposit of clastic particles, chemical precipitates and organic remains, accumulated at or near the surface of the earth under relatively low temperature and pressure conditions.

SC Clastic sediments

Rock derived from clastic sediments.

SC1 Conglomerate, breccia

SC2 Sandstone, greywacke, arkose

Sedimentary rock consisting of consolidated sands, grits, graywackes, and conglomerate.

SC3 Siltstone, mudstone, claystone

SC4 Shale

Sedimentary rock consisting of shales (clays/silts with fine stratification).

SO Organic sedimentary rock

SO1 Limestone and other carbonate rocks

Sedimentary rock consisting of limestone, coral reef limestones or travertines.

SO2 Marl and other mixtures

An earthy, unconsolidated deposit consisting chiefly of calcium carbonate mixed with clay in approximately equal proportions.

SO3 coals, bitumen and related rocks

SE Evaporites

Chemical sediments.

SE1 Anhydrite, gypsum

Calcium sulphate (anhydrite) and/or hydrous calcium sulphate (gypsum).

SE2 Halite

Rock salt, sodium chloride (halite).

U Unconsolidated materials

Unconsolidated mineral or organic deposits.

UF Fluvial

Sediment generally consisting of gravel and sand or silt and clay. The gravels are typically rounded and contain interstitial sand. Fluvial sediments are commonly moderately to well sorted and display stratification. Examples: channel deposits, overbank deposits, terraces, alluvial fans, deltas, and backswamps.

UC Colluvial

Massive to moderately well stratified, non-sorted to poorly sorted sediments with any range of particle sizes from clay to boulders that have reached their present position only by direct, gravity-induced movement (excepting snow-avalanches). Processes include slow displacements such as creep and solifluction and rapid movements such as earth flows, rockslides, avalanches, and falls.

UE Eolian

Sediment, generally consisting of medium to fine sand and coarse silt particle sizes, that is well sorted, poorly compacted, and may show internal structures such as cross bedding or ripple laminae, or may be massive. Individual grains may be rounded and show signs of frosting. These materials have been transported by wind action. Examples: dunes, shallow deposits of sand and coarse silt, and loess but not tuffs.

UG Glacial

(Morainal) sediment generally consisting of well-compacted material that is nonstratified and contains a heterogenous mixture of sand, silt and clay particles sizes in a mixture that has been transported beneath, beside, on, within, or in front of a glacier and not modified by any intermediate agent. Examples: basal till (ground moraine), lateral and terminal moraines, rubbly moraines of cirque glaciers, hummocky ice-desintegration moraines, and pre-existing, unconsolidated sediments reworked by a glacier so that their original character is largely or completely destroyed.
(Fluvioglacial) material moved by glaciers and subsequently sorted and deposited by streams flowing from the melting ice. The deposits are stratified and may occur in the form of outwash plains, deltas, kames, eskers, and kame terraces.

UL Lacustrine

Sediment generally consisting of either stratified fine sand, silt and clay deposited on the lake bed or moderately well sorted stratified sand and coarser materials that are beach and other nearshore sediments transported and deposited by wave action. These materials that either have settled from suspension in bodies of standing fresh water or have accumulated at their margins through wave action. Examples are lake sediments and beaches.

UM Marine

Unconsolidated deposits of clay, silt, sand, or gravel that are well to moderately well sorted and well to moderately well stratified (in some places containing shells). They have settled from suspension in salt or brackish water bodies or have accumulated at their margins through shoreline processes such as wave action and longshore drift. Non-fossiliferous deposits may be judged marine, if they are located in an area that might reasonably be considered to have contained salt water at the time the deposits were formed.

UP Pyroclastic

Deposits, produced by usually explosive, aerial ejection of clastic particles from a volcanic vent either on land or under water.

UO Organic

Organic materials known as peat, muck, bog or swamp, that are commonly saturated with water for prolonged periods. They contain 17% or more organic C by weight.

ANNEX 2. HIERARCHY OF VEGETATION

formation class	formation subclass	formation group
I CLOSED FOREST	**IA** mainly evergreen forest	**IA1** tropical ombrophilous forest **IA2** tropical and subtropical evergreen seasonal forest **IA3** tropical and subtropical semi-deciduous forest **IA4** subtropical ombrophilous forest **IA5** mangrove forest **IA6** temperate and subpolar evergreen ombrophilous forest **IA7** temperate evergreen seasonal broad-leaved forest **IA8** winter-rain evergreen broad-leaved sclerophyllous forest **IA9** tropical and subtropical evergreen needle-leaved forest **IA10** temperate and subpolar evergreen needle-leaved forest
	IB mainly deciduous forest	**IB1** tropical and subtropical drought-deciduous forest **IB2** cold-deciduous forest with evergreen trees (or shrubs) **IB3** cold-deciduous forest without evergreen trees
	IC extremely xeromorphic forest	**IC1** sclerophyllous-dominated extremely xeromorphic forest **IC2** thorn-forest **IC3** mainly succulent forest
II WOODLAND	**IIA** mainly evergreen woodland	**IIA1** evergreen broad-leaved woodland **IIA2** evergreen needle-leaved woodland
	IIB mainly deciduous woodland	**IIB1** drought-deciduous woodland **IIB2** cold-deciduous wood-land with evergreen trees **IIB3** cold-deciduous wood-land without evergreen trees
	IIC extremely xeromorphic woodland	subdivisions as extremely xeromorphic forest
III SCRUB (Shrubland or Thicket)	**IIIA** mainly evergreen scrub	**IIIA1** evergreen broad-leaved shrubland (or thicket) **IIIA2** evergreen needle-leaved and microphyllous shrubland (or thicket)
	IIIB mainly deciduous scrub	**IIIB1** drought-deciduous scrub with evergreen woody plants admixed **IIIB2** drought-deciduous scrub without evergreen woody plants admixed **IIIB3** cold-deciduous scrub
	IIIC extremely xeromorphic (subdesert) shrubland	**IIIC1** mainly evergreen subdesert shrubland **IIIC2** deciduous subdesert shrubland
IV DWARF-SCRUB AND RELATED COMMUNITIES	**IVA** mainly evergreen dwarf-scrub	**IVA1** evergreen dwarf-scrub thicket **IVA2** evergreen dwarf-shrubland **IVA3** mixed evergreen dwarf-shrubland and herbaceous formation
	IVB mainly deciduous dwarf-scrub	**IVB1** facultatively drought-deciduous dwarf-thicket (or dwarf-shrubland) **IVB2** obligatory, drought-deciduous dwarf-thicket (or dwarf-shrubland) **IVB3** cold-deciduous dwarf-thicket (or dwarf-shrubland)
	IVC extremely xeromorphic dwarf-shrubland	subdivisions as extremely xeromorphic (sub-desert) shrubland
	IVD tundra	**IVD1** mainly bryophyte tundra **IVD2** mainly lichen tundra

formation class	formation subclass	formation group
	IVE mossy bog formations with dwarf-shrub	IVE1 raised bog IVE2 non-raised bog
V HERBACEOUS VEGETATION	VA tall graminoid vegetation	VA1 tall grassland with a tree synusia covering 10-40% VA2 tall grassland with a tree synusia covering less than 10% VA3 tall grassland with a synusia of shrubs VA4 tall grassland with a woody synusia consisting mainly of tuft plants (usually palms) VA5 tall grassland practically without woody synusia
	VB medium tall grassland	VB1 medium tall grassland with a tree synusia covering 10-40% VB2 medium tall grassland with a tree synusia covering less than 10% VB3 medium tall grassland with a synusia of shrubs VB4 medium tall grassland with an open synusia of tuft plants (usually palms) VB5 medium tall grassland practically without woody synusia
	VC short grassland	VC1 short grassland with a tree synusia covering 10-40% VC2 short grassland with a tree synusia covering less than 10% VC3 short grassland with a synusia of shrubs VC4 short grassland with an open synusia of tuft plants (usually palms) VC5 short grassland practically without woody synusia VC6 short to medium tall mesophytic grassland VC7 graminoid tundra
	VD forb vegetation	VD1 tall forb communities VD2 low forb communities
	VE hydromorphic fresh-water vegetation	VE1 rooted fresh-water communities VE2 free-floating fresh-water communities

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I Closed forest

Formed by trees at least 5 m tall with their crowns interlocking.

IA Mainly evergreen forest

The canopy is never without green foliage. However, individual trees may shed their leaves.

IA1 Tropical ombrophilous forest (tropical rain forest)

Consisting mainly of broad-leaved evergreen trees, neither cold or drought resistant. Truly evergreen, i.e. the forest canopy remains green all year though a few individual tree may be leafless for a few weeks.

IA2 Tropical and subtropical evergreen seasonal forest

Consisting mainly of broad-leaved evergreen trees. Foliage reduction during the dry season noticeable, often as partial shedding.

IA3 Tropical and subtropical semi-deciduous forest

Most of the upper canopy trees drought-deciduous; many of the understorey trees and shrubs evergreen and more or less sclerophyllous[1].

IA4 Subtropical ombrophilous forest

Forest with a dry season and more pronounced temperature differences between summer and winter than tropical ombrophilous forest.

IA5 Mangrove forest

Composed almost entirely of evergreen sclerophyllous broad-leaved trees/shrubs with either stilts roots or pneumatophores.

IA6 Temperate and subpolar evergreen ombrophilous forest

Consisting mostly of truly evergreen hemi-sclerophyllous trees and shrubs. Rich in epiphytes and herbaceous ferns.

IA7 Temperate evergreen seasonal broad-leaved forest

Consisting mainly of hemi-sclerophyllous evergreen trees and shrubs, rich in herbaceous undergrowth.

IA8 Winter-rain evergreen broad-leaved sclerophyllous forest (Mediterranean forest)

Consisting mainly of sclerophyllous evergreen trees and shrubs, most of them showing rough bark. Herbaceous undergrowth almost lacking.

IA9 Tropical and subtropical evergreen needle-leaved forest

Consisting mainly of needle-leaved evergreen trees. Broad-leaved trees may be present.

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[1] Sclerophyllous: thick, hard leaves

IA10 Temperate and subpolar evergreen needle-leaved forest

Consisting mainly of needle-leaved or scale-leaved evergreen trees, but broad-leaved trees may be admixed.

IB Mainly deciduous forest

Majority of trees shed their foliage simultaneously in connection with the unfavourable season.

IB1 Tropical and subtropical drought-deciduous forest

Unfavourable season mainly characterized by drought, in most cases winter-drought. Foliage is shed regularly every year. Most trees with relatively thick, fissured bark.

IB2 Cold-deciduous forest with evergreen trees (or shrubs)

Unfavourable season mainly characterized by winter frost. Deciduous broad-leaved trees dominant, but evergreen species present.

IB3 Cold-deciduous forest without evergreen trees

Deciduous trees absolutely dominant.

IC Extremely xeromorphic forest

Dense stand of xeromorphic phanerophytes such as bottle trees, tuft trees with succulent leaves and stem succulents. Undergrowth with shrubs of similar xeromorphic adaptations.

IC1 Sclerophyllous-dominated extremely xeromorphic forest

Predominance of sclerophyllous trees.

IC2 Thorn forest

Species with thorny appendices predominate.

IC3 Mainly succulent forest

Tree-formed and shrub-formed succulents

II Woodland

Composed of trees at least 5 m tall with crowns not usually touching but with a coverage of at least 40%.

IIA Mainly evergreen woodland

The canopy is never without green foliage.

IIA1 Evergreen broad-leaved woodland

Mainly sclerophyllous trees and shrubs.

IIA2 Evergreen needle-leaved forest

Mainly needle-leaved or scale-leaved.

IIB Mainly deciduous woodland

Majority of trees shed their foliage simultaneously in connection with the unfavourable season.

IIB1 Drought deciduous woodland

Unfavourable season mainly characterized by winter-drought. Foliage is shed regularly every year. Most trees with relatively thick, fissured bark.

IIB2 Cold-deciduous woodland with evergreen trees

Unfavourable season mainly characterized by winter frost. Deciduous broad-leaved trees dominant, but evergreen species present.

IIB3 Cold-deciduous woodland without evergreen trees

Deciduous trees absolutely dominant.

IIC Extremely xeromorphic woodland

Open stand of xeromorphic phanerophytes such as bottle trees, tuft trees with succulent leaves and stem succulents. Undergrowth with shrubs of similar xeromorphic adaptations.

IIC1 Sclerophyllous-dominated extremely xeromorphic woodland

Predominance of sclerophyllous trees.

IIC2 Thorn woodland

Species with thorny appendices predominate.

IIC3 Mainly succulent woodland

Tree-formed and shrub-formed succulents

III Scrub (shrubland or thicket)

Mainly composed of woody plants 0.5 to 5 m tall. Subdivisions:
- Shrubland: most of the individual shrubs not touching each other; often grass undergrowth
- Thicket: individual shrubs interlocked

IIIA Mainly evergreen scrub

The canopy is never without green foliage. However, individual shrubs may shed their leaves.

IIIA1 Evergreen broad-leaved shrubland (or thicket)

Mainly sclerophyllous shrubs.

IIIA2 Evergreen needle-leaved and microphyllous shrubland (or thicket)

Mainly needle-leaved or scale-leaved shrubs.

IIIB Mainly deciduous scrub

Majority of shrubs shed their foliage simultaneously in connection with the unfavourable season.

IIIB1 Drought-deciduous scrub with evergreen woody plants admixed

IIIB2 Drought-deciduous scrub without evergreen woody plants admixed

IIIB3 Cold-deciduous scrub

IIIC Extremely xeromorphic (subdesert) shrubland

Very open stands of shrubs with various xerophytic adaptations, such as extremely scleromorphic or strongly reduced leaves, green branches without leaves, or succulents stems, etc., some of them with thorns.

IIIC1 Mainly evergreen subdesert shrubland

In extremely dry years some leaves and shoot portions may be shed.

IIIC2 Deciduous subdesert shrubland

Mainly deciduous shrubs, often with a few evergreens

IV Dwarf-scrub and related communities

Rarely exceeding 50 cm in height. Subdivisions:
- Dwarf-scrub thicket: branches interlocked
- Dwarf-shrubland: individual dwarf-shrubs more or less isolated or in clumps.

IVA Mainly evergreen dwarf-scrub

Most dwarf-scrubs evergreen.

IVA1 Evergreen dwarf-scrub thicket

Densely closed dwarf-scrub cover, dominating the landscape.

IVA2 Evergreen dwarf-shrubland

Open or more loose cover of dwarf-shrubs.

IVA3 Mixed evergreen dwarf-shrub and herbaceous formation

IVB Mainly deciduous dwarf-scrub

Most dwarf-scrubs deciduous.

IVB1 Facultatively drought-deciduous dwarf-thicket (or dwarf-shrubland)

Foliage is shed only in extreme years.

IVB2 Obligatory, drought-deciduous dwarf-thicket (or dwarf-shrubland)

Densely closed dwarf-shrub stands which loose all or at least part of their leaves in the dry season.

IVB3 Cold-deciduous dwarf-thicket (or dwarf-shrubland)

Densely closed dwarf-shrub stands which loose all or at least part of their leaves at the beginning of a cold season.

IVC Extremely xeromorphic dwarf-shrubland

More or less open formations of dwarf-shrubs, succulents and other life forms adapted to survive or to avoid a long dry season. Mostly subdesertic.

IVC1 Mainly evergreen subdesert dwarf-shrubland

In extremely dry years some leaves and shoot portions may be shed.

IVC2 Deciduous subdesert dwarf-shrubland

Mainly deciduous dwarf-shrubs, often with a few evergreens

IVD Tundra

Slowly growing, low formations, consisting mainly of dwarf-shrubs and graminoids beyond the subpolar tree line.

IVD1 Mainly bryophyte tundra

Dominated by mats or small cushions of mosses.

IVD2 Mainly lichen tundra

Mats of lichen dominating.

IVE Mossy bog formations with dwarf-shrub

Oligotrophic peat accumulations formed by *Sphagnum* or other mosses.

IVE1 Raised bog

By growth of *Sphagnum* species raised above the general ground-water table.

IVE2 Non-raised bog

Not or not very markedly raised above the mineral-water table of the surrounding landscape.

V Herbaceous vegetation

VA Tall graminoid vegetation

Dominant graminoids over 2 m tall. Forb coverage less than 50%.

VA1 Tall grassland with a tree synusia[2] covering 10-40%

More or less like a very open woodland.

VA2 Tall grassland with a tree synusia covering less than 10%.

VA3 Tall grassland with a synusia of shrubs

VA4 Tall grassland with a woody synusia consisting mainly of tuft plants (usually palms)

VA5 Tall grassland practically without woody synusia

VB Medium tall grassland

The dominant graminoid growth forms are 50 cm to 2 m tall. Forbs cover less than 50%.

VB1 Medium tall grassland with a tree synusia covering 10-40%

VB2 Medium tall grassland with a tree synusia covering less than 10%

VB3 Medium tall grassland with a synusia of shrubs

VB4 Medium tall grassland with an open synusia of tuft plants (usually palms)

VB5 Medium tall grassland practically without woody synusia

VC Short grassland

The dominant graminoid growth forms are less than 50 cm tall. Forbs cover less than 50%.

VC1 Short grassland with a tree synusia covering 10-40%

VC2 Short grassland with a tree synusia covering less than 10%

VC3 Short grassland with a synusia of shrubs

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[2] Synusia: layer

VC4 Short grassland with an open synusia of tuft plants (usually palms)

VC5 Short grassland practically without woody synusia

VC6 Short to medium tall mesophytic grassland

VC7 Graminoid tundra

VD Forb vegetation

Mainly forbs, graminoid cover less than 50%.

VD1 Tall forb communities

Dominant forb growth forms are more than 1 m tall.

VD2 Low forb communities

Dominant forb growth forms are less than 1 m tall.

VE Hydromorphic fresh-water vegetation

VE1 Rooted fresh-water communities

VE2 Free floating fresh-water communities

ANNEX 3. HIERARCHY OF LAND USE

land use order	land use group	land use system
S SETTLEMENT/INDUSTRIES	SR residential use SI industrial use ST transport SC recreational SX excavations	
A AGRICULTURE	AA annual field cropping	AA1 shifting cultivation AA2 fallow system cultivation AA3 ley system cultivation AA4 rainfed arable cultivation AA5 wet rice cultivation AA6 irrigated cultivation
	AP perennial field cropping	AP1 non-irrigated cultivation AP2 irrigated cultivation
	AT tree & shrub cropping	AT1 non-irrigated tree crop cultivation AT2 irrigated tree crop cultivation AT3 non-irrigated shrub crop cultivation AT4 irrigated shrub crop cultivation
H ANIMAL HUSBANDRY	HE extensive grazing	HE1 nomadism HE2 semi-nomadism HE3 ranching
	HI intensive grazing	HI1 animal production HI2 dairying
F FORESTRY	FN exploitation of natural forest and woodland	FN1 selective felling FN2 clear felling
	FP plantation forestry	
M MIXED FARMING	MF agro-forestry MP agro-pastoralism (cropping & livestock systems)	
E EXTRACTION/COLLECTING	EV exploitation of natural vegetation	
	EH hunting and fishing	
P NATURE PROTECTION	PN nature and game preservation	PN1 reserves PN2 parks PN3 wildlife management
	PD degradation control	PD1 non-interference PD2 with interference
U UNUSED		

S Settlement/industries

Rural, industrial use.

SR Residential use

Cities.

SI Industrial use

Industries.

ST Transport

Roads, railways etc.

SC Recreation

In use for recreation.

SX Excavations

Land is used for excavations, quarries.

A Agriculture

Land used for cultivation of crops.

AA Annual field cropping

One or more crops harvested within one year. Land under temporary crops.

AA1 Shifting cultivation

Agricultural systems that involve an alternation between cropping for a few years on selected and cleared plots and a lengthy period when the soil is rested. The land is cultivated for less than 33% of the years.

AA2 Fallow system cultivation

Agricultural systems that involve an alternation of cropping periods and fallow periods. The land is cultivated between 33 and 67% of the growing seasons; bush or grass fallows are typical.

AA3 Ley system cultivation

Several years of arable cropping are followed by several years of grass and legumes utilized for livestock production.

AA4 Rainfed arable cultivation

Agricultural systems where the land is cultivated in more than 67% of the growing seasons.

AA5 Wet rice cultivation

Annual field cropping system for the production of rice. Paddies with or without controlled water supply and drainage system. Plots are inundated during at least some part of the cropping period.

AA6 Irrigated cultivation

Annual field cropping system with an artificial supply of water, in addition to rain.

AP Perennial field cropping

Land under perennial crops. Crops harvested more than one year after planting. Examples of perennial field crops are sugar-cane, bananas, pineapples and sisal.

AP1 Non-irrigated cultivation

AP2 Irrigated cultivation

AT Tree & shrub cropping

Crops harvested annually or perennially; trees or shrubs produce more than one crop.
Examples of tree crops are oil-palm, rubber, cacao, coconuts and cloves; typical shrub crops are coffee and tea.

AT1 Non-irrigated tree crop cultivation

AT2 Irrigated tree crop cultivation

AT3 Non-irrigated shrub crop cultivation

AT4 Irrigated shrub crop cultivation

H Animal husbandry

Animal products.

HE Extensive grazing

Grazing on natural or semi-natural grassland or savanna vegetation.

HE1 Nomadism

Systems in which the animal owners do not have a permanent place of residence. No regular cultivation practices. People move with herds.

HE2 Semi-nomadism

Animal owners have a permanent place of residence where supplementary cultivation is practised. Herds are moved to distant grazing areas.

HE3 Ranching

Grazing within well defined boundaries, movements less distant and higher management level as compared to semi-nomadism.

HI Intensive grazing

Stationary animal husbandry. Grazing on permanent/semi-permanent improved grassland systems.

HI1 Animal production

HI2 Dairying

F Forestry

Activities related to the production of wood. Exploitation of forest for wood, with reforestation. A commercial activity.

FN Exploitation of natural forest and woodland

Wood is extracted from natural forest and woodland for commercial purpose.

FN1 selective felling

Only selected species are removed from the natural vegetation.

FN2 clear felling

All natural vegetation is cleared after which the area is reforested. This land use system develops into a plantation forestry system.

FP Plantation forestry

Forested areas. Relatively high management level. Homogeneous tree stands.

M Mixed farming

Activities concerning cropping and forestry or animal husbandry are mixed.

MF Agro-forestry

Combination of agriculture and forestry (with reforestation).

MP Agro-pastoralism

Combination of agriculture and animal husbandry, also called transhumance (farmers with a permanent place of residence send their herds, tended by herdsman, for long periods of time to distant grazing areas).

E Extraction/collecting

Extraction of products from the environment.

EV exploitation of natural vegetation

Land used for extraction of wood or other products from the vegetation; for domestic use.

EH hunting and fishing

Extraction of animals or fish from ecosystem.

P Nature protection

No, or low intensity of use, but under management system; low level of interference with natural environment or ecosystem.

PN Nature and game preservation

PN1 Reserves

PN2 Parks

PN3 Wildlife management

PD Degradation control

Degradation of land, in most cases further degradation, is not desirable and the land is protected.

PD1 Non-interference

All uses of the land are prohibited.

PD2 Interference

The land is managed. Works are implemented in order to stop degradation and limit the degradation risk.

U Unused

Not used and not managed.

ANNEX 4. COUNTRY CODES

Derived from FAO's registration form on country codes, 1985.

Afghanistan	AFG
Albania	ALB
Algeria	ALG
Andorra	AND
Angola	ANG
Antigua	ANT
Argentina	ARG
Australia	AUL
Austria	AUS
Bahamas	BHA
Bahrain	BAH
Bangladesh	BGD
Barbados	BAR
Belgium	BEL
Belize	BZE
Benin	BEN
Bhutan	BHU
Bolivia	BOL
Botswana	BOT
Brazil	BRA
British Virgin Islands	BVI
Brunei	BRU
Bulgaria	BUL
Burkina Faso	BKF
Burma	BUR
Burundi	BDI
Byelorussian SSR	BYE
Cameroon	CMR
Canada	CAN
Cape Verde	CVI
Cayman Islands	CAY
Central African Republic	CAF
Chad	CHD
Chile	CHI
China	CPR
Colombia	COL
Comoros	COI
Congo, People's Rep. of	PRC
Cook Islands	CKI
Costa Rica	COS
Cuba	CUB
Cyprus	CYP
Czechoslovakia	CZE
Denmark	DEN
Djibouti	DJI
Dominica	DMI
Dominican Republic	DOM
Ecuador	ECU
Egypt	EGY
El Salvador	ELS
Equatorial Guinea	EQG
Ethiopia	ETH
Fiji	FIJ
Finland	FIN
France	FRA
French Polynesia	FPL
Gabon	GAB
Gambia	GAM
Germany, Democratic Republic	GDR
Germany, Federal Republic	GFR
Ghana	GHA
Greece	GRE
Grenada	GRN
Guatemala	GUA
Guinea	GUI
Guinea-Bissau	GBS
Guyana	GUY
Haiti	HAI
Honduras	HON
Hong Kong	HOK
Hungary	HUN
Iceland	ICE
India	IND
Indonesia	INS
Iran	IRA
Iraq	IRQ
Ireland	IRE
Israel	ISR
Italy	ITA
Ivory Coast	IVC
Jamaica	JAM
Japan	JPN
Jordan	JOR
Kampuchea Democratic	KAM
Kenya	KEN
Kiribati	KIR
Korea, Dem. People's Rep. of	DRK
Korea, Republic of	ROK
Lao	LAO
Lebanon	LEB
Lesotho	LES
Liberia	LIR
Libya	LIB
Liechtenstein	LIE
Luxembourg	LUX
Macao	MAC
Madagascar	MAG
Malaysia	MAL
Malawi	MLW
Maldives	MDV
Mali	MLI
Malta	MAT

Mauritania	MAU	Tanzania	URT
Namibia	NAM	Thailand	THA
Nepal	NEP	Togo	TOG
Nauru	NAU	Tokelau Islands	TOK
Netherlands	NET	Tonga	TON
Netherlands Antilles	NAN	Trinidad and Tobago	TRI
New Caledonia	NCA	Tunisia	TUN
New Zealand	NZE	Turkey	TUR
Nicaragua	NIC	Turks and Caicos Islands	TCI
Niger	NER	Tuvalu	TUV
Nigeria	NIR	Uganda	UGA
Niue	NIU	Ukrainian SSR	UKR
Norway	NOR	Union of Soviet Socialist Rep.	USR
Oman	OMA	United Arab Emirates	UAE
Pakistan	PAK	United Kingdom	UK
Panama	PAN	United States of America	USA
Papua New Guinea	PNG	Uruguay	URU
Paraguay	PAR	Vanatu	VAN
Peru	PER	Venezuela	VEN
Philippines	PHI	Viet Nam	VIE
Poland	POL	Wallis and Futuna Islands	WFI
Portugal	POR	Yemen, Arab Republic	YEM
Puerto Rico	PRI	Yemen, People's Democratic Rep.	PDY
Qatar	QAT	Yugoslavia	YUG
Romania	ROM	Zaire	ZAI
Rwanda	RWA	Zambia	ZAM
Samoa	SAM	Zimbabwe	ZIM
San Marino	SNM		
Sao Tomé and Principe	STP		
Saudi Arabia	SAU		
Seychelles	SEY		
Senegal	SEN		
Sierra Leone	SIL		
Singapore	SIN		
Somalia	SOM		
South Africa	SAF		
Spain	SPA		
Sri Lanka	SRL		
St. Helena	STH		
St. Kitts-Nevis-Nevila	STK		
St. Lucia the Grenadines	STL		
Sudan	SUD		
Suriname	SUR		
Swaziland	SWA		
Sweden	SWE		
Switzerland	SWI		
Syria	SYR		

ANNEX 5. CONVERSION OF DIMENSIONS OF UNITS

1 mS/m	0.01 mmhos/cm
10 mmol(+)/kg	1 meq/100g
1 mg/kg	1 ppm