

# Africa Soil Profiles Database

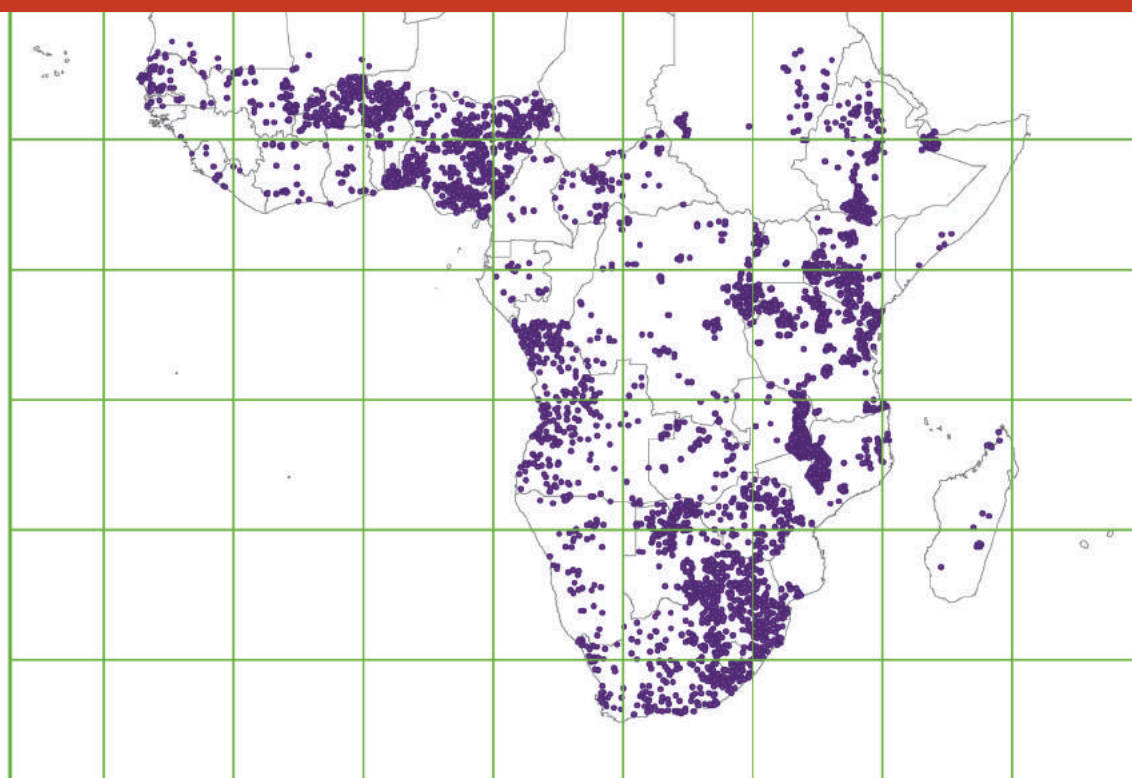
## Version 1.0

A compilation of georeferenced and standardised  
legacy soil profile data for Sub-Saharan Africa (with dataset)



World Soil Information

ISRIC Report 2012/03



J.G.B. Leenaars



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**ISRIC Report 2012/03**

Wageningen, 2012



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#### Citation

Leenaars J.G.B., 2012. *Africa Soil Profiles Database, Version 1.0. A compilation of georeferenced and standardised legacy soil profile data for Sub-Saharan Africa (with dataset)*. ISRIC Report 2012/03. Africa Soil Information Service (AfSIS) project and ISRIC - World Soil Information, Wageningen, the Netherlands. 148 pp.; 15 fig.; 10 tab.; 25 ref.



**ISRIC Report 2012/03**

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# Preface

The compilation and release of the Africa Soil Profiles Database is at the heart of ISRIC's mandate, which is to serve the international community as custodian of global soil information and to increase awareness and understanding of soils in major global issues.

Soil data are at the basis of soil research needed to provide science based insights in the current debates about enriching soils as key to improve food security in Africa (see e.g. recent exposé in Nature (Gilbert, 2012).

ISRIC is determined, also as ICSU World Data Centre for Soils, to continue contributing to alleviating these pressing issues by serving and improving access to both old and new soil data, information and knowledge.

The Africa Soil Profiles Database is intended to contribute to the production of evidence-based high-resolution soil property maps of the entire Sub Sahara African continent which will permit to convey spatially explicit information to policy makers and local land users.

This research has been carried out within the framework of the Africa Soil Information Service (AfsIS) project, funded by AGRA and the Bill and Melinda Gates Foundation, for which much gratitude is due.

Many have contributed to this report as has been mentioned in the acknowledgement, in spirit of the aim of ISRIC to advance soil information through collaborative actions.

Prem Bindraban  
Director ISRIC – World Soil Information



# Summary

Version 1.0 of the Africa Soil Profiles Database is compiled from a wide variety of digital and analogue data sources reporting soil profile data in various formats and standards. The soil-attribute values are compiled and standardised according to SOTER conventions and are submitted to routine quality control. The soil profile data are georeferenced, permitting to establish and model the relationships between soil data and auxiliary spatial information prior to soil property mapping.

The Africa Soil Profiles Database Version 1.0 holds attribute values for 12,574 soil profiles, consisting of 50,150 soil layers. The profile attributes are originally observed or measured by methods and standards which typically vary from one study or survey to another – these have been documented in the dataset. The Africa Soil Profiles Database inevitably includes gaps of data, of varying nature, and as a result not all the data may be fit for modelling and analysis purposes without prior gap filling. The quality of the data is by definition use- and resolution-dependent. The present standardised and quality controlled, legacy soil profile data are considered appropriate to underpin digital soil property mapping at moderate resolution (1-10 km<sup>2</sup> pixel size, depending on the attribute concerned) as well as to serve other purposes such as conventional area class mapping and exploratory studies of soil properties across Sub-Saharan Africa.

This report describes the sources and methods used to compile the database, the structure and content of the database and presents examples of use of the data. This report only serves to describe the database; a procedures manual will be prepared upon embedding of the database into the World Soil Information Service (WoSIS).

The database is accessible at:  
[www.isric.org/data/africa-soil-profiles-database-version-01-0](http://www.isric.org/data/africa-soil-profiles-database-version-01-0)

**Keywords:** soil profiles, legacy soil data, soil database, digital soil mapping, Africa, ISRIC, AfSIS



# 1 Introduction

Soils deliver various ecosystem services of provisioning and regulating character. The capacity of soils to deliver these services largely depends on soil functions and the underlying soil properties. The latter are the result of soil formation including soil genesis and management. Soil management aims at changing soil properties for improving the soil's capacity of delivering services.

Information on soil properties and on how to manage them, where and when, is of key importance for improving the soil's services delivering capacity and has been subject to large efforts of soil research and soil mapping. Soil research in Sub-Saharan Africa started in the late 1800s. The initial focus was on commodity crops for export and most research took place on soil fertility. From the 1950s onwards, food crops received research attention. Soil mapping in Sub-Saharan Africa started in the 1920s but very few areas and countries were mapped prior to World War II. Since then, soil survey organisations were established in most African countries and a large number of reconnaissance and detailed surveys was carried out. Since the 1980s, after publication of the first soil map of the world (FAO-Unesco, 1981), soil survey and mapping capacity in Africa has diminished importantly, and soil data collection continued more sporadically in especially the context of soil fertility research. In general, these soil data are referred to as legacy soil data.

At the basis of much of the soil research and soil mapping has been the understanding of soil formation, basically as mechanistically described by Jenny (1941) as a function of climate, organisms, relief, parent material and time (CORPT). Soil management, or the only factor through which man can directly target impact on soil properties, is implicitly included in the equation through the organisms factor.

Present day and near future demands for e.g. food provisioning and water and climate regulation call for adequate soil management and supporting policies, underpinned by reliable, accurate and spatially explicit soil information (Sanchez et al., 2009). The *GlobalSoilMap.net* consortium aims to produce that soil information at an increasingly fine resolution. Legacy soil data are a rich, and cost efficient, source of information to serve this goal, subject to screening and standardisation.

Soil information relevant for local soil management decision making should be detailed, both geographically and thematically, while soil information relevant for supporting policy-making may be less detailed but should be standardised and generalised for vast areas. Combining both aspects, as is aimed for by *GlobalSoilMap.net*, is a true challenge. A large population of primary soil data is required to produce regionally or continentally standardised soil information that is detailed in resolution as well as accurate and spatially explicit. For instance, according to conventional, pre-covariate, soil mapping approaches with one soil observation per  $\text{cm}^2$  map area, for  $18 \times 10^6 \text{ km}^2$  of Sub Saharan Africa at a targeted resolution of 90 m (approximately 1: 90,000), a total of  $22 \times 10^6$  soil profile observations would be required. This number would be 100 times smaller for a targeted scale of 10 times less detail (1: 900,000).

McBratney et al. (2003) proposed an adapted version of Jenny's equation with a view to use the soil forming factors as soil spatial prediction functions for soil mapping purposes, known as the scorpan formulae. Two additional factors are introduced to predict the soil property or soil class at a given location; these are 'spatial position' and 'another soil property', with the latter accommodating for legacy soil data. According to McBratney et al. (2003) the sample size of primary soil data required to set up the model for deriving soil maps is about 10 - 100 times smaller than that required by conventional methods, with the required sample size

increasing with increasing resolution and with the number of environmental attributes or covariates included in the model.

In spite of this reduction in required sample size, due to modern Digital Soil Mapping techniques, the availability of sufficient primary soil data remains crucial input. Sustained investments and efforts are needed to develop and populate such large soil profile databases. The good news is that the situation in Africa seems to be changing for the better where the compilation of digital soil databases is concerned (Paterson and Mushia, 2012).

One major component of the Globally Integrated – Africa Soil Information Service (AfSIS) project, funded by the Bill and Melinda Gates Foundation, aims at generating new soil data for 60 sentinel sites through sampling of a total number of 9600 soil profiles in Sub Saharan Africa. Another component of the project is to collect and collate legacy soil data (<http://www.africasoils.net/data/legacyprofile>). This report and associated database are the first result of the second component.

Within the project it has been concluded that standardised legacy soil data for at least 30,000 to 40,000 georeferenced soil profiles are required to set up and test the model for predicting soil properties for the entire Sub Saharan Africa area. That is a tangible goal and is achievable with sufficient capacity. This report describes version 1.0 of the database, compiling and standardising georeferenced legacy soil data for >12,000 soil profiles for the region.

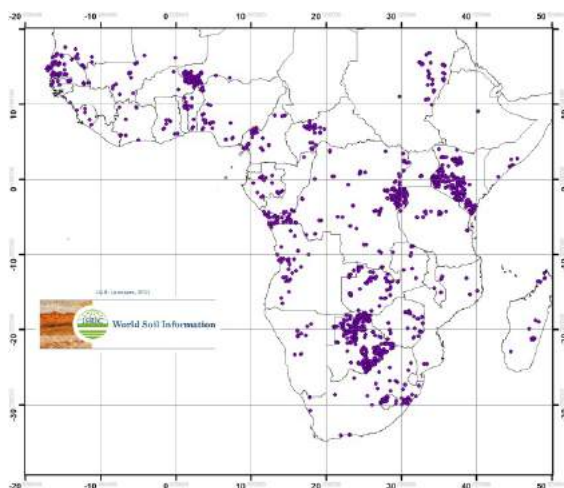
Chapter 2 describes the materials and methods used to compile the data. It explains the inventory of data, their entry and collation, the database structure used to store the data, the types of data that distinguish between features, attributes, methods and values, and the standardisation and quality control of entered values. Chapter 3 discusses the contents of the database by giving summary statistics and by presenting data use cases. Chapter 4 presents a brief discussion with conclusions.

## 2 Materials and methods

### 2.1 Data inventory

The present database is a compilation of legacy soil profile data for Sub Saharan Africa that have been geo-referenced and standardised. Procedures for data standardisation are described in Section 2.4.3 and 2.4.5.

The basis for the Africa Soil Profiles data compilation was derived from the digital profile dataset ISRIC-WISE3 (Batjes, 1998) which includes soil data for some 2,770 geo-referenced profiles south of the Sahara (Figure 1), and was used by AfSIS for preliminary analyses. These profiles were harmonised, and screened, according to their FAO soil classification.



**Figure 1**

*Spatial distribution of the initial data (ISRIC-WISE3) of the Africa Soil Profiles database.*

Additional profile data were derived from other digital datasets as well as from analogue reports, books and publications available in the ISRIC World Soil Library and other holdings in partner countries, international partner organisations and the internet. The identification of additional profile data required an inventory of possible data holdings (e.g. libraries A, B and C) followed by an inventory of possible data sources (e.g. reports A01, A02 and A03) and of actual, useable profile records (e.g. profiles A01-1, A01-2 and A01-3). This means that possible data sources are inventoried for content of geo-referenced, or geo-referable, soil profile data, with particular focus on soil analytical layer data and important soil field layer data such as coarse fragments content.

Data holders considered in the inventory for data sources include:

- ISRIC – World Soil Information (The Netherlands)
- FAO – UN Food and Agriculture Organisation (Italy)
- WOSSAC - World Soil Surveys Archive and Catalogue (United Kingdom)
- IRD – Institut de Recherche pour le Développement, France

- USDA / NRCS – Department of Agriculture, Natural Resources Conservation Service, USA
- Wageningen University (Department of Environmental Sciences), The Netherlands
- Ghent University (Laboratory of Soil science), Belgium
- Texas A&M (Spatial Sciences Laboratory), USA
- Hohenheim University, Germany
- IER – Institut d'Economie Rurale, Sotuba, Mali
- NSS – National Soil Service, Mlingano, Tanzania
- Abbu Bello university (Department of Soil Science), Zaria, Nigeria
- EARO – Ethiopian Agricultural Research Organisation (National Soil Research Center, NSRC), Ethiopia

### **2.1.1 Source datasets**

Digital soil datasets adding to the data derived from WISE3 include datasets made available by ISRIC ([www.isric.org/data/data-download](http://www.isric.org/data/data-download)), knowing: SOTERSAF2004 & 2007, ZASOTER, KENSOTER2007, SOTER\_UT2011, SOTERCAF, SENSOTER, WASP and ISIS5 (see Annex 1a for a full overview of source datasets, including acronyms and referencing to the dataset authors and holders). Collation of these datasets resulted in a total of 4,300 geo-referenced unique profiles. At this stage of collation, profile duplicates (some 3,000) were identified by tracing recorded lineages. It is estimated that herewith most duplicates are removed, resulting in unique profile feature IDs, with referencing to the original profile IDs used in the different source datasets (and source reports).

The attribute data of the profile duplicates were compared and, where necessary, merged to produce as completely as possible profile data attribution. Herein, profile layer data from WISE3, with a relatively 'narrow' range of profile layer attributes seen its objectives (Batjes and Bridges 1994), are replaced by profile layer data of profile duplicates from SOTER datasets in which a larger range of attributes may be characterised, when available. Subsequently, the collated profiles were compared with the profiles from WASP and the data of possible duplicates were replaced by the data derived from WASP. Upon comparison of these datasets, some ISIS profiles proved not included in any of the above datasets and those profiles, including profile data, were collated as well.

Other digital source datasets include the online National Cooperative Soil Characterization Database (NCSS), also accessible as the Laboratory Pedon Data Map, of NRCS-USDA (Natural Resources Conservation Service), from which the majority of Sub Saharan Africa profile data were already included in the above referred to ISRIC datasets. The remaining profiles, only 6, were added to the Africa Soil Profiles Database. Further, digital data sources accessed and collated include the LREP dataset for Malawi (Land Resources Evaluation Project, UNDP/FAO), the TZSDB98 soil database for Tanzania (originally produced for SOTER purposes), the VALSOL dataset for Burkina Faso as served online by IRD, the PEDI dataset for Sanmatenga province of Burkina Faso as produced by Wageningen University, the SOTER datasets for South Benin and West Niger as produced and put online by the University of Hohenheim and the BORENA district Land Use project database as kindly shared by the National Soil Research Centre of Ethiopia.

Annex 1a lists the source datasets together with as completely as possible referencing to the dataset authors and holders.

For each profile feature compiled in the database, the source database, if any, is specified.



### 2.1.2 Source reports

Source reports used for data entry, adding to the soil profile data assembled in Section 2.1.1, are uniquely identified by an ISN number, linking to the ISRIC library item identifiers as accessible through the ISRIC World Soil Information database (<http://library.isric.org/>). This database provides the report's metadata and a link to the scanned full text original (pdf), when available, which enhances traceability of the data. ISN identifiers also have been assigned to source reports acquired from external holdings, for subsequent data entry, and added to the ISRIC World Soil Information database.

The ISRIC library holds over 29,500 ISN numbered items, also including reports that were source of the soil data compiled in various ISRIC datasets. Those source reports received different identifiers in the different datasets, which posed a challenge to the inventory for additional source reports. The source report identifiers in the various datasets have been harmonised during this study by conversion to ISN. This process also facilitated the identification of duplicate profiles.

For each profile feature compiled in the database, the source report, if any, is specified. The report ID connects to a dictionary table (Annex 1b) which lists the 290 source reports together with as complete as possible referencing to authors and publishers.

Lineage of the profile data can be rather complicated in some cases, where source datasets have derived selections of soil data from each other and/or where source datasets have different, overlapping, selections of soil data from similar source reports or from different source reports with overlapping selections of profile data.

No lineage could be established yet to the source reports of the data compiled and shared by IER, Mali.

### 2.1.3 Source overview

The Africa Soil Profiles Database is derived from over 300 data sources. About 35% thereof was extracted from ISRIC datasets, 35% from other digital datasets and 30% from analogue reports (Table 1).

**Table 1**  
*Overview of data sources (acronyms in Annex 1a).*

Data source	Data holder	Number of profiles
Analogue reports	Diverse (mainly ISRIC library)	3,828
BJSOTER	Hohenheim University	708
BORENA	Ethiopia	212
VALSOL	IRD	308
ISIS5	ISRIC	9
SOTER	ISRIC	1,889
WASP	ISRIC	445
WISE3	ISRIC	1,972
LREP	Malawi	2,972
NCSS	USDA	6
PEDI	Wageningen University	227
Total		12,574

In total, 15,727 unique profiles have been inventoried, of which 14,626 are geo-referenced including 12,574 profiles with layer data. Only the latter are selected and included in version 1.0 of the Africa Soil Profiles database. This adds 9,804 profiles to the initial subset for Sub Sahara Africa derived from WISE3.

The current database includes an inventory of unique profile IDs, together with full lineage to source datasets and source reports, including the original profile IDs in those data sources, and with lineage to maps and corresponding mapping units.

Note that the various data sources originally produced for various, specific purposes, provide soil data, of various degrees of validation and associated inherent quality and reliability. Reference soil profile data (ISIS, NRCS) as well as soil profile data representative for FAO soil units or WRB reference groups and harmonised using consistent procedures ( SOTER, WISE, WASP) are thus compiled here together with soil profile data of lesser inherent representativeness and lesser degree of previous validation. The inferred quality and reliability of the soil profile data have been rated subjectively per profile record.

## **2.2 Data digitisation and collation**

Prior to the setup of the database, a preliminary study of soil data models with soil definitions and standards was carried out, including ISRIC- ISIS, WISE, WASP, SOTER, SoterML, FAO-SDBm, EU-SPADE, INRA-DONESOL, CSIRO-ASRIS, USDA-NCSS, CANSIS, ISO. These models and standards are very diverse in configuration and content and pose a challenge to standardisation and interoperability. For this purpose, a soil data modelling workshop was held in Wageningen (2009) and it was concluded to initiate the SoilML initiative to come forward to long term purposes while setting up a pragmatic data entry vehicle to meet immediate AfSIS purposes.

Data entry and collation took place by means of excel tables assuring pragmacym and speed. The tables are organised in a way that reflects basic steps of the workflow and that aligns with basic principles underlying the above mentioned data models. A simplified version of the data entry template is visualised in Figure 2.

NR	DATASET	DATASETACCESS	DATASETHOLDER
1	WISE3	http://www.isric.org/isric/CheckRegistration.aspx?dataset=8	ISRIC
2	SOTERSAF2004	http://www.isric.org/isric/CheckRegistration.aspx?datasets=18	ISRIC

NR	REPORTID	REPORTACCESS
1	13514	http://library.wur.nl/WebQuery/isric/13514
2	13578	http://library.wur.nl/WebQuery/isric/13578
3	27974	http://library.wur.nl/WebQuery/isric/26974

PRID	SRC_DSET	SRC_DSET_PRID	SRC_DSET2	SRC_DSET2_PRID	SRCREPORT	SRCREPORT_PRID	X	Y	Z	T	KEYMETHOD
1	WISE3	TZ120	-	-	13514	101	35.039	-4.298	1635	1979	TZ WISE3/13514/WISE3.TZ02
2	-	-	-	-	13514	104	35.190	-4.507	1690	1979	TZ NA/13514/WISE3.TZ02
3	SOTERSAF2004	TZ1MBP38	WISE3	TZ0014	13578	1MBP38	35.290	-3.700	1335	1995	TZ SOTERSAF2004/13578/SOTERSAF.TZ01
4	-	-	-	-	13578	MP38	35.519	-3.836	1760	1988	TZ NA/13578/SOTERSAF.TZ01
5	-	-	-	-	26974	KP1	32.586	-3.496	1170	1996	TZ NA/26974/AFSP.TZ05

PROFILEID	LAYERID	TOPDEPTH	BOTDEPTH	FLDHORIZON	FLDCOLOR	FLDTEXTURE	GRAVEL	LABCLAY	LABPH	LABOC
2	2_2	15	50	Brg	-	SCL	3	22	6.5	0.3
2	2_3	50	60	R	-	-	80	-	-	-
3	3_1	0	20	A1	2.5YR3/4	-	-	44	5.7	16.30
3	3_2	20	40	B21t	2.5YR3/4	-	-	55	5.4	10.20
3	3_3	40	90	B22t	2.5YR3/4	-	-	54	5.6	8.20
3	3_4	90	140	B31	2.5YR3/4	-	-	15	6.8	2.10
4	4_1	0	36	-	7.5YR2.5/0	C	0	74	7.6	25.20
4	4_2	36	85	-	7.5YR2.5/0	C	0	77	7.9	18.60
4	4_3	85	125	-	7.5YR2.5/0	C	0	79	7.5	18.20
5	5_1	0	10	-	-	S	0	4	5.5	2.1
5	5_2	10	30	-	-	S	0	8	4.3	0.2

KEYMETHOD	LABMANUAL	FIELDMANUAL	GEOREF	SOILCLASS	GRAVEL	LABCLAY	LABPH	LABOC
TZ WISE3/13514/WISE3.TZ02	WISE3.TZ02	TZCA	WGS84, DMS	FAO1974	CF02	TE01	PC04	OC01
TZ NA/13514/WISE3.TZ02	WISE3.TZ02	TZCA	WGS84, DMS	FAO1974	CF02	TE01	PC04	OC01
TZ SOTERSAF2004/13578/SOTERSAF.TZ01	SOTERSAF.TZ01	FAO1977	UTM375, M, CLARKE1880	FAO1988	CF04	TE01	PH02	OC01
TZ NA/13578/SOTERSAF.TZ01	SOTERSAF.TZ01	FAO1977	UTM375, M, CLARKE1880	FAO1988	CF04	TE01	PH02	OC01
TZ NA/26974/AFSP.TZ05	AFSP.TZ05	FAO-ISRIC1990	UTM365, M, CLARKE1880	FAO1988	CF02	TE01	PH02	OC01

**Figure 2**  
Data entry tables, with five illustrative profiles.

The central entry table (in the black rectangle) represents the inventory of soil profile records. For each profile record, the profile ID is included together with profile attribute values such as X-Y coordinates (WGS84), soil type and site data. The profile ID also serves as a key to connect to a separate table for the profile layers with profile layer attribute-values. The profile record includes keys that specify lineage to source datasets and reports (the upper two tables) and a key that specifies the collection of methods applied to assess the reported attribute values (the lower table).

A number of data models explicitly defines the attribute as a separate entry, thus not as a column heading. Figure 3 illustrates an additional data entry table, wherein the attribute names are defined explicitly by separate entries. These attribute names correspond to the column headings of the two central tables of Figure 2 that hold the actual soil data.

aAttr	aLyrObj	aCfPc	aCfLabPc	aSand	aSilt	aClay	aSumTxtr	aBlkDens	aPHH2O	aPHKCl	aPHCaCl2	aEC
Attr	LyrObj	CfPc	CfLabPc	Sand	Silt	Clay	SumTxtr	BlkDens	PHH2O	PHKCl	PHCaCl2	EC

**Figure 3**  
Data entry table, for explicit definition of attributes.

Prioritisation of data entry is much dependent on the labour intensity of the workflow. Priority is given to digital datasets, which are relatively easy and quickly processed and imported into the entry tables. Data from scanned reports, which are made machine readable by OCR'ing, are simply copy-pasted into tables for being

checked/corrected and converted when necessary prior to collation into the definitive entry tables. Manual data entry is slowest, but necessary for areas that still lack digital data.

Subsequently, the data entry tables have been imported into a spatial database environment (see next section) to enhance robustness and ensure data integrity, to permit for data querying and to verify geo-locations.

## **2.3 Database structure**

The Africa Soil Profiles Database is a relational spatial database. It is compiled in an ArcGIS environment (mxd) and consists of a number of interlinked dbf tables and a shapefile with spatial point features. The data are readily converted to other formats, such as Access, Excel, Filemaker, Fusion tables, XML, KML or ASCII text. The database itself will be embedded into the federated database of the World Soil Information Service or WoSIS (Tempel and Kraalingen, 2011).

Included with the Africa Soil Profiles Database is a query, exported as a flat table into KMZ format (AfSP01Qry.kmz), to facilitate viewing of a selection of the data in Google Earth.

### **2.3.1 Considerations**

The database structure is set up such that querying of the different tables permits that the feature, attribute, method and value, as well as lineage, can be reconstructed and made explicit for each entry in the database. Herewith, the soil profile data are expressed as results of observations and measurements (O&M), in line with GeoSciML and WoSIS conventions. This also implies that each entry is considered to be composed of a feature, attribute (plus unit), method and value.

Rigid application of the O&M concept, compiling the data as individual observations or measurements, entry by entry, would yield a single basic table with only five basic columns (feature, attribute, method, value and lineage). However, this would make data entry very time inefficient and would create much redundancy, particularly because of the considerable number of different attributes that are associated with each feature combined with comparable numbers of corresponding methods and values. The resulting table would be hundreds of thousands of records (rows) long.

Therefore, the data are compiled as 'collections of observations and measurements', with the profile record corresponding to such a collection. Such record is basically composed of the above mentioned five basic columns, with 1) the profile ID (serving as record ID and feature ID), 2) the lineage ID and 3) the associated collection of attribute-values, with two additional keys to relate to separate tables for 4) the associated collection of attribute-methods and 5) the associated collection of attribute-names.

The nature of legacy soil profile data dictates a slightly more elaborated setup. The features (profiles) include subfeatures (profile layers), with profile-attribute values distinguished from layer-attribute values. The values, standardised and quality controlled, are distinguished from the original values. A query or join of the various separate tables would result in a single flat table comparable to that illustrated in Table 2, showing how the lineage, feature (and subfeature), value (and original value), method and attribute are reconstructed and made explicit for each entry in the database.

**Table 2**

Simplified outline of a flat table resulting from a query or join of related tables.

Lineage	Feature & subfeature		Value		OriginalValue		Method		Attribute	
	Source	ProfileID	LayerID	Sand	Clay	oSand	oClay	mSand	mClay	aSand
A	A01	A01_1	24	48	42	-	TE02	TE02	Sand	Clay
A	A01	A01_2	10	40	-	-	TE02	TE02	Sand	Clay
A	A01	A01_3	-	-	-	-	-	-	Sand	Clay
A	A02	A02_1	65	5	-	50	TE01	TE01	Sand	Clay
B	B01	B01_1	98	1	-	-	-	-	Sand	Clay

### 2.3.2 Tables

The full schema of the current database holds seventeen tables, including seven dictionaries, as specified in Table 3. *Profiles* is the central table of the database, through which all other tables relate. It holds the profile inventory and the IDs and keys to relate to the other tables, as well as the profile soil and profile site data.

**Table 3**

Overview of the names of tables included in the database.

Data tables	Dictionaries
<u>Profiles, with profile soil attribute-values</u>	<i>DictioSrcDBases</i>
<b>Profiles</b> (central table)	<i>DictioSrcReports</i>
<i>OriProfiles</i>	
<i>GeoPoints</i> (shapefile)	
<u>Layers, with layer soil attribute-values</u>	
<i>Layers</i>	
<i>OriLayers</i>	
<u>Methods</u>	<i>DictioLabs</i>
<i>AttrMethods</i>	<i>DictioLabMethods</i>
<u>Attributes</u>	<i>DictioAttributes</i>
<i>Attrs_1Profiles</i>	<i>DictioRefs</i>
<i>Attrs_2LayerFld</i>	<i>DictioClassValues</i>
<i>Attrs_3Layerlab</i>	
<i>AttrUnits</i>	

Note: The *Attrs* tables (*Attrs\_1Profiles*, *Attrs\_2LayerFld* and *Attrs\_3LayerLab*) have no specific added value for the database or for the soil data, except for making the attributes, associated with the reported attribute-values, explicit by entry, and for relating the attribute-values to the attribute dictionary.

### 2.3.3 Table column headings

An overview of the table column headings, except for those of the dictionary tables, is given in Annex 2. Each column in this annex represents a table, and each row a column heading in that table. All these 'parallel' column headings are near-similar and are all associated with the same attribute code as given by the annex' most left column.

The meaning of the column headings is explained, indirectly, by the attribute codes of the annex' most left column. Annex 3a gives the same list of attribute codes with their explanation. The explanation includes the data type, the unit of expression, a boolean indicating whether the attribute reflects a soil property or not (1/0), and a short and long description of the attribute plus a reference to the standard definition of the attribute, if available.

Annex 3b describes the column headings of the dictionary tables. Annexes 2 and 3 are extracted from the attribute dictionary table, *DictioAttributes*.

The tables *Profiles*, *Layers* and *GeoPoints* compile the actual soil features and soil attribute values. The column headings of these tables are identical to the attribute codes listed in annexes 2 and 3a.

The column headings of the other tables are almost similar, with an additional letter added as prefix. The prefix is o, m, u and a in tables *OriProfiles & OriLayers*, *AttrMethods*, *AttrUnits* and *Attrs*, respectively, and indicates that the column heading refers to original values, to method codes, to units and to attribute codes, respectively.

The length of the list of attribute codes in annexes 2 and 3a is a five-fold reduction of the length of the list that would be necessary to explain all column headings in a direct manner. Note that the attribute codes of annexes 2 and 3a are those as made explicit by entry in the *Attrs* tables (*Attrs\_1Profiles*, *Attrs\_2LayerFld*, *Attrs\_3LayerLab*).

As an example, OrgC is the heading of the column in table *Layers* that gives the standardised values for OrgC. aOrgC is the heading of the column in the *Attrs* table (*Attrs\_3LayerLab*) that explicits the attribute code concerned (which is OrgC and thus described in the attribute dictionary (Annex 3a) as Organic Carbon). uOrgC is the heading of the column in table *AttrUnits* that specifies the unit of expression for OrgC, which is g/kg, and mOrgC heads the column in table *AttrMethods* that specifies (a code for) the method applied to measure OrgC. This method code is described in the method dictionary table, *DictioMethods* (Annex 4). oOrgC heads the column in table *OriLayers* that gives the original values for OrgC.

### 2.3.4 Relations between tables

Figure 4 shows the full schema of the relational database, visualising how the various tables relate to one another. Each block represents a database table, with the texts representing the table column headings. The lines between tables represent relations between tables with a column with equal relational keys in both tables. The relational structure permits to select records in one table based on the querying of records in another table.

Table *Profiles* is the central database table through which all other tables connect. It compiles the profile records inventory, with for each record a specification of the relational keys to relate to the other tables.

The column headings for the relational keys in the *Profiles* table are given by Table 4 together with the column headings for the corresponding keys in the related tables (as extracted from Annex 2).

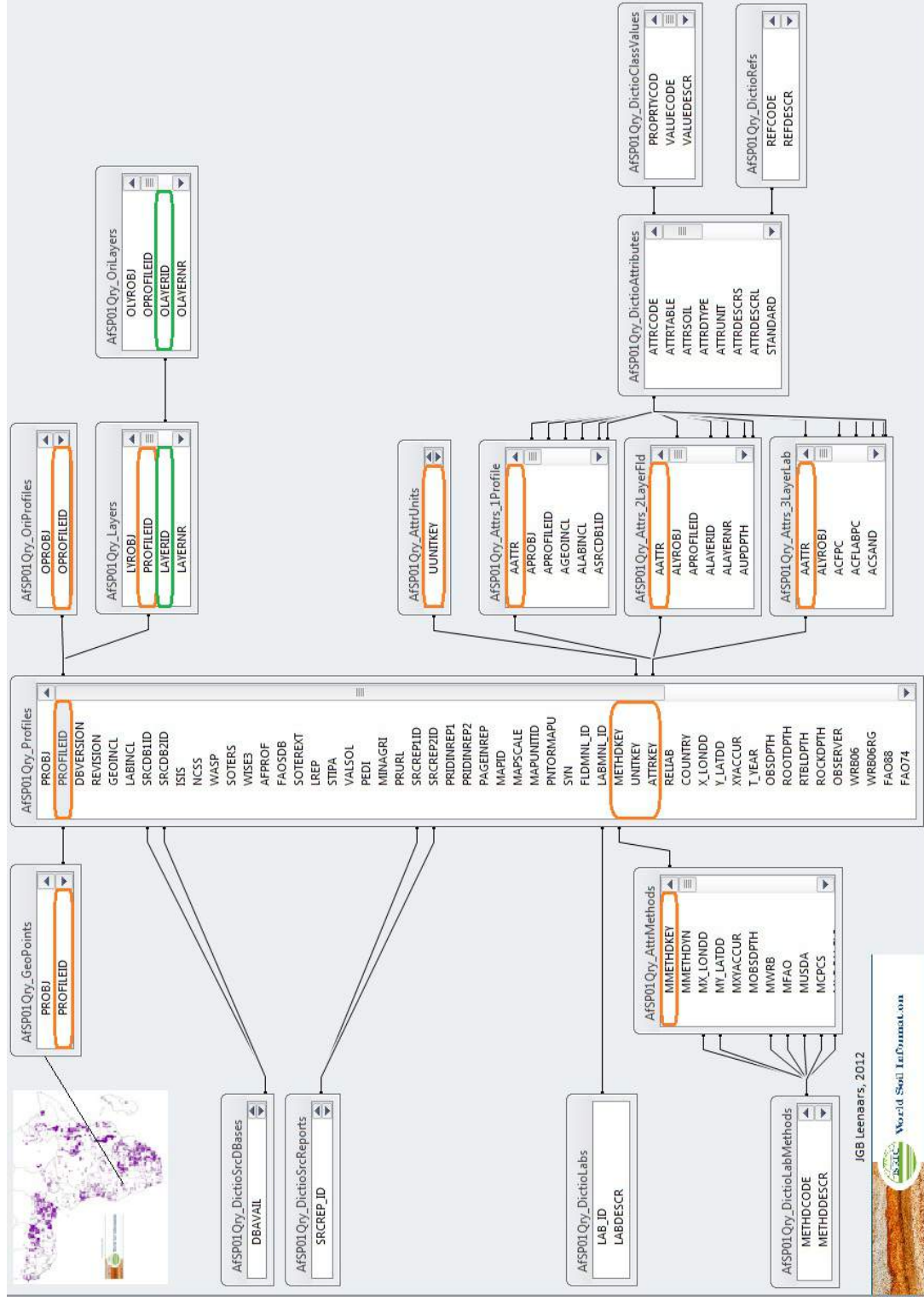
SrcDBase1ID (and 2ID) and SrcRep1ID (and 2ID) are keys that relate to the lineage dictionary tables, *DictioSrcDBases* and *DictioSrcReports*, respectively, giving the full references for the source datasets and reports.

LabMnl\_ID is a key to relate to the dictionary table, *DictioLabs*, wherein the laboratory is described with a reference to a laboratory manual, when available.

The ProfileID key relates to the *GeoPoint* table with shapefile. Besides Profile IDs, this table also includes columns with layer IDs to facilitate the creation of flat tables with the layer values of subsequent layers compiled in a single row (rather than in subsequent rows as is the case in the *Layers* table).

The ProfileID is also the key to relate to the *Layers* table. This table compiles the profile layer subfeatures combined with the associated collections of standardised layer-attribute-values.

The ProfileID and the LayerID are keys that relate to the *OriProfiles* and *OriLayers* tables, respectively, wherein the original values, prior to standardisation or possible correction, are compiled.



**Figure 4**  
Database schema visualised, including 17 tables and 1 shapefile.



**Table 4**

*Table column headings with relational keys, to relate the central table Profiles to the directly associated tables.*

Profiles	Layers	OriProfiles	OriLayers	GeoPoints	AttrMethods	AttrUnits	Attrs	DictioSrcDbases	DictioSrcReports	Dictiolabs
PrObj	-	oPrObj	-	PrObj	-	-	-	-	-	-
ProfileID	ProfileID	oProfileID	oProfileID	ProfileID	-	-	-	-	-	-
SrcDb1ID	-	-	-	-	-	-	-	SrcDb_ID	-	-
SrcDb2ID	-	-	-	-	-	-	-	SrcDb_ID	-	-
SrcRep1ID	-	-	-	-	-	-	-	-	SrcRep_ID	-
SrcRep2ID	-	-	-	-	-	-	-	-	SrcRep_ID	-
MapID	-	-	-	-	-	-	-	-	-	-
FidMn_ID	-	-	-	-	-	-	-	-	-	-
LabMn_ID	-	-	-	-	-	-	-	-	-	Lab_ID
MethodKey	-	-	-	-	mMethodKey	-	-	-	-	-
UnitKey	-	-	-	-	-	uUnitKey	-	-	-	-
AttrKey	-	-	-	-	-	-	aAttrKey	-	-	-
-	LayerID	-	oLayerID	LayerID00	-	-	-	-	-	-
-	LayerID	-	oLayerID	LayerID99	-	-	-	-	-	-

The MethdKey, UnitKey and AttrKey are keys relate to the *AttrMethods*, *AttrUnits* and *Attrs* tables, respectively. These tables compile the collections of attribute-methods (codes), attribute-units and attribute names (codes) as associated with the compiled collections of soil feature attribute values.

(The *Attrs* table is for technical reasons split into tables *Attrs\_1Profiles*, *Attrs\_2LayersFld* and *Attr\_3LayerLab*. The reason is that the table, with only a single row, would be too wide containing too many columns to fit into an Excel spreadsheet).

To relate the *AttrMethods* table and *Attrs* tables to their respective dictionaries is a bit more elaborate. The configuration is copied from the WISE3 database, wherein the method codes given in different columns relate to the method codes as given in a single column (different rows) in the dictionary. This implies that each column in the *AttrMethods* table and *Attrs* tables serves as a key to relate to its dictionary. Table 5 illustrates this for four columns in the *AttrMethods* table and four columns in the *Attrs* table.

**Table 5**

Table column headings with relational keys, to relate the tables *AttrMethods* and *Attrs* to the associated dictionary tables.

<i>AttrMethods</i>	<i>Attrs</i>	<i>DictioMethods</i>	<i>DictioAttribs</i>	<i>DictioClassVal</i>	<i>DictioRefs</i>
<b>mMethdKey</b>	-	-	-	-	-
-	<b>aAttrKey</b>	-	-	-	-
mX_LonDD	-	MethdCode	-	-	-
mSand	-	MethdCode	-	-	-
mClay	-	MethdCode	-	-	-
mOrgC	-	MethdCode	-	-	-
-	aX_LonDD	-	AttrCode	ProprtCod	-
-	aSand	-	AttrCode	ProprtCod	-
-	aClay	-	AttrCode	ProprtCod	-
-	aOrgC	-	AttrCode	ProprtCod	-
-	-	-	Standard	-	RefCode
-	-	-	Standard2	-	RefCode

The table column AttrCode in the *DictioAttributes* table is the key that relates 1 : n to table column heading ProprtCod in the *DictioClassValues* table which explains the meaning of the class values compiled by attribute (see Annex 5a). Standard and Standard2 are column headings that are keys that relate to RefCode in the *DictioRefs* table which lists and gives reference to a number of soil standards.

Note that empty numeric fields (no value) are represented with -9999 and empty text fields by NA.

## 2.4 Observations and measurements

### 2.4.1 Profile records inventory

The profile record is considered a collection of observations and measurements, implying that the feature, attribute, method and value can be reconstructed and made explicit for each entry associated with the profile record.

The profile records inventory is compiled in database table *Profiles*. As described in the previous section, the profile record is composed of keys to relate to the other database tables, with IDs for the profile record itself (ProfileID; corresponding with the profile feature), for the data sources, and for the collections of attributes, units, methods and values (with the values for the profile feature attributes compiled into the same table).

The uniqueness of the profile record is defined by its lineage. Details on lineage include IDs for source databases and source reports, as described in Section 2.1 and given in annex 1a and 1b, and the original profile IDs as originally noted in the data source. This explicit administration of original profile IDs facilitates the identification of duplicate records and enhances the traceability of the data compiled. Lineage to the original mapping unit, if any, is also given.

Also included with the record inventory are booleans to facilitate querying according to data completeness. Information is given on whether the reported soil data represent primary data as observed or measured from a true profile or represent secondary data as derived from a mapping unit, or whether the data are synthesised. In fact, all compiled data represent true profile point observations, except for 0.4% of the records derived from (generalised) mapping units. The perceived reliability and overall quality of the recorded soil data is rated on a scale from 1 to 4 (high to low reliability). See Section 2.4.3 for more details about the data compiled for the profile record.

## **2.4.2 Profile features**

The feature represents an actual physical piece of soil, upon which an observation or measurement is carried out. Whereas the uniqueness of the profile record is defined by its lineage, the observed profile feature is defined by its position in spatio-temporal 4D space (geographic location, depth interval and date of observation).

The profile features are compiled together with the profile records inventory in database table *Profiles*, with ProfileID as the profile feature ID. The profile is defined by its attribute values, compiled in the same table, including values for geographic coordinates (x, y), depth of observation (z) and year of observation (t), as well as the name of the observer(s).

Other data given for the profile feature are depth of rooting, rootability and bedrock, as specified by the data source, and the type of soil according to different classification systems, also as specified by the data source. Compiled with the data on the profile are data on the profile site, including values for topography, parent material, land cover, drainage, etc. See Section 2.4.3 for details about the profile feature and site attributes that are compiled in the database.

### **2.4.2.1 Spatial profile features**

The geographic location of the soil profile feature can be defined as a point (derived from a pair of x-y coordinates), a polygon (derived from a mapping unit) and/or a raster grid cell (derived from a point or a polygon).

The current version of the database includes the shapefile *GeoPoints*. The *GeoPoints* shapefile projects x-y coordinate pairs, or points, upon a geographic surface and is thus a map or visualisation of the profile-feature point locations. Figure 1 is such a map, as are Figures 5 and 7, both produced with the same shapefile *GeoPoints*.

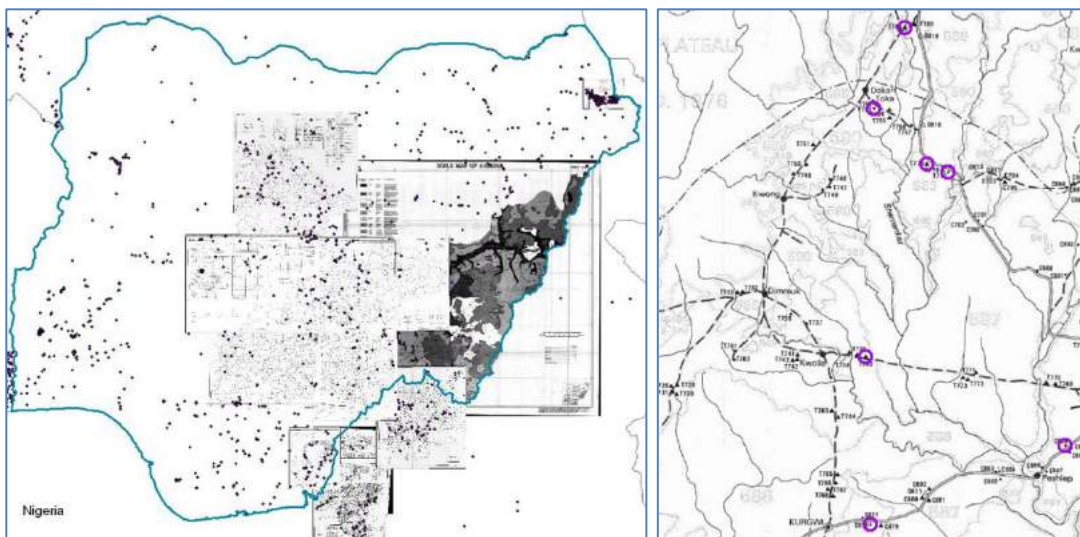
The shapefile is purposely separated from the *Profiles* table in anticipation of the possible digitisation of legacy soil maps with the mapping units compiled into a single shapefile. Such a shapefile permits to project

the profile features as geographic polygons instead of geographic points. It can be argued that the profile location is represented more reliably by a (inaccurate) mapping unit or polygon, serving as a spatial domain of likelihood of occurrence of the profile, compared to an (inaccurate) point, especially when considering to relate the soil profile data to environmental (scorpan) covariate data. The lineage of the profile record to mapping units is therefore included with the record inventory.

The original geographic coordinate system may differ from one batch of profile records to another. If specified in the data source, the coordinates (and system used) are simply copied into the database. When necessary, these are converted from the original projected coordinate system (e.g. UTM 37-S, meters) to the standard system (WGS84, decimal degrees). Profile locations are plotted using the standard WGS84 coordinates to verify their location; i.e. whether they correspond with the site description, the study area or at least the country outline. It is not uncommon that the data source provides coordinates where lat-lon have been inverted (for example, E/N instead of W/S). In such case, the original coordinates recorded in the *OriProfiles* table are maintained and the standard coordinates in the *Profiles* table are corrected.

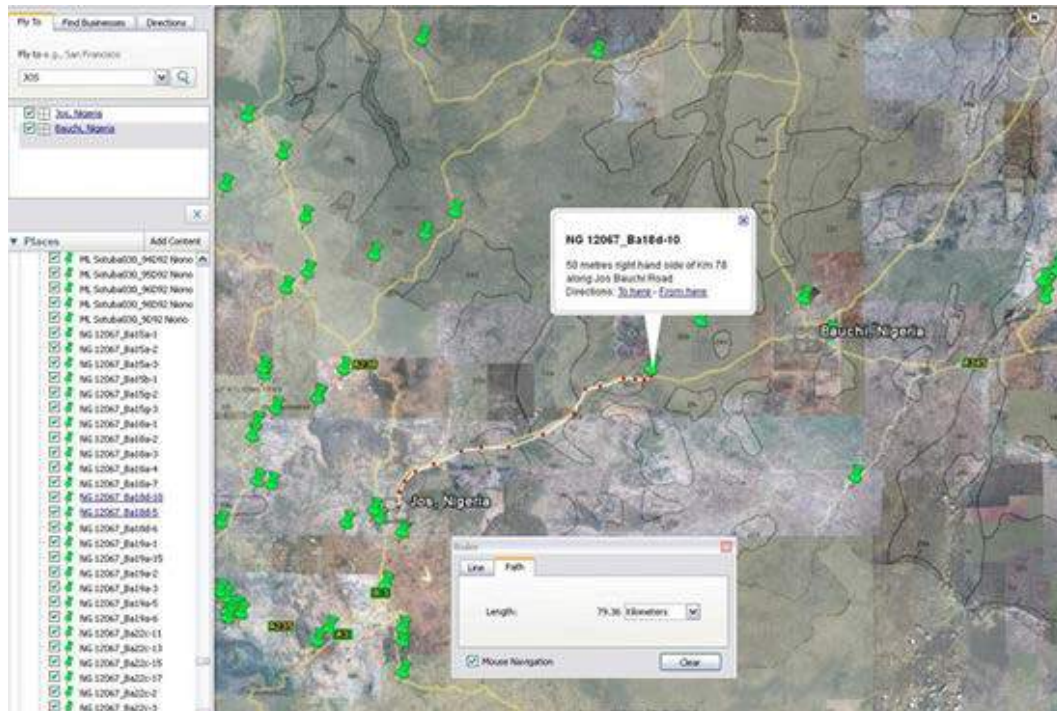
A large portion of the data sources, from the pre-GPS era, does not provide any explicit coordinates. In such situations, a profile's point location is plotted on a paper map or is only given as a descriptive location (e.g., 5 km from village X in the direction of village Y, in county Z). Sometimes, only the location of the study area is provided. This inferred level of accuracy in X-Y coordinates has been documented in the database.

When available, the point location map is scanned, geo-referenced and projected upon WGS84, and the coordinates for the points are assessed. See Figure 5 for examples from Nigeria (also described by Odeh et al. (2012)).



**Figure 5**  
*Assessment of WGS84 coordinates by means of point location maps projected upon a WGS84 defined geographic surface.*

Less accurate are descriptive locations of which the actual point location, with coordinates, is interpreted and arbitrarily assessed with the help of functionalities of GeoNames or Google Earth. This laborious approach (referred to by method code GE under column *mX\_LonDD* in table *AttrMethods*) is illustrated by Figure 6, where the descriptive location is combined with the reference made to the soil mapping-unit in an effort to estimate the location as accurately as possible.



**Figure 6**  
*Assessment of WGS84 coordinates by interpretation of descriptive locations, combined with reference to the reported mapping unit, by projection of the soil map upon the WGS84 defined geographic surface of Google Earth.*

For batches of profile records that lack geographic information but are located in data scarce regions, a next level of lesser accuracy is accepted out of necessity. The profiles from such batches are all georeferenced by the coordinates from the centre of the (relatively small) study area concerned.

The *Profiles* table gives the estimated accuracy (in WGS84, decimal degrees) of the lon-lat coordinates per feature; this uncertainty should be considered explicitly in geo-statistical analyses. On average, the positional accuracy is 0.033 decimal degrees (some 3 km). Consequently, relationships with spatial covariate data should be studied at a low resolution only.

#### **2.4.2.2 Spatial profile subfeatures**

The profile subfeature or profile layer is defined by its position in 4D space. The difference with the profile feature is the narrower depth interval observed.

The profile subfeatures are compiled in database table *Layers* and are identified by LayerID. On average, four layers are reported per profile. The layers are sequentially numbered, with positive numbers increasing with increasing depth below ground. The depth interval is defined by the upper and lower limits in cm, with positive limits increasing with increasing depth belowground. One single aboveground layer (e.g. litter) can be added to the sequence of profile layers, with layer number = 0, and a negative upper depth limit. (Note that the latter is not in accordance with international standards).

The profile subfeatures can represent in-field distinguished and described morphologic horizons as well as in-field sampled depth intervals, with the sample submitted to a laboratory for chemical and physical analyses. Sampled depth intervals may coincide with or fall within morphologic depth intervals, with the samples being considered representative for the horizons, but also may not coincide with morphologic depth intervals. In the

latter case, the sequential layers with sequential depth limits are defined based on the soil analytical sample layering, but with adaptation to morphology if possible or if necessary according to expert insight. Where relevant, a distinction has been made between depth of layers, depth of samples and depth of horizons, in the table *OrilLayers* (see Section 2.4.6).

Profile features for which only one subfeature (top layer) is reported are generally excluded from the compilation, except when the profile is actually very shallow over bedrock (e.g. lithic Leptosols) or hardpan, and when the profile is located in a data scarce area.

The layer data include attribute values observed in the field and attribute values measured in the laboratory. See Section 2.4.3 for details about the list of layer attribute data that are accommodated in the database.

Besides ProfileIDs, the attribute table for shapefile *GeoPoints* gives separate columns with LayerIDs (00-14). This facilitates the creation of a single flat table, with all soil data per profile compiled into a single row, including the layer data of subsequent layers. (Note that such particular data model is not efficient for compilation and manipulation of legacy soil data, but maybe efficient for certain applications).

The *GeoPoint* shapefile with flat table can be exported into KML format for simple data exchange and visualisation in Google Earth, as illustrated in Figure 7.

Included with the Africa Soil Profiles Database is such file (AfSP01Qry.kmz) holding data for a selection of attributes. (Note that the data headings for the different layers, as illustrated for the 2<sup>nd</sup> and 3<sup>rd</sup> layers in Figure 7, cannot correspond to the column headings of the *Layers* table because the flat table requires the layer numbering to be included in the data headings, which is not the case in the *Layers* table).



**Figure 7**

Visualisation in Google Earth of a query of soil profile and layer data exported as a flat table to KML format, with the data of subsequent layers aggregated into a single profile record (a single row).

### 2.4.3 Attributes

The attribute is the feature property that is intended to be observed or measured by applying a given method to a feature to generate a value. By definition, the reported value is the outcome of the method applied to the feature. The grouping of outcomes of different methods under a single soil attribute is basically the simplest form of soil data harmonisation. (Harmonised values are defined as values that meet a standard attribute definition; see Section 2.4.5.3).

The attribute-values are compiled by tables *Profiles*, *OriProfiles*, *GeoPoints*, *Layers* and *OriLayers*. The corresponding attributes are made explicit by entry of attribute codes, into the *Attrs\_123* tables. These attribute codes are described in detail by the *DictioAttributes* table and Annex 3a.

These attributes are, as explained in Section 2.3.3, not necessarily soil attributes, but also include auxiliary attributes that describe the observation itself (e.g. name of the observer, source report title) or that facilitate database functioning (e.g. object identifier, key to dictionary).

The soil attributes are as much as possible defined according to SOTER conventions (Van Engelen and Dijkshoorn, 2012, in prep.). This is the case for attributes with reference to eSOTER2012, as specified in the column 'Standard' of Annex 3a. The actual definitions, however, are less specific though, because the soil attribute definitions in the Africa Soil Profiles Database are exclusive of standard-method. Other referred to standards to define attributes are also given in Annex 3a.

For numerical attributes, the standard unit of measurement is specified, in accordance with eSOTER2012 standards, where applicable. Descriptive values are standardised by codification (see Annex 5a), where applicable according to eSOTER2012 coding conventions.

Exceptions to eSOTER2012 conventions for standardisation include:

- Abundance of (surface) salt or alkali is expressed as presence (Y/N) of salt or alkali.
- Abundance and thickness of roots is expressed as presence (Y/N) of roots.
- Abundance, distinctness and colour of mottles are expressed as presence (Y/N) of mottles.
- Abundance of mineral concretions, nodules, rock fragments etc. is aggregated and expressed as coarse fragments content.
- P<sub>2</sub>O<sub>5</sub> is expressed as P
- Fe<sub>2</sub>O<sub>3</sub> is expressed as Fe
- Al<sub>2</sub>O<sub>3</sub> is expressed as Al
- Parent material is expressed as class values according to -an intermediate version developed for eSOTER2012, as given in Annex 5b.
- Horizon designation is expressed as provided by the data source (i.e., not converted to FAO1990/FAO2006 standards).
- Layer numbering starts with number 1 for the first belowground (mineral) layer, and not necessarily for the first layer of observation which, in eSOTER2012 and according to international standards, may also include aboveground layers (e.g. litter). The aboveground layer, if reported, is given number 0, with negative values for depth.
- The standard method to assess the attribute is not included in the attribute definition.

An overview of the attributes, for which values are standardised and compiled in the *Profiles* and *Layers* tables, is given in Table 6 and 7, respectively. The definitions are given in Annex 3a. The attributes highlighted in purple are the key soil attributes for GlobalSoilMap. The attribute definitions according to GlobalSoilMap specifications are given in Annex 7. Data for these attributes are compiled with priority, together with those in red, defining the features, and those in blue, defining the associated methods, attributes and units.

Available water holding capacity, which is a key soil property according to GlobalSoilMap specifications, is routinely assessed by subtracting water content at wilting point from that at so-called field capacity. According to GlobalSoilMap specifications (see Annex 7) the water holding capacity is to be assessed by a (continuous) pedotransfer function. Wösten et al. (2012, in prep.) validated such pedotransfer function, for assessing Van Genuchten parameters derived by Hodnett and Tomasella (2002) for tropical soils, with soil data from the Africa Soil Profile Database including volumetric water content assessed at various tensions.

To serve purposes other than those of GlobalSoilMap, such as soil and terrain area class mapping requiring profile data to be classifiable, other soil attributes, also requiring descriptive values, are included as much as possible.

The consistency of the actual entry of descriptive values was not optimal in all cases, depending on the relative importance given to the attribute and on the associated effort required. Soil type, classified according to WRB (2006), FAO1988, FAO1974, USDA, CPCS and/or the local classification system, is included if provided by the data source. However, no attempt has been made here to correlate all profiles to the FAO Legends or WRB system, unlike for eSOTER2012 and similar, seen the objectives and means given for this AfSIS project activity. Site attribute data such as landform or land use, observed in the field, are included in near all cases if provided by the data source, while morphologic horizon attribute data, also observed in the field, are excluded in most cases except when digitally available. Effort is given to at least include descriptive values for field observed volume of coarse fragment content as this attribute is, together with depth, determinant for soil volume. Soil analytical layer attributes, measured by laboratory methods (quantitative data), are included in all cases, except for very rare attributes.

The following colours are used in Tables 6 and 7 to indicate different types of attributes:

**Feature identifier**

Attribute that defines feature

Attribute that keys to other tables

Attribute that is mapped by GlobalSoilMap.net

Attribute

**Table 6**

*Profile attributes\* in database table Profiles.*

<b>Database administration</b>	<b>Position of feature</b>
Profile record number	Country
<b>Profile ID (Feature key)</b>	Longitude WGS84 DD
Database version	Latitude WGS84 DD
Database revision	Lat-lon accuracy WGS84 DD
Geo data included Y/N	Year of observation
Analytical data included Y/N	Observation depth
<b>Lineage</b>	Rooted depth
1st source dataset	Rootable depth
2nd source dataset	Depth to bedrock
Original profile ID in source dataset ISIS	Observer
Original profile ID in source dataset NCSS	<b>Soil classification</b>
Original profile ID in source dataset WASP	WRB 2006 reference soil group, incl. qualifiers
Original profile ID in source dataset SOTER(S)	WRB reference soil group
Original profile ID in source dataset WISE3	FAO 1988 soil unit
Original profile ID in source dataset FAOSDB	FAO-Unesco 1974 soil unit
Original profile ID in source dataset SOTER-EXT	USDA soil class



Original profile ID in source dataset LREP	CPCS soil class
Original profile ID in source dataset STIPA	Local soil class
Original profile ID in source dataset VALSOL	<b>Site</b>
Original profile ID in source dataset PEDI	Descriptive location
Original profile ID in source dataset MINAGRI	Altitude
Source url	Slope gradient
1st source report	Topography
2nd source report	Major landform, conform to SOTER
Original profile ID in 1st source report	Slope form at site
Original profile ID in 2nd source report	Position on slope
Page in report	Flooding frequency
Map identifier	Parent material at site
Map scale	Lithology of surroundings
Mapping unit	Regolith
Profile or mapping unit	Land cover
Synthetic profile Y/N	Land use
<b>Keys to Method and Attribute codes</b>	Drainage
Field manual identifier	Surface drainage
Laboratory (manual) identifier	Surface stoniness
<a href="#">Key to methods</a>	Surface salt or alkali
<a href="#">Key to units of expression</a>	
<a href="#">Key to attributes</a>	
Inferred profile data quality	

\* Profile attribute definitions, exclusive of specific method, are given in Annex 3a.

**Table 7**

*Profile layer attributes \* in database table Layers.*

<b>Database administration</b>	Exchangeable H
Layer object number	Exchangeable Al
<b>Profile ID</b> ( <a href="#">Feature key</a> )	Exchangeable acidity
<b>Layer ID</b> ( <a href="#">Subfeature key</a> )	<a href="#">Effective CEC</a>
Layer number in profile	CEC soil
<b>(Sub)feature definition</b>	CEC soil, 2nd measurement
<a href="#">Layer upper depth</a>	Base saturation
<a href="#">Layer lower depth</a>	Base saturation, 2nd measurement
Sample composition	CaSO <sub>4</sub>
Sample identifier	CaCO <sub>3</sub>
Sample availability	Inorganic carbon
<b>Layer field observations</b>	Total carbon
Horizon designation	<a href="#">Organic carbon</a>
Colour - moist soil	Total nitrogen
Colour - dry soil	CN ratio
Mottles - presence	Total P
Structure grade	Volumetric moisture content at pF 0.0
Structure size	Volumetric moisture content at pF 0.5
Structure type	Volumetric moisture content at pF 1.0
Stickiness when wet	Volumetric moisture content at pF 1.5
Salt or alkali - presence	Volumetric moisture content at pF 1.7
Roots - presence	Volumetric moisture content at pF 1.8
Particle size class - field	<a href="#">Volumetric moisture content at pF 2.0</a>
Coarse fragments class - field	Volumetric moisture content at pF 2.2
<a href="#">Coarse fragment content</a>	Volumetric moisture content at pF 2.3
<b>Layer lab measurements</b>	Volumetric moisture content at pF 2.4
Coarse fragment content -lab	<a href="#">Volumetric moisture content at pF 2.5</a>
<a href="#">Sand</a>	Volumetric moisture content at pF 2.7

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Silt	Volumetric moisture content at pF 2.8
Clay	Volumetric moisture content at pF 2.9
Sum of fine earth fractions	Volumetric moisture content at pF 3.0
Bulk density	Volumetric moisture content at pF 3.3
pH H <sub>2</sub> O	Volumetric moisture content at pF 3.4
pH KCl	Volumetric moisture content at pF 3.5
pH CaCl <sub>2</sub>	Volumetric moisture content at pF 3.6
Electrical conductivity	Volumetric moisture content at pF 3.7
Electrical conductivity, 2nd measurement	Volumetric moisture content at pF 4.0
Soluble cations	Volumetric moisture content at pF 4.2
Soluble anions	Volumetric moisture content at pF 5.0
Exchangeable Ca	Volumetric moisture content at pF 5.8
Exchangeable Mg	Volumetric available water content
Exchangeable Na	Lab derived texture class
Exchangeable K	Clay mineralogy
Exchangeable bases	

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\* Profile layer attribute definitions, exclusive of specific method, are given in Annex 3a.

## 2.4.4 Methods of observation or measurement

The method refers to how a feature-attribute-value is observed or measured.

The wide variety of data sources (>300) reflects a wide variety of methods applied to observe, measure and record soil property values. This variety is further accentuated by the large number of laboratories (>100) associated with the various data sources with inter-laboratory variability in cases exceeding inter-method variability (also see Labex programme, <http://www.isric.org/projects/laboratory-methods-and-data-exchange-labex>, and WEPAL). This has impact on the comparability of values reported for similar attributes. Different analytical methods and class-limits, applied to assess a similar feature-attribute, may result in different outcomes or values. The key question then is to what extent this inter-method and inter-laboratory variation compromises the value of the data itself and the explanatory value of (scorpan) covariate data at specific resolutions. The finer the spatial resolution, the more important the issue of comparability of soil analytical methods is.

For each profile, reference is made to the laboratory (see Table 6), and if possible to the laboratory manual, where the soil analytical attributes are measured and to the field manual. The method key refers to the collection of attribute-methods in database table *AttrMethods*. The attribute-methods are specified as method code, though only for geo-location, classification (versions) and analytical attributes, if reported by the data source. The laboratory method codes are explained, with the methods briefly described, by the dictionary table *DictioLabMethods*. This dictionary, including the codes, is copied from the eSOTER2012 procedures manual (Van Engelen and Dijkshoorn, in prep.), as adopted from WISE3, and given in Annex 4.

Note that the analytical methods distinguished in the methods dictionary (Annex 4) require reclassification for obtaining consistently defined method groupings. The reclassification implies aggregation or disaggregation, depending on the soil attribute under consideration.

The methods used to observe profile site attributes and morphologic profile layer attributes are not specified, in the *AttrMethods* table, by method codes per attribute but are given implicitly by specification of the field manual used. Method codes are given for the methods used to assess X-Y coordinates, and for the versions of the soil classification systems (e.g. USDA1975, USDA1998).

One method key (MethKey) represents a collection of methods that applies to all -or a large proportion of- profiles from a given data source. In total, 420 method collections are distinguished and listed in the *AttrMethods* table based on the data sources compiled so far. Note that many data sources do not report about the methods applied. Consequently, methods are specified for part of the collections only.

## 2.4.5 Values

The value is the outcome from a method applied to a feature to observe or measure a feature-attribute.

The feature-attribute values, or soil data, are compiled under a common standard. The standardisation of the data, including numeric and descriptive values, is as was described in Section 2.4.3. The standardisation of data thus applies to the values, not to the naming of attributes or column headings.

The standardised values, compiled in tables *Profiles and Layers*, have been routine quality controlled. Original values, as compiled in tables *OriProfiles and OriLayers*, are not routine quality controlled and are provided as is.

### 2.4.5.1 Original values

The original values for profile attributes are given in database table *OriProfiles* and for profile layer attributes by table *OriLayers*. These original values have been maintained only if different from the standardised and routine quality controlled values.

Original descriptive values need interpretation, prior to being coded according to the standard conventions (which may involve a loss of detail). See Figure 8 for examples, including e.g. 'Shire plain' (in black rectangle) as a value for topography or 'colluvions dérivées d'altération de Schistes' as a value for parent material (interpreted and standardised in Figure 9). The original descriptive values are maintained for two reasons. First, the standard coding is prone to errors due to misinterpretations. Second, the coding conventions are developed to serve standardisation at global scale, which implies that detailed information is lost. The current standard coding conventions may well be replaced by other conventions, and then it is better to restandardise based on original descriptions rather than on coded values.

(Note that descriptive values have been standardised already upon entry in many cases at especially the beginning of the compilation process. In those cases, original values are to be traced back in the data source.)

Original numeric values are standardised upon entry and are transferred to the separate tables for standardised values (see next Section). The standardised value is maintained as original value in case the standardised value is changed, by correction or exclusion, upon routine quality control. In those cases, the standardised value before correction is stored as the original value.

Adding to these numeric values are original numeric values, for other attributes (as listed in Table 8), that are standardised but that are not transferred to the separate tables for standardised values and that are not routine quality controlled. For those attributes, the values are given as original values only.

**Table 8**

Attributes\* for which the, not routine quality controlled, values are compiled in tables OriProfiles and OriLayers (not transferred to the tables Profiles and Layers with standardised and routine quality controlled values).

<b>OriProfiles</b>	<b>OriLayers</b>		
Profile object number	Layer object number	pH H2O, 2nd measurement	Extractable Fe - free
<b>Profile ID</b>	<b>Profile ID</b>	PH X	Extractable Fe - active
Easting	<b>Profile layer ID</b>	Soluble Ca	Extractable Fe - organic bound
Northing	<b>Horizon upper depth</b>	Soluble Mg	Extractable Fe - total
East or West	<b>Horizon lower depth</b>	Soluble Na	Extractable Al - free
Longitude degrees	<b>Sample upper depth</b>	Soluble K	Extractable Al - active
Longitude minutes	<b>Sample lower depth</b>	Soluble CO3	Extractable Al - organic bound
Longitude seconds	Diagnostic horizon	Soluble HCO3	Available K
North or South	Diagnostic property	Soluble Cl	Total K
Latitude degrees	Diagnostic material	Soluble SO4	Iron micro nutrient
Latitude minutes	Transition	Soluble NO3	Manganese micro nutrient
Latitude seconds	Nature of coarse fragments	Soluble F	Zinc micro nutrient
Projected coordinate system	Coarse sand	Exchangeable Ca & Mg	Copper micro nutrient
Terrain map unit	Medium sand	CecMin	Borium micro nutrient
Terrain map unit component	Fine sand	CecMax	Sulfur micro nutrient
Soil map unit component	Coarse silt	Available P	Organic matter
Land element	Fine silt	Available P, 2nd measurement	Total humic C
Parent material on site,	Humidity	P retention	Humic acid C
2nd observation		Porosity	Fulvic acid C
Land cover, 2nd observation	Hydraulic conductivity	Weight-based water holding capacity	Full horizon description
Remark, incl. full profile description			

\* Profile attribute definitions, exclusive of specific method, are given in Annex 3a.

Figure 8 gives examples of original numeric values, including e.g. 8299300 for UTM northing in meters (converted and standardised in Figure 9).

ProfileID	Y_North	YNS	Y_Deg	Y_Min	Y_Sec	OriTopography	OriParentMaterial	OriLandCover
CD 4143_79	-	-1	4	5	-	ondulée, légère pente	argile d'altération de schistes	forêt abattue
CD 4143_8	-	-1	10	10	-	plateau horizontale	sable Kalahari reposant sur carapace latérique.	Savana steppique zambézienne
CD 4143_80	-	-1	4	5	-	bordure de plateau	argile d'altération de schistes	jeune forêt secondaire
CD 4143_81	-	-1	4	5	-	plateau horizontal	argile d'altération de schistes	jeune forêt secondaire
CD 4143_82	-	-1	4	24	-	plateau	produit d'altération de phyllades	savane en bordure de la forêt
CD 4143_83	-	-1	4	5	-	plateau	produit d'altération des schistes del'Urundi	savane à Imperata
CD 4143_87	-	-1	11	38	-	pénéplaine fin tertiaire	argile d'altération de schistes	forêt claire dégradée en jachère
CD 4143_89	-	-1	11	30	-	dépression	colluvions dérivées d'altération de schistes	savane
CD 4143_92	-	-1	5	30	-	ondulée	produit d'altération de grès sublittoraux	savane paturée
CD 4143_93	-	-1	5	30	-	très ondulée	argile sableuse dérivant des quartzite micacés	savane très arbustive
CD 4143_94	-	1	0	55	-	pénéplaine fin-tertiaire	produit d'altération ultime de psammites de Lindi.	forêt équatoriale
CD 4143_95	-	1	0	55	-	pénéplaine fin-tertiaire	produit d'altération ultime de psammites de Lindi.	forêt équatoriale
CD 4143_98	-	1	3	6	-	dôme peu élevés	sable argilleux dérivés de grès	forêt secondarisée
CG 28638_1	-	-1	4	25	30	NA	Bateke sands	Savanna
CG 28639_1	-	-1	3	57	10	NA	NA	NA
CM 1868_1	8299300					almost flat	alluvium	Cultivation Fallow
CM 1868_108	8298250					rolling	tertiary basalt	grass
CM 1868_116	8299900					undulating	basement complex	savanna, with sparse grass
CM 1868_127	8300200					rolling	basalt	grass
CM 1868_13	8302500					gently sloping colluvium	lava colluvium	fallow
CM 1868_130	8310450					rugged (scarp foot hills)	Basement complex	savanna, grasses
CM 1868_138	8302400					rolling	basalt	tufts of sporobolus
CM 1868_161	8304800					undulating	lava	grassland with forrested valleys
CM 1868_177	8292750					rolling	lava	sporobolus
CM 1868_212	8297900					rolling to mountainous	Basement complex	sporobolus
MW Irep_G16	8354500					Shire plain	alluvium	dense tall grassland
MW Irep_G17	8353700					between plain & hilly	NA	NA
MW Irep_G18	8353400					hilly	residual	fallow grass
MW Irep_G19	8350600					convex slope of a crest	banded biotite gneiss	sward

**Figure 8**

Examples of original values, both descriptive and numeric, as collated into the data entry table OriProfiles (with old column headings).

### 2.4.5.2 Standardised values

Standardised values for profile feature and site attributes are given by database table *Profiles* and for profile layer subfeature-attributes by table *Layers*. These standardised values have been routine quality controlled, as is explained in Section 2.5.

Values are standardised to conform to the standard definition of the attributes given in Section 2.4.3. The standard attribute definitions are given in table *DictioAttributes* and in Annex 3a.

Standardisation of descriptive values implies interpretation to meet the standard attribute definition, followed by classification and codification of the value. For instance, the original value for parent material of 'colluvions dérivées d'altération de Schistes', as given in Figure 8, is in Figure 9 interpreted and standardised as value class 'MB', for basic metamorphic rocks. The coding is according to the conventions in database table *DictioClassValues* and Annex 5a. The coding conventions are those of eSOTER2012, unless specified otherwise. For a few attributes (e.g. MapUnit, WRB06, USDA, CPCS, Observer, Location), descriptive values are considered standardised without being coded.

Standardisation of numeric values is required to meet the standard attribute definition as well as the standard unit of expression, as specified per attribute in Annex 3a. A value conversion is needed to match the attribute, e.g. from easting to longitude, from P<sub>2</sub>O<sub>5</sub> to P or from CaCO<sub>3</sub> to inorganic C, as well as to match the unit, e.g. from degrees to decimal degrees or from % to ‰. Further, for analytical data there may be a need for harmonisation to, agreed upon, standard methods (see 2.4.5.3).

Figure 9 shows how the original value for UTM northing, in meters, of 8299300, as given in Figure 8, is converted to 5,969, meeting the standard attribute definition (WGS84 latitude) and the standard unit of expression (decimal degrees).

ProfileID	Y_LATDD	Topography	Landform_1M	Position	ParentMaterial	LandCover	LandUse	Drainage	ObservedDepthCm
CD 4143_79	-4.083	UO	NA	M	MB	IA	NA	W	150
CD 4143_8	-10.167	F0	LL	A	SI1	VB5	NA	M	75
CD 4143_80	-4.083	GO	LL	A	MB	IA	NA	NA	180
CD 4143_81	-4.083	NA	LL	A	MB	IA	NA	W	200
CD 4143_82	-4.400	F	LL	A	MB	VB	NA	W	180
CD 4143_83	-4.083	NA	LL	A	MB	VB5	NA	W	180
CD 4143_87	-11.633	UO	LP	M	MB	VB	AA2	W	150
CD 4143_89	-11.500	W0	LD	D	MB	VB	NA	P	120
CD 4143_92	-5.500	UO	NA	A	SA1	VB2	HE	W	150
CD 4143_93	-5.500	UO	NA	A	MA1	II	NA	W	200
CD 4143_94	0.917	F0	LP	A	MA1	IA1	NA	W	150
CD 4143_95	0.917	F0	LP	A	MA1	IA1	NA	W	177
CD 4143_98	3.100	UO	LP	M	SA1	IA	NA	W	200
CG 28638_1	-4.380	UO	L	L	US0F	VA1	AA2	W	260
CG 28639_1	-3.970	UO	LL	NA	SA1	NA	AT1	S	600
CM 1868_1	5.969	F0	LV	D	U00F	NA	MP	I	224
CM 1868_108	6.086	RO	S	M	VB1	VA1	HE	W	130
CM 1868_116	6.019	UO	L	M	MA	VA1	HE	W	127
CM 1868_127	6.164	RO	SH	M	VB1	VA2	AA2	W	135
CM 1868_13	6.062	GO	LF	M	UY0C	NA	AA2	W	170
CM 1868_130	6.021	RO	S	H	MA	VA1	MP	W	203
CM 1868_138	6.226	RO	SH	M	VB1	VA4	HE	W	114
CM 1868_161	6.066	UO	L	H	VB	NA	HE	W	84
CM 1868_177	5.846	RO	S	L	VB	NA	HE	W	107
CM 1868_212	6.050	T0	T	H	MA	NA	MP	W	132
MW Irep_G16	-14.870000	F0	L	L	U00F	NA	AA4	W	105
MW Irep_G17	-14.880000	UO	L	H	NA	NA	AA4	I	120
MW Irep_G18	-14.880000	RO	S	L	UR	NA	AA4	P	120
MW Irep_G19	-14.910000	UO	L	H	MA2	NA	AA4	W	60

**Figure 9**

Examples of standardised values, both descriptive and numeric, as collated into the data entry table *Profiles* (with old column headings).

### 2.4.5.3 Harmonised values

The harmonisation of a value implies the conversion of the value, observed or measured by a recorded non-standard method, to a target value as if observed or measured by a specific standard method. Formulated differently, standardised values meet the standard attribute definition that is exclusive of the method used to assess the attribute value. Harmonised values are standardised values that meet a standard attribute definition that is inclusive of a pre-defined standard method.

ISO TC190, SOTER or GlobalSoilMap define standard soil attributes, inclusive of associated standard method. These definitions could serve as the harmonisation target, for which pedotransfer functions or conversion rules need to be developed.

Annex 7 gives the standard soil attributes, inclusive of the associated standard method, as defined in the *GlobalSoilMap* specifications (version 1, release 2.1, July 2011). The careful reader of Annex 7 may discover quite a few inconsistencies in the attribute definitions, which may inhibit future data harmonisation (and even harmonised GlobalSoilMapping) if not corrected. Version 2.2 of the specifications is underway.

To convert standardised values (X) to the harmonisation target (Y), conversion rules (from X to Y) are needed. Such rules are not yet compiled or established and applicable within the domains or scales desired. Consequently, values have not been harmonised (if not according to its simplest format which is that values, assessed by various methods, have been allocated to the corresponding attribute).

Adding to the unavailability of conversion rules, are the current inconsistencies in the inventory and definitions of methods in *DictioLabMethods* often inhibiting a proper definition of X (values assessed with methods of class X). It is recommended to define coherent method classes and to reclassify the current list of methods accordingly.

Harmonisation is required to enable full quality control of values, including control of internal consistencies of values of two or more related soil attributes. This is elaborated upon in Section 2.5.3.

It should be noted that, though harmonisation is necessary for full quality control, harmonisation itself imposes a possible source of error or added uncertainty, as conversion rules, based on regression analysis, have a given goodness of fit only ( $R^2$ ).

## 2.5 Data quality control

Quantitative feature attribute values have been quality controlled. Three levels of quality control are distinguished, corresponding with the three levels of value standardisation. These are:

- Basic quality control upon entry of original values;
- Routine quality control of collated and standardised values;
- Full quality control of harmonised values.

Note that the values in the database have been basic and routine quality controlled. The values have not been fully controlled, as full control requires the values to be harmonised.

Note that the identification of possibly erroneous values is well doable. The follow-up, to verify and maintain, correct or exclude the value, is far less evident.

Note that (data) quality is by definition use dependent (Finke, 2006).

### **2.5.1 Basic quality control of original values**

Upon entry, original values are subjected to basic quality control. This implies checks on one-dimensional attribute-values, irrespective of values for other attributes (e.g. total nitrogen content, irrespective of the organic carbon content or C/N ratio).

Most important basic controls include:

- The unit of expression, e.g. % or ‰, w% or v%, meq/kg or cmol/kg
- The domain or value ranges, e.g. 0-100%
- The attribute definition, e.g. organic carbon, total organic carbon or total carbon, or sand fraction >0.05 mm or sand fraction >0.064 mm.
- Obvious mistakes, e.g. switch of latitude and longitude
- Extreme outliers, e.g. CEC = 300 cmol/kg, or extreme exceptions in the depth profile, e.g. pH = 6 – 7 for all layers except for one with pH = 3.

Where obvious and necessary, values are corrected or excluded.

The upon-entry inferred overall quality and reliability of the values is subjectively rated on a scale from 1 to 4, as specified per profile feature.

### **2.5.2 Routine quality control of standardised values**

Values that are collated and standardised are subjected to routine quality control. Scripts are run to verify one-dimensional attribute values and check on simple two-dimensional inconsistencies between attribute values (e.g. C/N ratio, sum of fine earth fractions, base saturation).

The criteria applied for routine quality control are given in Annex 6. Much is adopted from the WISE3 quality controls and from criteria defined in Driessen (1992), in combination with simple outlier analyses, relying on references set by ISRIC and NRCS datasets.

The rules lead to three possible outcomes:

- Value does not meet the criteria for being included: revisit data source and correct value, if possible, or exclude value.
- Value meets the criteria for being included, but is 'flagged' as 'odd': revisit data source and correct value, if possible, or maintain value.
- Value meets the criteria for being included.

Annex 6 indicates the implication of each rule by giving the number of corrected or excluded (standardised) value entries, relative to the number of value entries compiled. Table 9 summarises the absolute numbers of corrected or excluded layer-attribute values. For the majority of attributes, the percentage of entries actually excluded is only small.

**Table 9***Overview of numbers of corrected or excluded layer-attribute values.*

Layer upper depth	25	Exch. Ca	1298	Moisture at pF 1.5	0
Layer lower depth	60	Exch. Mg	1306	Moisture at pF 1.7	24
Horizon Designation	178	Exch. Na	1295	Moisture at pF 1.8	4
Colour	0	Exch. K	1307	Moisture at pF 2.0	418
Mottles - presence	7346	Exch. Bases	58	Moisture at pF 2.2	10
Structure	6308	Exch. H	13	Moisture at pF 2.3	4
Stickiness when wet	0	Exch. Al	12	Moisture at pF 2.4	34
Salt or alkali - presence	8411	Exch. Acidity	90	Moisture at pF 2.5	14
Roots - presence	6263	Effective CEC	117	Moisture at pF 2.7	10
Particle size class - field	4161	CEC soil	1510	Moisture at pF 2.8	9
Coarse fragments class	10270	CEC soil 2 <sup>nd</sup>	34	Moisture at pF 2.9	408
Coarse fragments	0	Base saturation	512	Moisture at pF 3.0	545
Coarse fragments -lab	11	Base saturation 2 <sup>nd</sup>	434	Moisture at pF 3.3	629
Sand	515	CaSO <sub>4</sub>	1	Moisture at pF 3.4	1599
Silt	670	CaCO <sub>3</sub>	0	Moisture at pF 3.5	1506
Clay	446	Inorganic carbon	0	Moisture at pF 3.6	384
Sum of fractions	567	Total carbon	183	Moisture at pF 3.7	386
Bulk Density	16	Organic carbon	2181	Moisture at pF 4.0	451
pH H <sub>2</sub> O	60	Total N	1224	Moisture at pF 4.2	166
pH KCl	73	C/N ratio	1860	Moisture at pF 5.0	154
pH CaCl <sub>2</sub>	22	Total P	4431	Moisture at pF 5.8	157
Electrical conductivity	187	Moisture at pF 0.0	15	Lab texture class	770
Soluble cations	0	Moisture at pF 0.5	0		
Soluble anions	0	Moisture at pF 1.0	14		

Annex 6 gives for each rule the number of value entries flagged, relative to the number of value entries compiled.

One may ask what to do with values that are evaluated and flagged, as 'odd'. It is simpler to distinguish between correct and incorrect values only and to restrict the dataset to 'correct' data by excluding flagged data. Relevant in this context are three quotes of Batjes (2008):

- all flagged values are potential errors only, and need not to be wrong;
- defining too stringent rules for data collection and data comparison would exclude many legacy data;
- many possibly imprecise measurements may be considered more efficient (and accurate) than a few expensive ones carried out in a few reference laboratories, particularly for broad scale applications of the data.

The approach applied is in line with that applied for WISE3. The criteria defined for exclusion are not very stringent. The criteria to control, and flag, for possible inconsistencies and 'odd' values are more stringent. Flagged values are to be verified visually against the source data and if possible the classification. Verification generally shows that possible inconsistencies and 'odd' values are in most instances correctly copied from the original data source, including ISRIC data sources with previously thoroughly screened data.

The criteria are subjective and arbitrary by definition. The follow-up of the criteria, after revisiting of the data source, risks being subjective and arbitrary as well.



It is difficult to decide what to do with inconsistencies in the case of criteria that include more than a single attribute. For example, it is not uncommon that particle size classes do not add up to 100% or that C/N ratios are out of the normal range. For individual, within profile, cases, the problem can be solved by comparison with above and below layers followed by an informed correction. For batches though, of e.g. too high C/N ratios, the problem is less evidently solved as it is unknown whether the value for C is too high or that for N too low (or whether the reported unit of expression (% vs. ‰) is erroneous for one or both). A, highly arbitrary, correction of one or both is a possible source of large error while the exclusion of both values has repercussions on the size of the dataset. Moreover, it might bias the dataset since awkward values are removed while (part of) these may be real values.

It is therefore justified to include rather than to exclude 'odd' values. Data quality is use-specific and therefore the user is advised to adopt fit-for-use criteria. For instance, accurate soil property mapping is well possible, at medium resolution, based on primary data that are somewhat inaccurate. A continental-wide evidence-based soil property map is likely more accurate when informed by many values of varying accuracy, well covering covariate space, compared to when informed by only a few values of constant and high accuracy, not completely covering the covariate space.

### **2.5.3 Full quality control of harmonised values**

Full quality control implies two- or multidimensional checks on in-pedon consistencies. It requires harmonised data that are complete and stratified. None of these criteria are met in the Africa Soil Profiles Database Version 1.0. Consequently, the data are not fully quality controlled. Nevertheless, the routine control described in the previous section includes some checks on within-pedon consistencies. The criteria applied reflect some oversimplified assumptions about the verifiability of within-pedon consistency.

An example of controlling relations between two or more properties is e.g. the relationship between base saturation and say pH-water or pH-KCl. Note that base saturation is an important criterium in soil classification. It is a composite value of four exchangeable bases and of CEC, with CEC depending on the content and the type of organic carbon and of clay. With a variety of methods used to assess the values for each of these properties, including that for pH, the variance of the property values is very likely to be large, with the expected relations between the property values very likely to be weak. In-house tests show that preliminary data harmonisation reduces variance and strengthens relationships indeed, enhancing the applicability of criteria, but only to a limited extent.

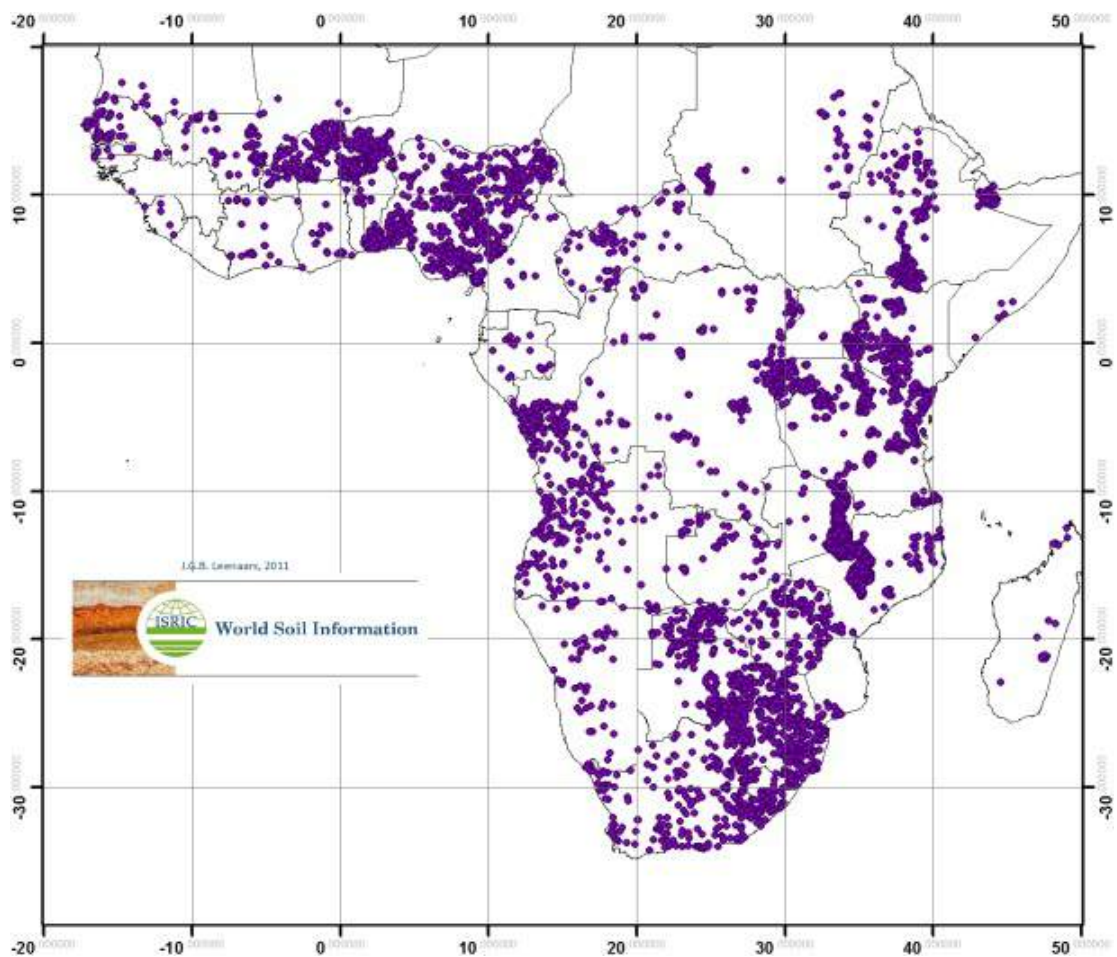
It can be concluded that the complex nature of soils, with its heterogeneity of possible attribute values, combined with the nature of legacy soil data, with its range in methods used to assess attribute values (with sometimes specific analytical methods required for specific soil types, e.g. to assess available P), combined with the lack of conversion rules to harmonise these values, inhibit the establishment of sensible criteria for full proper control of within-pedon soil data consistency and quality.



### 3 Results - database contents

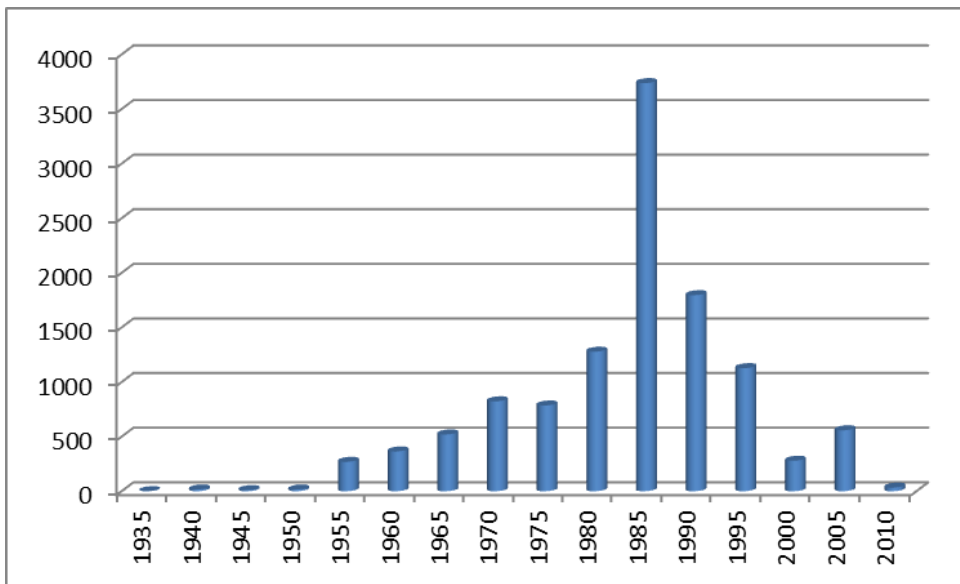
Soil profile observations and measurements are compiled from over 300 data sources, and include values for approximately 140 soil attributes, with the soil analytical attribute values measured in over 100 laboratories with over 300 methods specified, for 50,150 layers of 12,574 profiles. The values are standardised for 25 profile and site attributes and for 75 layer attributes, and the values for some 60 analytical layer attributes are also routine quality controlled.

Figure 10 illustrates the spatial distribution of the georeferenced soil profile data included in version 1.0 of the Africa Soil Profiles Database. In total, relative to a Sub Saharan Africa area of 18,000,000 km<sup>2</sup>, the density is approximately two profiles per 3,000 km<sup>2</sup>. As yet, no data are compiled for Gambia, Guinea Bissau, Equatorial Guinea, Chad and Eritrea.



**Figure 10**  
*Spatial distribution of the soil profile data included in the Africa Soil Profiles Database version 1.0.*

Figure 11 shows the temporal distribution of the profile records, more or less reflecting the intensity of soil surveys carried out in Africa, peaking in the 1980s. The high peak between 1985 and 1990 reflects the inclusion of a few large datasets with especially LREP Malawi bringing in relatively much weight.



**Figure 11**  
Temporal distribution of the profile records, aggregated per 5 year period.

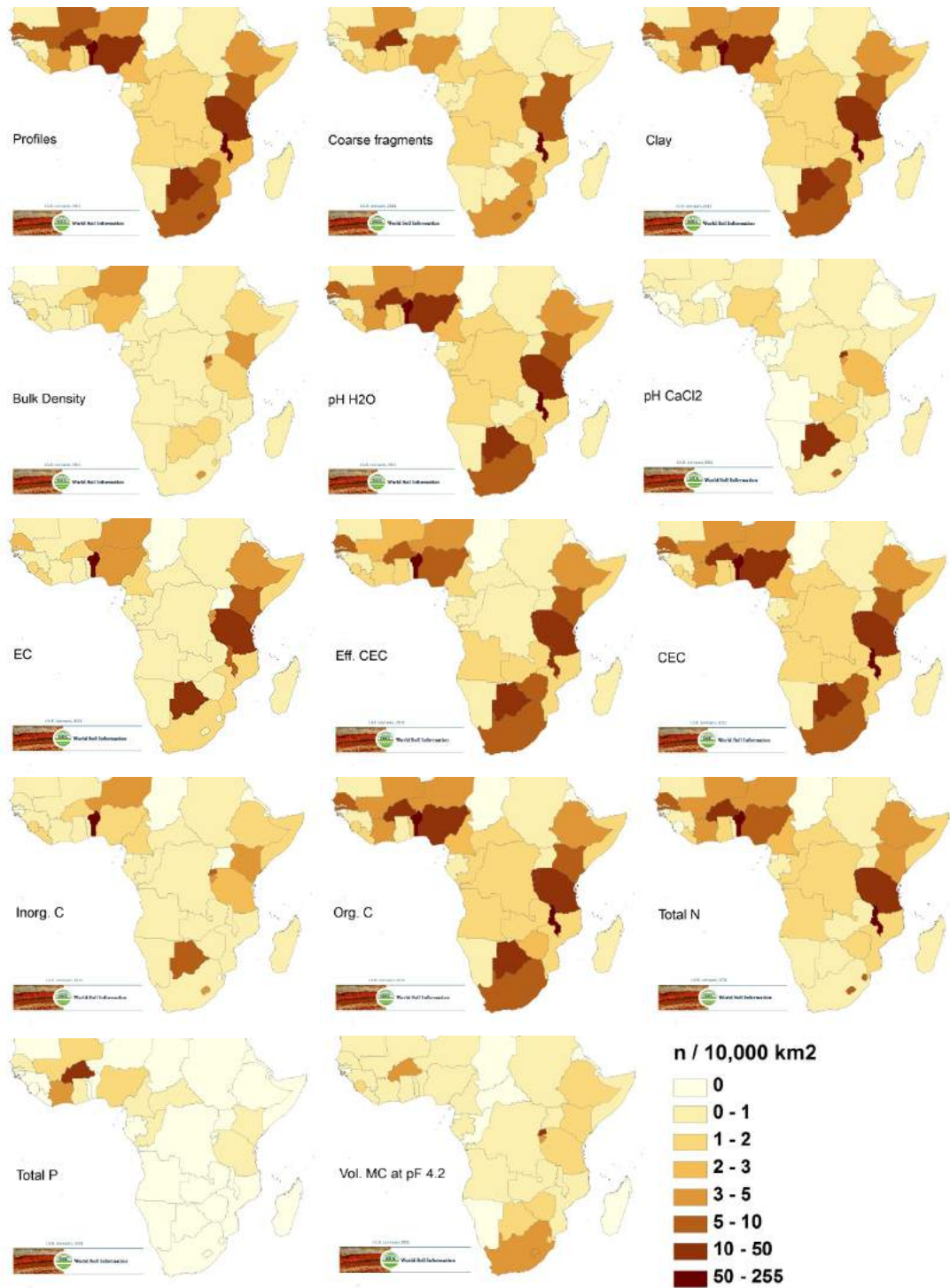
### 3.1 Summary statistics

Annex 8 gives a full overview of summary statistics about the data compiled and standardised in database tables *Profiles* and *Layers*. The overview specifies, for the whole of Sub Sahara Africa as well as by country, the number of profiles and layers and the number of value entries per attribute, together with the associated minimum and maximum value, average value and standard deviation. Table 10 gives an extract from this annex.

Note that the statistics in Annex 8 were assessed before exclusion of, later identified, 11 duplicated profiles. The associated number of profiles was 12,585 instead of 12,574 and of layers 50,163 instead of 50,150.

The summary statistics reveal that two-thirds (66%) of the soil profiles are classified according to one or more of the various systems. Of the 10,206 soil profiles with soil analytical data 77% is classified. The percentage classified according to WRB, WRB reference group, FAO88, FAO74, USDA or CPCS is 22, 48, 61, 36, 14, 2%, respectively (i.e., for some profiles, different classifications systems have been used).

The data completeness or data density varies from country to country and from attribute to attribute. This is illustrated in Figure 12 for selected key attributes as the number of value entries per country area (n / 10,000 km<sup>2</sup>).



**Figure 12**

Density per country (n/10,000 km<sup>2</sup>) of geo-referenced soil profiles, with values for coarse fragments, clay content, bulk density, pH H<sub>2</sub>O, pH CaCl<sub>2</sub>, EC, effective CEC, CEC, inorganic carbon, organic carbon, total N, total P, and volumetric moisture content at pF 4.2.

The data density per country varies from nearly 0.1 to nearly 100 per 10,000 km<sup>2</sup>, with a relatively high density of over 250 per 10,000 km<sup>2</sup> for Malawi. The data completeness, relative to profile density, is very low over the entire area for especially bulk density, pH CaCl<sub>2</sub>, inorganic carbon, total P and volumetric moisture content.

**Table 10**

*Descriptive statistics for soil layer key-attributes, according to GlobalSoilMap specifications, per AFSIS pilot country and for all data for Africa.*

	Africa	Kenya	Mali	Malawi	Nigeria	Tanzania
<b>Lower depth layer (lowDpth)</b>						
Profiles, n	12585	423	626	2990	1141	1303
Layers, n	50163	1947	1965	10322	5420	5201
Min.	0	1	1	2	0	2
Max..	2000	750	500	1220	1120	405
Average	73	76	60	65	85	72
St. Dev.	59	61	47	48	66	54
<b>Coarse fragments content (CfPc)</b>						
Profiles, n	7465	322	401	2976	417	611
Layers, n	28470	1272	1277	10262	2011	2648
Min.	0	0	0	0	0	0
Max.	100	90	95	95	95	95
Average	8	6	6	7	15	8
St. Dev.	19	16	17	17	22	20
<b>Sand</b>						
Profiles, n	9941	416	602	811	1120	1181
Layers, n	37865	1788	1852	2335	5034	4348
Min.	0	1	2	18	0	0
Max.	100	98	99	96	100	98
Average	54	40	47	66	58	51
St. Dev.	25	24	21	17	24	25
<b>Clay</b>						
Profiles, n	9941	416	602	811	1120	1181
Layers, n	37864	1787	1852	2335	5034	4348
Min.	0	0	1	1	0	0
Max.	97	96	80	75	88	97
Average	30	41	28	27	25	33
St. Dev.	20	22	17	15	19	20
<b>Bulk Density (BlkDens)</b>						
Profiles, n	1781	274	17	10	260	115
Layers, n	6736	1057	68	69	1075	414
Min.	0.16	0.16	0.54	1.27	0.73	0.42
Max.	2.67	2.08	2.04	1.93	2.03	1.80
Average	1.39	1.32	1.55	1.53	1.31	1.29
St. Dev.	0.24	0.20	0.23	0.15	0.19	0.22
<b>pH water (PHH2O)</b>						
Profiles, n	9555	417	558	851	975	1184
Layers, n	36244	1803	1613	2468	4596	4172
Min.	2.4	3.6	4.1	4.0	3.6	2.5
Max.	11.0	11.0	10.5	10.5	10.1	10.8
Average	6.3	6.4	6.1	6.0	6.1	6.4
St. Dev.	1.2	1.3	1.1	0.8	1.1	1.2

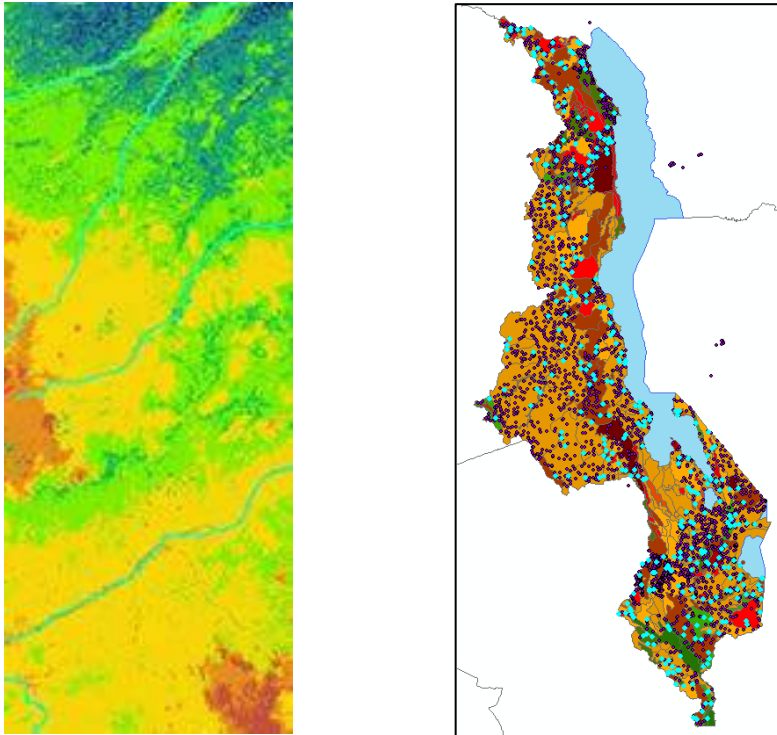
	Africa	Kenya	Mali	Malawi	Nigeria	Tanzania
<b>Electrical conductivity (EC)</b>						
Profiles, n	5204	375	66	89	407	1016
Layers, n	18771	1579	276	226	1804	3567
Min.	0.0	0.0	0.0	0.0	0.0	0.0
Max.	776.0	105.0	4.6	185.0	10.0	62.4
Average	1.1	0.7	0.1	7.8	0.2	0.8
St. Dev.	14.5	5.3	0.3	28.8	0.4	2.9
<b>Effective Cation Exchange capacity (Ecec)</b>						
Profiles, n	7681	370	352	405	615	1229
Layers, n	26932	1580	904	1200	2238	4273
Min.	0.0	0.1	0.4	1.0	0.0	0.1
Max.	206.1	206.1	72.1	27.1	60.0	173.1
Average	13.9	18.5	8.2	5.9	11.9	16.2
St. Dev.	17.4	20.4	9.2	3.6	13.2	18.4
<b>Organic carbon (OrgC)</b>						
Profiles, n	9713	408	537	843	1074	1269
Layers, n	32611	1633	1566	2056	3712	4209
Min.	0.0	0.2	0.0	0.3	0.0	0.0
Max.	570.0	363.0	48.5	48.8	111.0	136.0
Average	8.6	11.4	4.1	8.2	6.2	9.4
St. Dev.	15.6	20.4	4.2	7.2	7.3	10.1
<b>Volumetric moisture content at pF 2.5 (VMCpF25)</b>						
Profiles, n	1572	51	69	10	51	49
Layers, n	5279	180	143	68	170	149
Min.	1.0	4.0	1.1	7.9	4.5	4.8
Max.	98.0	52.1	59.8	44.0	98.0	61.7
Average	22.9	30.1	23.2	20.7	34.6	30.6
St. Dev.	15.1	10.6	13.0	5.8	20.8	13.0
<b>Volumetric moisture content at pF 4.2 (VMCpF42)</b>						
Profiles, n	1723	74	83	10	62	97
Layers, n	5878	243	193	75	201	348
Min.	0.0	0.3	0.5	2.7	1.1	0.5
Max.	83.3	46.5	32.0	21.7	66.4	58.0
Average	14.9	17.8	10.7	13.5	21.0	20.9
St. Dev.	10.7	8.8	7.6	4.6	13.5	10.5

## 3.2 Data use cases

The AfSIS project website refers to the work underway to produce the first generation of digital soil maps to a common global standard based on the 1<sup>st</sup> version of the Africa Soil Profiles Database and spatial covariate layers. Subsequent versions of the digital soil maps will incorporate the data from subsequent versions of the database.

Intermediate milestone versions (0.x) of the Africa Soil Profiles Database have been shared with the AfSIS project and have been used as input to studies and research about soils and soil mapping in Africa. Hengl (in prep.) used version 0.1 of the Africa Soil Profiles Database to test soil property mapping procedures to prepare for production mapping at a later stage, and will use version 1.0 to produce a full set of soil property maps for Malawi, according to GlobalSoilMap specifications. Odeh and Reuter (in prep.) produced soil property maps of Nigeria, according to GlobalSoilMap specifications, using version 0.2 of the Africa Soil Profiles database. Figure 13a illustrates predicted values for pH H<sub>2</sub>O in a 1: 5 solution for a here (purposely)

unspecified depth interval in a here unspecified part of Nigeria. Dijkshoorn (in prep.) used version 0.3 of the Africa Soil Profiles Database in building a Soil and Terrain database (SOTER) for Malawi (see Figure 13b); selected profiles, classified according to WRB2006, were identified as being representative for the distinguished soil components.

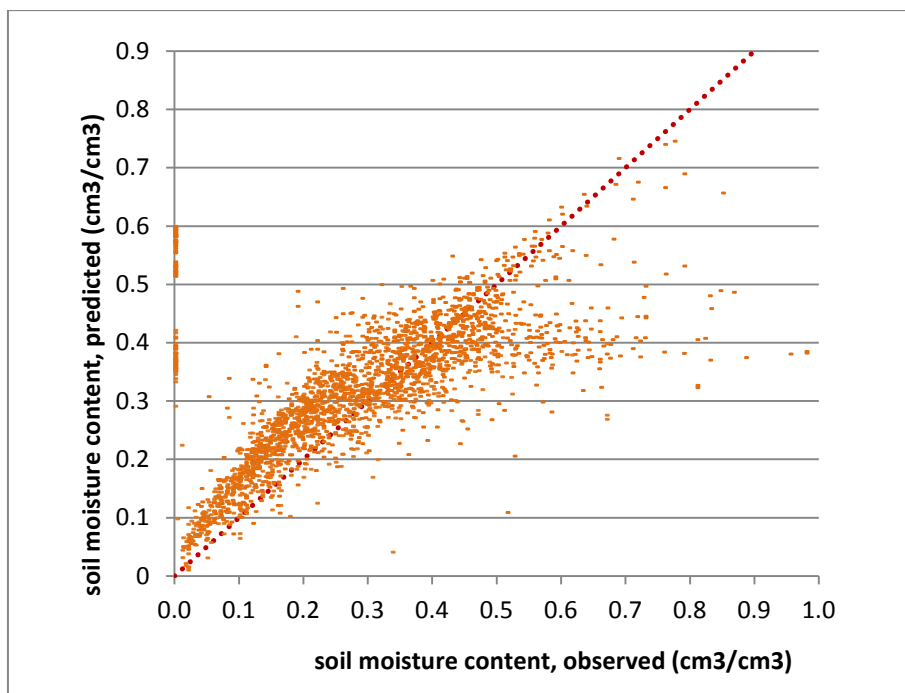


**Figure 13**

*Two soil maps produced with soil data from the Africa Soil Profiles database. 13a (left). Extract from a soil pH map of Nigeria. 13b (right). Soil and terrain (SOTER) database of Malawi, with representative soil profiles as blue dots.*

In line with Wösten et al. (1998) who used existing soil data to derive soil hydraulic properties for European soils, Wösten et al. (in prep.) used version 0.3 of the Africa Soil Profiles Database to parameterise and validate pedotransfer functions (continuous Van Genuchten equations) for predicting soil moisture contents at varying tensions. Figure 14 illustrates the predicted versus observed values for volumetric soil moisture content. The results were used as input to underpin the hydrological modelling of a catchment in an African environment.





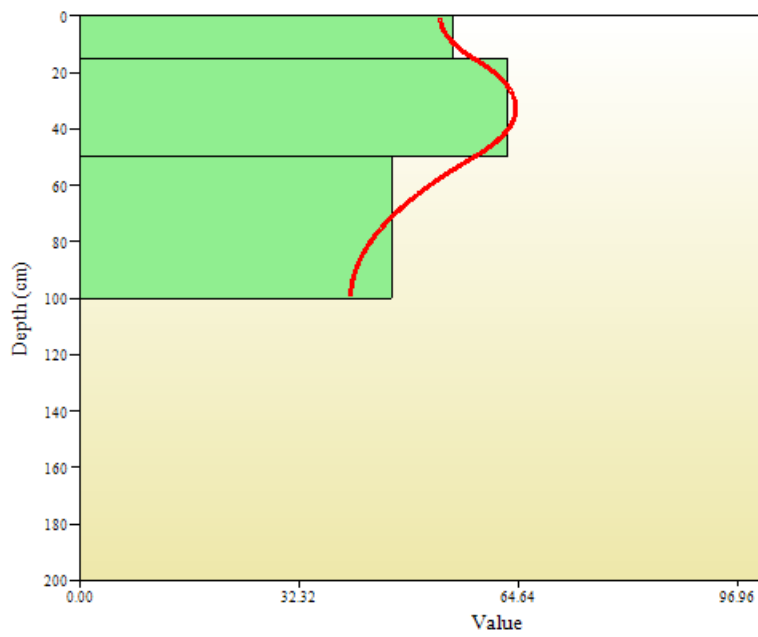
**Figure 14**

*Validation of continuous pedotransfer functions of Hodnett & Tomasella (2002) using soil data from the Africa Soil Profiles Database (Wösten et al., in prep.).*

The average organic carbon value, per layer, is 8.6 g/kg. Taking the relative weight of the layer depth intervals into account, relative to the average layer depth interval of 30 cm, the average organic carbon value is 6.9 g/kg. Combined with an average bulk density of 1.39 kg/dm<sup>3</sup>, an average coarse fragments content of 8 volume %, and an average (observed) soil depth of 125 cm, the average soil organic carbon profile represents approximately 110,000 kg/ha. Herewith is the total organic carbon content stored in the Sub-Saharan African soil (of  $18 \times 10^6$  km<sup>2</sup>) indicatively estimated as  $2 \times 10^{11}$  ton or 200 Pg. This indicative estimate is without consideration of the relative weight of the different soil profiles. More precise estimations require the soil profile data to be linked to the mapping units of an existing continent-wide soil area-class map or require the soil profile data to be input to continent-wide soil property mapping.

The total of 200 Pg is likely an overestimate because of the bias in the sampling, by profile, towards topsoil layers and, by country, towards relatively productive areas. A range of 50-75% or 100-150 Pg seems reasonably well in the range of, for the whole of Africa, 133-184 Pg as reported by Henry (2010) and of 170-180 Pg as reported by Batjes (2008b, 2003).

It is feasible to produce soil property maps of the whole of Sub-Saharan Africa, according to GlobalSoilMap specifications at reduced spatial resolution, based on soil data derived from the Africa Soil Profiles Database. To test this feasibility, layer attribute values are submitted to spline fitting functionality (Jacquier and Seaton, 2010), visualised in Figure 15, and the associated profile locations are related to covariate grids for building DSM prediction models, which will be applied to produce the maps.



**Figure 15**  
*Visualisation of spline fitted over depth (red line) to original clay values (green bars) of a 1 m deep soil profile.*

## 4 Discussion and conclusions

Version 1.0 of the Africa Soil Profiles Database contains standardised soil profile data for over 12,000 georeferenced soil profiles for 37 Sub Saharan African countries. The data were collected from over 300 data sources, both analogue and digital, and were converted to a common standard, and parsed through routine quality control rules and cleaning. Previously, the unstandardised data would only be accessible through a myriad of sources, and would therefore not be shareable and usable.

The compilation of legacy soil profile data is a labour- and knowledge-intensive process. There is no obvious way to automate the process of legacy soil data collation. Substantial manual effort remains necessary to overcome the endless variety of format layouts and to combine the data with metadata and coordinates. Scripting of rules for automated, and even semi-automated, processing of the various data sources, step by step, proves far less efficient and effective compared to manual efforts, which is confirmed by the conclusions of a dedicated feasibility study (Parker, in prep.). Crowd sourcing, also based on manual efforts, could be a way to collect large numbers of legacy soil data of defined quality, but consistent procedures are yet to be developed and tested.

Additional manual capacity is reflected directly in additional data collated. At present, the probably most effective and cost-efficient way to increase capacity might be to actively involve the data holders as these may also have access to the auxiliary information necessary to generate complete profile records, including geographic coordinates and the specification of laboratory methods.

Despite the costliness of manual capacity required, the compilation of legacy soil profile data is seen as a relatively cost-efficient approach to generate sufficient data, or evidence, to underpin continental or national soil property mapping, compared to the collection of new soil data.

The nature of soils, with its heterogeneity of possible attribute values, combined with the nature of legacy soil data, with its incompleteness and heterogeneity in methods used to assess attribute values combined with the lack of conversion rules to harmonise these values, inhibit the establishment of sensible criteria for proper full control of within-pedon soil data consistency and quality. Routine quality control of one-dimensional and simple multi-dimensional attribute values is well possible, though criteria for inclusion and exclusion are subjective by definition.

Despite repeated rigorous screening of the data, by means of visual checks and computer aided quality and integrity checks, the inclusion of data that are possibly inconsistent or erroneous cannot be avoided. Data gaps, of various natures, inevitably occur as well. Users should keep in mind the possible limitations of the data and reflect upon the appropriate level of scale, resolution or generalisation when analysing or applying the present dataset.

The accuracy of georeferencing of legacy soil profile point data is limited relative to that of new soil profile point data, as they are largely from the pre-GPS era. However, in principle, the accuracy of georeferencing of legacy soil profile data can be enhanced by using the associated mapping units, or polygons, as spatial domains of likelihood of profile location and such approaches should be tested and evaluated.

It is argued by some that the quality of legacy soil data is low by definition. This quality though is use dependent, and therewith resolution/scale dependent. The possible inaccuracy of some legacy soil data may well be very small relative to the on-ground variability within a covariate grid cell, making the legacy soil data fit for use.

The accuracy of legacy soil attribute-values is for certain, to be identified, attributes (as clay content, coarse fragments content, and others) as accurate as that of new soil data. The more time-stable the soil-attribute is, the more comparable the accuracy of the values, of legacy data and new data, likely is. Also, the impact of the variety of methods, associated with legacy soil data, on the variance of values is only small for certain, to be identified, attributes. It should be evaluated for which soil attributes the inherent accuracy of legacy data and new data is comparable.

Still, an accurate evidence-based final product at high resolution (Africa soil property maps) is most cost-efficiently and rapidly produced based on a combination of legacy soil data with new soil data. Accurate evidence-based soil property maps, at reduced resolution, are also attainable based on large quantities of spatially well distributed legacy soil data, of possibly limited inherent accuracy, while such is not attainable based on small quantities of spatially clustered new soil data, of possibly high or consistent inherent accuracy. Where legacy soil data are cost-efficient input for accurate mapping at reduced resolution, are accurately georeferenced new soil data expensive but necessary additional input for achieving high resolution. Herewith, legacy soil data and new soil data add value to each other.

# Acknowledgements

Acknowledgements are due to the Africa Soil Information Service (AfSIS) project, 1<sup>st</sup> phase, and to the Bill and Melinda Gates Foundation which has made the AfSIS project, and this study, possible. I specially thank Markus Walsh, daily project leader of the AfSIS project, for his confidence and continued positive and encouraging feedbacks.

Acknowledgements are also due to the entire ISRIC team, who contributed and assisted in numerous minor and major issues, including Niels Batjes, Prem Bindraban, Koos Dijkshoorn, Tom Hengl, Gerard Heuvelink, Bob MacMillan, Hannes I. Reuter and Otto Spaargaren. Special thanks are due to Alfred Hartemink for his vision to initiate this work, to Ger Naber for lifting and keeping the ISRIC library services up to standard, to Ad van Oostrum for his highly appreciated significant contributions to the actual, hard, work and for his soil analytical knowledge and to Piet Tempel for the most relevant advice in the entire trajectory, which is to keep in mind that most value is added to the legacy data by conversion from analogue to digital and that it is not the tool but the effort that will prove effective in doing the job.

Inakwu Odeh (Sydney University), Simone Verzandvoort and Henk Wösten (Wageningen University, Netherlands) are acknowledged for adding value to the data.

Last but certainly not least are the organisations and individuals who contributed to the inventory and collection of data sources and who shared digital datasets, in any format, including Todd Benson (IFPRI), Ashenafi Ali (EARO-NSRC, Ethiopia), Moro Buri (CSIR, Ghana), Joseph Mbogoni (NSS, Mlingano, Tanzania), Mamadou Doumbia and Jean-Paul Bitchibally (IER, Mali), Ishaku Amapu and Emmanuel Iwuafor (AB university, Nigeria). The digital datasets, recently shared by Philippe Lagacherie (IRD, France) and Christian Nolte (FAO, Italy) and agreed to be shared by Inakwu Odeh (Sydney University, Australia), are much appreciated and are collated into the next version of the Africa Soil Profiles Database, as are future contributions wherefore thanks are due on forehand.



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Unknown, -9999. INIA-DTA/Com64/Levantamento de Solos da Bolsa de Chilembene. SrcID = MZ05. Count = 2

Unknown, -9999. INIA-DTA/Com68/Invest.Solos de Acucareira de Mafambisse, Sofala. SrcID = MZ07. Count = 2

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Unknown, -9999. IRD. SrcID = SN\_IR65. Count = 6

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## Annex 2 Attribute codes (left column) with associated ‘parallel’ table column headings

Attribute	Associated table column headings									
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GeolIncl	aGeolIncl	-	-	GeolIncl	-	-	-	-		
LabIncl	aLabIncl	-	-	LabIncl	-	-	-	-		
SrcDb1ID	aSrcDb1ID	-	-	SrcDb1ID	-	-	-	-		
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Isis	asis	-	-	Isis	-	-	-	-		
Ncss	aNcss	-	-	Ncss	-	-	-	-		
Wasp	aWasp	-	-	Wasp	-	-	-	-		
Soters	aSoters	-	-	Soters	-	-	-	-		
Wise3	aWise3	-	-	Wise3	-	-	-	-		
Afprof	aAfprof	-	-	Afprof	-	-	-	-		
FaoSdb	aFaoSdb	-	-	FaoSdb	-	-	-	-		
SoterExt	aSoterExt	-	-	SoterExt	-	-	-	-		
Lrep	aLrep	-	-	Lrep	-	-	-	-		
Stipa	aStipa	-	-	Stipa	-	-	-	-		
Valsol	aValsol	-	-	Valsol	-	-	-	-		
Pedi	aPedi	-	-	Pedi	-	-	-	-		
Minagri	aMinagri	-	-	Minagri	-	-	-	-		
PrUhl	aPrUhl	-	-	PrUhl	-	-	-	-		

Associated table column headings									
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PridInRep1		aPridInRep	-	-	PridInRep1	-	-	-	-
PridInRep2		aPridInR_1	-	-	PridInRep2	-	-	-	-
PageInRep		aPageInRep	-	-	PageInRep	-	-	-	-
MapID		aMapID	-	-	MapID	-	-	-	-
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MapUnitID		aMapUnitID	-	-	MapUnitID	-	-	-	-
TerrainMU		aTerrainMU	-	-	-	oTerrainMU	-	-	-
TerrCmpMU		aTerrCmpMU	-	-	-	oTerrCmpMU	-	-	-
SoilCmpMU		aSoilCmpMU	-	-	-	oSoilCmpMU	-	-	-
PntOrMapU		aPntOrMapU	-	-	PntOrMapU	-	-	-	-
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Northing		aNorthing	-	-	-	oNorthing	-	-	-
EW		aEW	-	-	-	oEW	-	-	-
LonD		aLonD	uLonD	-	-	oLonD	-	-	-
LonM		aLonM	uLonM	-	-	oLonM	-	-	-
LonS		aLonS	uLonS	-	-	oLonS	-	-	-
NS		aNS	-	-	-	oNS	-	-	-
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LatM		aLatM	uLatM	-	-	oLatM	-	-	-
LatS		aLatS	uLatS	-	-	oLatS	-	-	-
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Attribute	Associated table column headings							
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T_Year	aT_Year	uT_Year	-	T_Year	oT_Year	-	-	-
ObsDpth	aObsDpth	uObsDpth	mObsDpth	ObsDpth	-	-	-	-
RootDpth	aRootDpth	uRootDpth	mRootDpth	RootDpth	-	-	-	-
RtblDpth	aRtblDpth	-	mRtblDpth	RtblDpth	-	-	-	-
RockDpth	aRockDpth	-	mRockDpth	RockDpth	-	-	-	-
Observer	aObserver	-	-	Observer	-	-	-	-
WRB06	aWRB06	-	mWRB	WRB06	oWRB06	-	-	-
WRB06rg	aWRB06rg	-	-	WRB06rg	oWRB06rg	-	-	-
FA088	aFA088	-	mFAO	FA088	oFA088	-	-	-
FA074	aFA074	-	-	FA074	oFA074	-	-	-
USDA	aUSDA	-	mUSDA	USDA	oUSDA	-	-	-
CPCS	aCPCS	-	mCPCS	CPCS	oCPCS	-	-	-
LocalCIs	aLocalCIs	-	mLocalCIs	LocalCIs	oLocalCIs	-	-	-
Location	aLocation	-	-	Location	-	-	-	-
Z_Alti	aZ_Alti	uZ_Alti	mZ_Alti	Z_Alti	-	-	-	-
Slope	aSlope	uSlope	-	Slope	oSlope	-	-	-
Topogrophy	aTopogrophy	-	-	Topogrophy	oTopogrophy	-	-	-
LndForm	aLndForm	-	-	LndForm	oLndForm	-	-	-
LndElem	aLndElem	-	-	LndElem	oLndElem	-	-	-
SlpForm	aSlpForm	-	-	SlpForm	oSlpForm	-	-	-
SlpPosit	aSlpPosit	-	-	SlpPosit	oSlpPosit	-	-	-
FrqFlood	aFrqFlood	uFrqFlood	-	FrqFlood	oFrqFlood	-	-	-
ParMat	aParMat	-	-	ParMat	oParMat	-	-	-
ParMat2	aParMat2	-	-	-	oParMat2	-	-	-
Litholo	aLitholo	-	-	Litholo	-	-	-	-
Regolith	aRegolith	-	-	Regolith	-	-	-	-
LndCov	aLndCov	-	-	LndCov	oLndCov	-	-	-
LndCov2	aLndCov2	-	-	-	oLndCov2	-	-	-
LndUse	aLndUse	-	-	LndUse	oLndUse	-	-	-
Drain	aDrain	-	-	Drain	oDrain	-	-	-

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SrfSalt	aSrfSalt	-	-	SrfSalt	oSrfSalt	-	-	-	-
Remarks	aRemarks	-	-	-	oRemarks	-	-	-	-
LyrObj	aLyrObj	-	-	-	-	LyrObj	oLyrObj	-	-
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LayerNr	aLayerNr	-	-	-	-	LayerNr	oLayerNr	-	-
UpDpth	aUpDpth	uUpDpth	mUpDpth	-	-	UpDpth	oUpDpth	-	-
LowDpth	aLowDpth	uLowDpth	mLowDpth	-	-	LowDpth	oLowDpth	-	-
UpHor	aUpHor	uUpHor	-	-	-	-	oUpHor	-	-
LowHor	aLowHor	uLowHor	-	-	-	-	oLowHor	-	-
UpSampl	aUpSampl	uUpSampl	-	-	-	-	oUpSampl	-	-
LowSampl	aLowSampl	uLowSampl	-	-	-	-	oLowSampl	-	-
Sampls	aSampls	-	-	-	-	Sampls	-	-	-
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SamplAvai	aSamplAvai	-	-	-	-	SamplAvai	-	-	-
HorDes	aHorDes	-	mHorDes	-	-	HorDes	oHorDes	-	-
DiagnHor	aDiagnHor	-	mDiagn	-	-	-	oDiagnHor	-	-
DiagnPrp	aDiagnPrp	-	-	-	-	-	oDiagnPrp	-	-
DiagnMat	aDiagnMat	-	-	-	-	-	oDiagnMat	-	-
Transitn	aTransitn	-	-	-	-	-	oTransitn	-	-
ColorM	aColorM	-	-	-	-	ColorM	oColorM	-	-
ColorD	aColorD	-	-	-	-	ColorD	oColorD	-	-
Mottling	aMottling	-	-	-	-	Mottling	oMottling	-	-
StrGrade	aStrGrade	-	-	-	-	StrGrade	oStrGrade	-	-
StrSize	aStrSize	-	-	-	-	StrSize	oStrSize	-	-
StrType	aStrType	-	-	-	-	StrType	oStrType	-	-
Sticknss	aSticknss	-	-	-	-	Sticknss	oSticknss	-	-
SaltAlkl	aSaltAlkl	-	-	-	-	SaltAlkl	oSaltAlkl	-	-
Roots	aRoots	-	-	-	-	Roots	oRoots	-	-
FidTxtr	aFidTxtr	-	-	-	-	FidTxtr	oFidTxtr	-	-
CfNature	aCfNature	-	-	-	-	-	oCfNature	-	-

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CfPc		aCfPc	uCfPc	mCfPc	-	-	CfPc	oCfPc	-
CfLabPc		aCfLabPc	uCfLabPc	mCfLabPc	-	-	CfLabPc	oCfLabPc	-
Csand		aCsand	uCsand	mCsand	-	-	-	oCsand	-
Msand		aMsand	uMsand	-	-	-	-	oMsand	-
Fsand		aFsand	uFsand	mFsand	-	-	-	of sand	-
Csilt		aCsilt	uCsilt	mCsilt	-	-	-	oCsilt	-
Fsilt		aFsilt	uFsilt	mFsilt	-	-	-	of silt	-
Humidity		aHumidity	uHumidity	-	-	-	-	oHumidity	-
Sand		aSand	uSand	mSand	-	-	Sand	oSand	-
Silt		aSilt	uSilt	mSilt	-	-	Silt	oSilt	-
Clay		aClay	uClay	mClay	-	-	Clay	oClay	-
SumTxtr		aSumTxtr	uSumTxtr	mSumTxtr	-	-	SumTxtr	oSumTxtr	-
BlkDens		aBlkDens	uBlkDens	mBlkDens	-	-	BlkDens	oBlkDens	-
Ksat		aKsat	uKsat	mKsat	-	-	Ksat	oKsat	-
InfiltrR		aInfiltrR	uInfiltrR	mInfiltrR	-	-	-	oInfiltrR	-
PHH2O		aPHH2O	-	mPHH2O	-	-	PHH2O	oPHH2O	-
PH2H2O		aPH2H2O	-	mPH2H2O	-	-	-	oPH2H2O	-
PHKCl		aPHKCl	-	mPHKCl	-	-	PHKCl	oPHKCl	-
PHCaCl2		aPHCaCl2	-	mPHCaCl2	-	-	PHCaCl2	oPHCaCl2	-
PHX		aPHNaF	-	mPHx	-	-	-	oPHX	-
EC		aEC	uEC	mEC	-	-	EC	oEC	-
EC2		aEC2	uEC2	mEC2	-	-	EC2	oEC2	-
SibCat		aSibCat	uSibCat	mSibCat	-	-	SibCat	oSibCat	-
SibAn		aSibAn	uSibAn	mSibAn	-	-	SibAn	oSibAn	-
SibCa		aSibCa	uSibCa	-	-	-	-	oSibCa	-
SibMg		aSibMg	uSibMg	-	-	-	-	oSibMg	-
SibNa		aSibNa	uSibNa	-	-	-	-	oSibNa	-
SibK		aSibK	uSibK	-	-	-	-	oSibK	-
SibCO3		aSibCO3	uSibCO3	-	-	-	-	oSibCO3	-
SibHCO3		aSibHCO3	uSibHCO3	-	-	-	-	oSibHCO3	-

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SlibNO3	aSlibNO3	uSlibNO3	-	-	-	-	oSlibNO3	-	
SlibF	aSlibF	uSlibF	-	-	-	-	oSlibF	-	
ExCaMg	aExCaMg	uExCaMg	mExCaMg	-	-	-	oExCaMg	-	
ExCa	aExCa	uExCa	mExCa	-	-	ExCa	oExCa	-	
ExMg	aExMg	uExMg	mExMg	-	-	ExMg	oExMg	-	
ExNa	aExNa	uExNa	mExNa	-	-	ExNa	oExNa	-	
ExK	aExK	uExK	mExK	-	-	ExK	oExK	-	
ExBases	aExBases	uExBases	mExBases	-	-	ExBases	oExBases	-	
ExH	aExH	uExH	mExH	-	-	ExH	oExH	-	
ExAl	aExAl	uExAl	mExAl	-	-	ExAl	oExAl	-	
ExAcid	aExAcid	uExAcid	mExAcid	-	-	ExAcid	oExAcid	-	
Ecec	aEcec	uEcec	mEcec	-	-	Ecec	oEcec	-	
CecSoil	aCecSoil	uCecSoil	mCecSoil	-	-	CecSoil	oCecSoil	-	
CecSoil2	aCecSoil2	uCecSoil2	mCecSoil2	-	-	CecSoil2	oCecSoil2	-	
CecMin	aCecMin	uCecMin	-	-	-	-	oCecMin	-	
CecMax	aCecMax	uCecMax	-	-	-	-	oCecMax	-	
Bsat	aBsat	uBsat	mBSat	-	-	Bsat	oBSat	-	
Bsat2	aBsat2	uBsat2	mBSat2	-	-	Bsat2	oBSat2	-	
CaSO4	aCaSO4	uCaSO4	mCaSO4	-	-	CaSO4	oCaSO4	-	
CaCO3	aCaCO3	uCaCO3	mCaCO3	-	-	CaCO3	oCaCO3	-	
InOrgC	aInOrgC	uInOrgC	mInOrgC	-	-	InOrgC	oInOrgC	-	
TotC	aTotC	uTotC	mTotC	-	-	TotC	oTotC	-	
OrgC	aOrgC	uOrgC	mOrgC	-	-	OrgC	oOrgC	-	
TotalN	aTotalN	uTotalN	mTotalN	-	-	TotalN	oTotalN	-	
CN	aCN	-	mCN	-	-	CN	oCN	-	
TotalP	aTotalP	uTotalP	mTotalP	-	-	TotalP	oTotalP	-	
AvailP	aAvailP	uAvailP	mAvailP	-	-	-	oAvailP	-	
AvailP2	aAvailP2	uAvailP2	mAvailP2	-	-	-	oAvailP2	-	
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Poros	aPoros	uPoros	mPoros	-	-	-	oPoros	-	

Attribute	Associated table column headings									
AttrCode	Attr_123	AttrUnits	AttrMethods	Profiles	OrfProfiles	Layers	OrilLayers	GeoPoints		
VMCpF00	aVMCpF00	uVMCpF00	mVMCpF00	-	-	VMCpF00	oVMCpF00	-		
VMCpF05	aVMCpF05	uVMCpF05	mVMCpF05	-	-	VMCpF05	oVMCpF05	-		
VMCpF10	aVMCpF10	uVMCpF10	mVMCpF10	-	-	VMCpF10	oVMCpF10	-		
VMCpF15	aVMCpF15	uVMCpF15	mVMCpF15	-	-	VMCpF15	oVMCpF15	-		
VMCpF17	aVMCpF17	uVMCpF17	mVMCpF17	-	-	VMCpF17	oVMCpF17	-		
VMCpF18	aVMCpF18	uVMCpF18	mVMCpF18	-	-	VMCpF18	oVMCpF18	-		
VMCpF20	aVMCpF20	uVMCpF20	mVMCpF20	-	-	VMCpF20	oVMCpF20	-		
VMCpF22	aVMCpF22	uVMCpF22	mVMCpF22	-	-	VMCpF22	oVMCpF22	-		
VMCpF23	aVMCpF23	uVMCpF23	mVMCpF23	-	-	VMCpF23	oVMCpF23	-		
VMCpF24	aVMCpF24	uVMCpF24	mVMCpF24	-	-	VMCpF24	oVMCpF24	-		
VMCpF25	aVMCpF25	uVMCpF25	mVMCpF25	-	-	VMCpF25	oVMCpF25	-		
VMCpF27	aVMCpF27	uVMCpF27	mVMCpF27	-	-	VMCpF27	oVMCpF27	-		
VMCpF28	aVMCpF28	uVMCpF28	mVMCpF28	-	-	VMCpF28	oVMCpF28	-		
VMCpF29	aVMCpF29	uVMCpF29	mVMCpF29	-	-	VMCpF29	oVMCpF29	-		
VMCpF30	aVMCpF30	uVMCpF30	mVMCpF30	-	-	VMCpF30	oVMCpF30	-		
VMCpF33	aVMCpF33	uVMCpF33	mVMCpF33	-	-	VMCpF33	oVMCpF33	-		
VMCpF34	aVMCpF34	uVMCpF34	mVMCpF34	-	-	VMCpF34	oVMCpF34	-		
VMCpF35	aVMCpF35	uVMCpF35	mVMCpF35	-	-	VMCpF35	oVMCpF35	-		
VMCpF36	aVMCpF36	uVMCpF36	mVMCpF36	-	-	VMCpF36	oVMCpF36	-		
VMCpF37	aVMCpF37	uVMCpF37	mVMCpF37	-	-	VMCpF37	oVMCpF37	-		
VMCpF40	aVMCpF40	uVMCpF40	mVMCpF40	-	-	VMCpF40	oVMCpF40	-		
VMCpF42	aVMCpF42	uVMCpF42	mVMCpF42	-	-	VMCpF42	oVMCpF42	-		
VMCpF50	aVMCpF50	uVMCpF50	mVMCpF50	-	-	VMCpF50	oVMCpF50	-		
VMCpF58	aVMCpF58	uVMCpF58	mVMCpF58	-	-	VMCpF58	oVMCpF58	-		
VolAWC	aVolAWC	uVolAWC	mVolAWC	-	-	VolAWC	oVolAWC	-		
WghtAWC	aWghtAWC	uWghtAWC	mWghtAWC	-	-	-	oWghtAWC	-		
Extr1Fe	aExtr1Fe	uExtr1Fe	mExtr1Fe	-	-	-	oExtr1Fe	-		
Extr2Fe	aExtr2Fe	uExtr2Fe	mExtr2Fe	-	-	-	oExtr2Fe	-		
Extr3Fe	aExtr3Fe	uExtr3Fe	mExtr3Fe	-	-	-	oExtr3Fe	-		
ExtrTFe	aExtrTFe	uExtrTFe	mExtrTFe	-	-	-	oExtrTFe	-		
Extr1AI	aExtr1AI	uExtr1AI	mExtr1AI	-	-	-	oExtr1AI	-		
Extr2AI	aExtr2AI	uExtr2AI	mExtr2AI	-	-	-	oExtr2AI	-		

Associated table column headings									
Attribute	AttrCode	Attr_123	AttrUnits	AttrMethods	Profiles	OrfProfiles	Layers	OrlLayers	GeoPoints
Extr3AI		aExtr3AI	uExtr3AI	mExtr3AI	-	-	-	oExtr3AI	-
AvailK		aAvailK	uAvailK	mAvailK	-	-	-	oAvailK	-
TotalK		aTotalK	uTotalK	mTotalK	-	-	-	oTotalK	-
Fe		aFe	uFe	mMicroNutr	-	-	-	oFe	-
Mn		aMn	uMn	-	-	-	-	oMn	-
Zn		aZn	uZn	-	-	-	-	oZn	-
Cu		aCu	uCu	-	-	-	-	oCu	-
B		aB	uB	-	-	-	-	oB	-
S		aS	uS	-	-	-	-	oS	-
OrgMat		aOrgMat	uOrgMat	mOrgMat	-	-	-	oOrgMat	-
TotHumC		aTotHumC	uTotHumC	mTotHumC	-	-	-	oTotHumC	-
HumAcidC		aHumAcidC	uHumAcidC	mHumAcidC	-	-	-	oHumAcidC	-
FulAcidC		aFulAcidC	uFulAcidC	mFulAcidC	-	-	-	oFulAcidC	-
LabTxtr		aLabTxtr	-	mLabTxtr	-	-	LabTxtr	oLabTxtr	-
ClyMinera		aClyMinera	-	-	-	-	ClyMinera	-	-
FullDescr		aFullDescr	-	-	-	-	-	oFullDescr	-
FID		aFID	-	-	FID	-	-	-	-
Shape		aShape	-	-	Shape	-	-	-	-
PrPntObj		aPrPntObj	-	-	-	-	-	-	-
PrPntID		aPrPntID	-	-	-	-	-	-	-
LayerID00		aLayerID00	-	-	LayerID00	-	-	-	-
LayerID99		aLayerID99	-	-	LayerID99	-	-	-	-
oProfileID		-	-	-	-	-	-	-	-
oLayerID		-	-	-	-	-	-	-	-
mMethodKey		-	-	-	-	-	-	-	-
mMethodYN		-	-	-	-	-	-	-	-
uUnitKey		-	-	-	-	-	-	-	-
aAttr		-	-	-	-	-	-	-	-



## Annex 3a Dictionary of attributes codes

Attr Code	Attr Table	Attr Soil	Attr DType	Attr Unit	AttrDescrS (description short)	AttrDescrL (description long)	Standard
OID	Profiles	0	Num integer	-	In-table object ID	Identifier of the in-table object (row)	NA
PrObj	Profiles	0	Num integer	-	AFSP profile object ID	Identifier of the profile record or object	NA
ProfileID	Profiles	0	Text	-	AFSP profile ID	Identifier of the soil profile feature, composed of country code<->source code_original profile code	eSOTER2012
DbVersion	Profiles	0	Num integer	-	AFSP database version	Version number of the AFSP database wherein the profile identifier and data are added	NA
Revision	Profiles	0	Num double	-	AFSP database revision number	Version number of the AFSP database wherein profile data values were revised	NA
GeoIncl	Profiles	0	Num integer	-	AFSP boolean of inclusion of georeferencing data	Indicator (boolean) of whether profile is georeferenced in AFSP (1=yes,0=no)	NA
LabIncl	Profiles	0	Num integer	-	AFSP boolean of inclusion of laboratory layer data	Indicator (boolean) of whether profile has soil analytical layer data in AFSP (1=yes,0=no)	NA
SrcDb1ID	Profiles	0	Text	-	AFSP-ID of 1st source dataset	Identifier of the 1st digital source dataset	NA
SrcDb2ID	Profiles	0	Text	-	AFSP-ID of 2nd source dataset	Identifier of the 2nd digital source dataset	NA
Isis	Profiles	0	Text	-	Profile ID originally in ISIS	Profile ID originally in source dataset ISIS	NA
Ncss	Profiles	0	Text	-	Profile ID originally in NCSS	Profile ID originally in source dataset NCSS	NA
Wasp	Profiles	0	Text	-	Profile ID originally in WASP	Profile ID originally in source dataset WASP	NA
Soters	Profiles	0	Text	-	Profile ID originally in SOTER(S)	Profile ID originally in source datasets ISRIC SOTERs	NA
Wise3	Profiles	0	Text	-	Profile ID originally in WISE3	Profile ID originally in source dataset WISE3	NA
Afprof	Profiles	0	Text	-	Profile ID originally in AFPROF	Profile ID originally in source dataset AFPROF	NA
FaoSdb	Profiles	0	Text	-	Profile ID originally in FAOSDB	Profile ID originally in source dataset FAOSDB	NA
SoterExt	Profiles	0	Text	-	Profile ID originally in SOTEREXT	Profile ID originally in source datasets External SOTERs	NA
Lrep	Profiles	0	Text	-	Profile ID originally in LREP	Profile ID originally in source dataset LREP	NA
Stipa	Profiles	0	Text	-	Profile ID originally in STIPA	Profile ID originally in source dataset STIPA	NA
Valsol	Profiles	0	Text	-	Profile ID originally in VALSOL	Profile ID originally in source dataset VALSOL	NA
Pedi	Profiles	0	Text	-	Profile ID originally in PEDI	Profile ID originally in source dataset PEDI	NA
Minagri	Profiles	0	Text	-	Profile ID originally in MINAGRI	Profile ID originally in source dataset MINAGRI	NA

Attr Code	Attr Table	Attr Soil	Attr DType	Attr Unit	AttrDescrS (description short)	AttrDescrL (description long)	Standard
PrUrl	Profiles	0	Text	-	URL source to profile data	URL source link to online profile data	NA
SrcRep1ID	Profiles	0	Text	-	AFSP-ID of 1st source report	Identifier of the 1st report, book or publication that is source of the profile data. Where possible, the identifier is harmonised by using the unique ISRIC library identifier (ISN).	eSOTER2012
SrcRep2ID	Profiles	0	Text	-	AFSP-ID of 2nd source report	Identifier of the 2nd report, book or publication that is source of the profile data. Where possible, the identifier is harmonised by using the unique ISRIC library identifier (ISN).	NA
PridInRep1	Profiles	0	Text	-	Original Profile ID in 1st source report	Profile ID originally in 1st source report	NA
PridInRep2	Profiles	0	Text	-	Original Profile ID in 2nd source report	Profile ID originally in 2nd source report	NA
PageInRep	Profiles	0	Text	-	Page in report	Page in the document where the profile data can be found	eSOTER2012
MapID	Profiles	0	Text	-	Map identifier	Identifier of the map associated with the profile data.	eSOTER2012
MapScale	Profiles	0	Num integer	cm/cm	Map scale	Scale of the map (1 : xxxx cm/cm)	eSOTER2012
MapUnitID	Profiles	0	Text	-	Mapping unit	Legend entry of the mapping unit	NA
TerrainMU	OriProfiles	0	Text	-	Terrain mapping unit	Terrain mapping unit	NA
TerrCmpMU	OriProfiles	0	Text	-	Terrain mapping unit component	Terrain component within the given (terrain) mapping unit	NA
SoilCmpMU	OriProfiles	0	Text	-	Soil mapping unit component	Soil component within the given terrain component of the given (terrain) mapping unit	NA
PntOrMapU	Profiles	0	Text	-	Indicator for point or polygon	Indicator for whether the profile data are derived from soil point observations (P) or from soil mapping units (M)	NA
Syn	Profiles	0	Num integer	-	Indicator for synthetic profile	Indicator for whether the profile is synthetic (1) or true (0)	NA
FldMnl_ID	Profiles	0	Text	-	AFSP-ID of field manual	Identifier of the field manual or guidelines used for observing and describing the soil in the field.	NA
LabMnl_ID	Profiles	0	Text	-	AFSP-ID of laboratory manual	Identifier of the soil laboratory where the soil samples were analyzed, with -if available- the laboratory manual	eSOTER2012
MethdKey	Profiles	0	Text	-	AFSP-key to methods	Key from Inventory to AttrMethods (mMethKey) with collection of methods applied to assess feature-attribute-values	NA
UnitKey	Profiles	0	Text	-	AFSP-key to units of expression	Key from Inventory to AttrUnits (uUnitKey) with collection of units to express feature-attribute-values	NA
AttrKey	Profiles	0	Text	-	AFSP-key to attributes	Key from Inventory to Attrs (aAttr) with collection of attributes, including soil properties, observed or measured	NA
Reliab	Profiles	0	Text	-	Profile description status	Soil profile description status, referring to the inferred quality (incl. completeness) of the soil descriptive and analytical data, indicative for the reliability of the data. Classes are adapted from (FAO 2006).	eSOTER2012

Attr Code	Attr Table	Attr Soil	Attr DType	Attr Unit	AttrDescrS (description short)	AttrDescrL (description long)	Standard
Country	Profiles	0	Text	-	Country	Country where the profile is located.	eSOTER2012
Easting	OriProfiles	0	Text	-	Easting	(Projected) easting (e.g. in degrees or UTM meters)	NA
Northing	OriProfiles	0	Text	-	Northing	(Projected) northing (e.g. in degrees or UTM meters)	NA
EW	OriProfiles	0	Num integer	-	East or West	East or West (1 or -1)	NA
LonD	OriProfiles	0	Num double	deg	Longitude degrees	Longitude degrees	NA
LonM	OriProfiles	0	Num double	min	Longitude minutes	Longitude minutes	NA
LonS	OriProfiles	0	Num double	sec	Longitude seconds	Longitude seconds	NA
NS	OriProfiles	0	Num integer	-	North or South	North or South (1 or -1)	NA
LatD	OriProfiles	0	Num double	deg	Latitude degrees	Latitude degrees	NA
LatM	OriProfiles	0	Num double	min	Latitude minutes	Latitude minutes	NA
LatS	OriProfiles	0	Num double	sec	Latitude seconds	Latitude seconds	NA
ProjCS	OriProfiles	0	Text	-	Projected coordinate system	Geographic projection and coordinate system, datum	NA
X_LonDD	Profiles	0	Num double	DD	Longitude	Longitude in decimal degrees. Longitudes in the Eastern hemisphere are positive/ in the Western hemisphere negative.	NA
Y_LatDD	Profiles	0	Num double	DD	Latitude	Latitude in decimal degrees. Longitudes in the Northern hemisphere are positive/ in the Southern hemisphere negative.	NA
XYAccur	Profiles	0	Num double	DD	Profile location status, accuracy	Indicative accuracy of the profile location, expressed in decimal degrees	eSOTER2012
T_Year	Profiles	0	Num integer	yr	Year of observation or measurement	The year when the profile was described and sampled. If these activities were carried out on different dates, the date of sampling should be given/ format is YYYY	eSOTER2012
ObsDpth	Profiles	0	Num integer	cm	Observation depth	Depth of observation, which can be shallower or deeper than profile depth, expressed in cm	NA
RootDpth	Profiles	1	Num integer	cm	Rooted depth	Depth of presence of roots, more than very few and thicker than very fine, expressed in cm	NA
RtblDpth	Profiles	1	Text	-	Rootable depth	Estimated depth to which root growth is not restricted by any physical or chemical impediment, such as impenetrable or toxic layers, to be determined as effective soil depth using land evaluation. Strongly fractured rocks, such as shale, may be considere	eSOTER2012
RockDpth	Profiles	1	Text	-	Depth to bedrock	Depth to consolidated bedrock or iron pan in meters. For depths less than 2 m the depth is rounded to nearest 0.1 meter. When depth exceeds observation depth, deeper as e.g. 1.2 (>1.2) is applied. Expressed as text.	eSOTER2012
Observer	Profiles	0	Text	-	Observer	Name(s) of observer(s) of the profile, or author of the profile description	NA
WRB06	Profiles	0	Text	-	WRB soil reference group incl.	Soil feature classified according to the World Reference Base for Soil	eSOTER2012

Attr Code	Attr Table	Attr Soil	Attr DType	Attr Unit	AttrDescrS (description short)	AttrDescrL (description long)	Standard
WRB06g	Profiles	0	Text	-	WRB soil reference group code	Resources (IUSS 2007), preferably up to the lowest level (prefix and suffix) of the Reference Soil Group (RSG), as provided in the data source. The sequential order of the lower level Soil feature classified according to the World Reference Base for Soil Resources (IUSS 2007), at the highest level (reference group) and expressed as class code	NA
FA088	Profiles	0	Text	-	Soil class according to FAO 1988	Soil classified according to Revised Legend of the FAO-Unesco Soil Map of the World (FAO 1988, 1990), as provided in the data source, expressed as class code (major soil groupings and soil units)	eSOTER2012
FA074	Profiles	0	Text	-	Soil class according to FAO 1974	Soil classified according to the legend of the FAO-Unesco Soil Map of the World (FAO, 1974), as provided in the data source, expressed as class code (major soil groupings and soil units)	NA
USDA	Profiles	0	Text	-	Soil class according to USDA	Soil classified according to USDA Soil Taxonomy, as provided in the data source, expressed in full (not standardised)	eSOTER2012
CPCS	Profiles	0	Text	-	Soil class according to CPCS	Soil classified according to CPCS, as provided in the data source, expressed in full (not standardised)	NA
LocalCls	Profiles	0	Text	-	Soil class according to local classification	Soil classified or named according to the local or national system, as provided in the data source, including series and ethnic namings, expressed in full	eSOTER2012
Location	Profiles	0	Text	-	Descriptive profile location	Description of the profile location, expressed in free text	NA
Z_Alti	Profiles	1	Num integer	m	Altitude	Altitude of the profile above mean sea level. Assumes locations are accurate.	eSOTER2012
Slope	Profiles	1	Num integer	%	Slope gradient	Slope gradient (%) at the site	NA
TopogrpHy	Profiles	1	Text	-	Topography	Topography, interpreted from the dominant slope gradient (%) of the surroundings, expressed as class code	eSOTER2012
LndForm	Profiles	1	Text	-	Major landform	Landform class as defined by SOTER, described foremost by their morphology and not by their genetic origin, or processes responsible for their shape. The dominant slope is the most important differentiating criterion, followed by the relief intensity. At	eSOTER2012
LndElem	OrnProfiles	1	Text	-	Land element	Land element as part of major landform, comparable to terrain component of the SOTER unit, expressed in full -not standardised	NA
SlpForm	Profiles	1	Text	-	Slope form at site	Form of the slope at site, expressed as class code	NA
SlpPosit	Profiles	1	Text	-	Position on slope	Relative position of the feature on the slope, at the scale of the land element or terrain component, expressed as class code	eSOTER2012
FrgFlood	Profiles	1	Text	yr <sup>-1</sup>	Flooding frequency	Frequency of flooding, expressed as class code (yr <sup>-1</sup> )	NA

Attr Code	Attr Table	Attr Soil	Attr DType	Attr Unit	AttrDescrS (description short)	AttrDescrL (description long)	Standard
ParMat	Profiles	1	Text	-	Parent material on site	Lithologic parent material on site, expressed as class codes	eSOTER2012
ParMat2	OriProfiles	1	Text	-	Parent material on site, 2nd observation	Lithologic parent material on site, 2nd observation (from WASP)	NA
Litholo	Profiles	1	Text	-	Lithology in surroundings	Lithology associated to parent material (also known as General/Surface Lithology of TerrainComponent or dominant parent material of SoTerUnit in SOTER2002), expressed as class code	eSOTER2012
Regolith	Profiles	1	Text	-	Regolith	Regolith	NA
LndCov	Profiles	1	Text	-	Land cover	Land cover or (largely undisturbed) vegetation at the profile site at time of observation/sampling, expressed as class code	eSOTER2012
LndCov2	OriProfiles	1	Text	-	Land cover, 2nd observation	Land cover or (largely undisturbed) vegetation at the profile site, 2nd observation (from WASP)	NA
LndUse	Profiles	1	Text	-	Land use	Land use at the profile site at time of observation/sampling, expressed as class code	eSOTER2012
Drain	Profiles	1	Text	-	Drainage	Drainage of the profile, expressed as class codes	eSOTER2012
SrfDrain	Profiles	1	Text	-	Surface drainage	Surface drainage at the profile site, expressed as class codes	NA
SrfStone	Profiles	1	Text	%	Surface stoniness	Percentage cover of coarse fragments (>2 mm) incl. gravel, stones and boulders, that are completely or partly at the surface, expressed in class codes	eSOTER2012
SrfSalt	Profiles	1	Text	-	Surface salt or alkali	Notable presence of salt or alkali at the surface, expressed as text boolean (Y/N)	NA
Remarks	OriProfiles	0	Text	-	Remarks	Original remarks with the profile or profile site; including full profile descriptions	NA
LyrObj	Layers	0	Num integer	-	AFSP profile layer object ID	Identifier of the profile layer record or object	NA
LayerID	Layers	0	Text	-	AFSP profile layer ID	Identifier of the soil profile layer subfeature, composed of ProfileID_LayerNr	NA
LayerNr	Layers	0	Num integer	-	Layer number in profile	Consecutive, in profile, layer number is allocated to each distinguished profile layer, starting with 1 for the uppermost surface layer. A litter layer on top of the soil surface can be included with layer nr 0 (not according to FAO, 2006). Note that the	NA
UpDpth	Layers	0	Num integer	cm	Layer upper depth	Depth in cm of the upper (top) boundary of each distinguished layer. Note that all layers have positive depths measured from the top of the surface of the soil (upper depth = 0 cm), excluding a litter layer on top of the surface with negative upper depth	NA
LowDpth	Layers	0	Num integer	cm	Layer lower depth	Depth in cm of the lower (bottom) boundary of each distinguished layer. Note that all layers have positive depths measured from the top of the surface of the soil, excluding a litter layer on top of the surface with lower depth = 0 cm. Note	NA

Attr Code	Attr Table	Attr Soil	Attr DType	Attr Unit	AttrDescrS (description short)	AttrDescrL (description long)	Standard
UpHor	Orilayers	1	Num integer	cm	Horizon upper depth	that the posi Depth in cm of the upper (top) boundary of each horizon	eSOTER2012
LowHor	Orilayers	1	Num integer	cm	Horizon lower depth	Depth in cm of the lower (bottom) boundary of each horizon	eSOTER2012
UpSampl	Orilayers	0	Num integer	cm	Sample upper depth	Depth in cm of the upper (top) boundary of the sample	NA
LowSampl	Orilayers	0	Num integer	cm	Sample lower depth	Depth in cm of the lower (bottom) boundary of the sample	NA
SampIs	Layers	0	Num integer	-	Sample composition	Sample composition, specifying the amount of separate samples taken and mixed to create the considered (composite) sample	NA
Samp_ID	Layers	0	Text	-	Sample identifier	Identifier of the sample (in the field or laboratory) as provided in the data source	NA
SampAvai	Layers	0	Text	-	Sample availability	Availability in storage of the original physical sample, expressed as text boolean (Y/N)	NA
HorDes	Layers	1	Text	-	Horizon designation	Horizon designation codings, unstandardised as provided by the data source. Ideally, horizons are distinguished according to FAO, 2006, with master horizon and layers incl. subordinate characteristics being coded according to (FAO, 2006/ FAO-ISRIC, 1990)	eSOTER2012
DiagnHor	Orilayers	1	Text	-	Diagnostic horizon	Diagnostic horizon, according to the World Reference Base for Soil Resources 2nd edition (IUSS 2006, 2007). (Note: SOTER databases completed before 2006 use criteria of the Revised Legend.)	eSOTER2012
DiagnPp	Orilayers	1	Text	-	Diagnostic property	Diagnostic property, according to the World Reference Base for Soil Resources (IUSS 2007). (Note: SOTER databases completed before 2006 use criteria of the Revised Legend). The full definition of all the diagnostic properties is given in ANNEX 3.	eSOTER2012
DiagnMat	Orilayers	1	Text	-	Diagnostic material	Diagnostic material, according to the World Reference Base for Soil Resources (IUSS 2007). Diagnostic soil materials are intended to reflect (partly) the properties of the original parent materials, in which pedogenetic processes have not yet been very a	eSOTER2012
Transitn	Orilayers	1	Text	-	Transition	Abruptness or distinctness of horizon boundary to underlying horizon (FAO 2006/ FAO and ISRIC 1990).	eSOTER2012
ColorM	Layers	1	Text	-	Colour - moist soil	Colour of the moist soil matrix, expressed as hue, value and chroma according to munsell codes	eSOTER2012
ColorD	Layers	1	Text	-	Colour - dry soil	Colour of the dry soil matrix, expressed as hue, value and chroma according to munsell codes	eSOTER2012
Mottling	Layers	1	Text	-	Mottles - presence	Indicates the presence of mottles (after FAO-ISRIC, 1990/ FAO, 2006), expressed as text boolean (Y/N)	eSOTER2012

Attr Code	Attr Table	Attr Soil	Attr DType	Attr Unit	AttrDescrS (description short)	AttrDescrL (description long)	Standard
StrGrade	Layers	1	Text	-	Structure grade	Grade of the primary structure elements, defined according to guidelines for soil description (FAO 2006/FAO and ISRIC 1990), expressed as class code	eSOTER2012
StrSize	Layers	1	Text	-	Structure size	Size of the primary structure elements, defined according to guidelines for soil description (FAO-ISRIC, 1990/FAO, 2006/SSS 1951), expressed as class code	eSOTER2012
StrType	Layers	1	Text	-	Structure type	Type of the primary structure elements, defined according to guidelines for soil description (FAO 2006/FAO and ISRIC 1990), expressed as class code	eSOTER2012
Sticknss	Layers	1	Text	-	Stickiness when wet	Stickiness for consistency of soil when wet. Indicative for major land qualities	NA
SaltAlkI	Layers	1	Text	-	Salt or alkali	Presence of salt or alkali, according to (FAO-ISRIC, 1990/FAO, 2006), expressed as text boolean (Y/N)	NA
Roots	Layers	1	Text	-	Roots	Presence of roots, according to (FAO-ISRIC, 1990/FAO, 2006), more than very few and thicker than very fine, expressed as text boolean (Y/N)	NA
FltTxtr	Layers	1	Text	-	Particle size class	Particle size class of the fine earth (<2 mm) observed in the field, derived from USDA texture classes which assumes particle size fractions (esd) defined according to (Soil Survey Division Staff 1993b): sand (2 ù 0.05 mm)/ silt (0.05 ù 0.002 mm) and c	eSOTER2012
CfNature	Orilayers	1	Text	-	Nature of coarse fragments	Nature of coarse fragments	NA
CfFldClS	Layers	1	Text	-	Coarse fragments field class	Abundance of coarse fragments (incl. mineral concretions, nodules and any rock fragments >2 mm) observed in the field, according to FAO-ISRIC1990, FAO2006, expressed as class code	eSOTER2012
CfFldPc	Layers	1	Num double	v %	Coarse fragments field	Abundance of coarse fragments (incl. mineral concretions, nodules and any rock fragments >2 mm) observed in the field, according to FAO-ISRIC1990, FAO2006, and possibly concerted from class code, expressed as volume percentage	NA
CfPc	Layers	1	Num double	v %	Coarse fragments	Abundance of coarse fragments (incl. mineral concretions, nodules and any rock fragments >2 mm) observed in the field and/or measured in the laboratory, expressed as volume percentage	NA
CfLabPc	Layers	1	Num double	v %	Coarse fragments lab	Abundance of coarse fragments (incl. mineral concretions, nodules and any rock fragments >2 mm) measured in the laboratory, expressed as volume percentage	NA
Csand	Orilayers	1	Num double	g/100g	Coarse sand	Weight% of particles 1.0-0.5 mm (coarse sand, SDCO) and 2.0-1.0 mm (very coarse sand, SDVC) in fine earth fraction	eSOTER2012
Msand	Orilayers	1	Num double	g/100g	Medium sand	Weight% of medium sand particles in fine earth fraction	eSOTER2012

Attr Code	Attr Table	Attr Soil	Attr DType	Attr Unit	AttrDescrS (description short)	AttrDescrL (description long)	Standard
Fsand	Orilayers	1	Num double	g/100g	Fine sand	Weight% of particles 0.25-0.1 mm (fine sand, SDF) and 0.1-0.05 mm (very fine sand, SDVF) in fine earth fraction	eSOTER2012
Csilt	Orilayers	1	Num double	g/100g	Coarse silt	Weight% of coarse silt particles in fine earth fraction	NA
Fsilt	Orilayers	1	Num double	g/100g	Fine silt	Weight% of fine silt particles in fine earth fraction	NA
Humidity	Orilayers	1	Num double	g/100g	Humidity	Weight% of humidity in fine earth fraction	NA
Sand	Layers	1	Num double	g/100g	Sand	Weight% of particles 2.0-0.05 mm (sand) in fine earth fraction. The total sand fraction, either as an absolute value, or as the sum of the subfractions.	eSOTER2012
Silt	Layers	1	Num double	g/100g	Silt	Weight% of particles 0.05-0.002 mm (silt) in fine earth fraction	eSOTER2012
Clay	Layers	1	Num double	g/100g	Clay	Weight% of particles less than 0.002 mm (clay) in fine earth fraction	eSOTER2012
SumTxtr	Layers	1	Num double	g/100g	Sum of fine earth fractions	Sum of weight% of fine earth fractions, theoretically equal to 100%	NA
BlkDens	Layers	1	Num double	kg/dm <sup>3</sup>	Bulk density	Oven-dry bulk density, in kg dm <sup>-3</sup>	eSOTER2012
Ksat	Orilayers	1	Num double	cm/h	Hydraulic conductivity	Saturated hydraulic conductivity, in cm/hour	SOTER1995
InfiltrR	Orilayers	1	Num double	cm/h	Infiltration rate	Infiltration rate, in cm/hour	NA
PHH2O	Layers	1	Num double	-	pH H2O	pH determined in a 1:x mixture of soil : water	eSOTER2012
PH2H2O	Orilayers	1	Num double	-	pH H2O, 2nd measurement	pH determined in a 1:x mixture of soil : water, 2nd measurement	eSOTER2012
PHKCl	Layers	1	Num double	-	pH KCl	pH determined in the supernatant suspension of a 1:x mixture of soil : KCl	eSOTER2012
PHCaCl2	Layers	1	Num double	-	pH CaCl2	pH determined in the supernatant suspension of a 1:x mixture of soil : CaCl2	eSOTER2012
PHX	Orilayers	1	Num double	-	PH NaF or PH Co	pH determined in the supernatant suspension of a 1:x mixture of soil : NaF, or soil : HexamineCobalt TriChloride	NA
EC	Layers	1	Num double	dS/m	Electrical conductivity	Electrical conductivity determined in a 1:x soil water mixture, in dS m <sup>-1</sup> , often measured in the same run as pHH2O	eSOTER2012
EC2	Layers	1	Num double	dS/m	Electrical conductivity, 2nd measurement	Electrical conductivity determined in a 1:x soil water mixture, 2nd measurement (other method), in dS m <sup>-1</sup>	eSOTER2012
SblCat	Layers	1	Num double	cmol/l	Soluble cations	Sum of soluble cations, in cmol l <sup>-1</sup>	NA
SblAn	Layers	1	Num double	cmol/l	Soluble anions	Sum of soluble anions, in cmol l <sup>-1</sup>	NA
SblCa	Orilayers	1	Num double	cmol/l	Soluble Ca	Content of soluble Ca <sup>++</sup> , in cmol l <sup>-1</sup>	NA
SblMg	Orilayers	1	Num double	cmol/l	Soluble Mg	Content of soluble Mg <sup>++</sup> , in cmol l <sup>-1</sup>	NA
SblNa	Orilayers	1	Num double	cmol/l	Soluble Na	Content of soluble Na <sup>+</sup> , in cmol l <sup>-1</sup>	NA
SblK	Orilayers	1	Num double	cmol/l	Soluble K	Content of soluble K <sup>+</sup> , in cmol l <sup>-1</sup>	NA
SblCO3	Orilayers	1	Num double	cmol/l	Soluble CO3	Content of soluble CO <sub>3</sub> <sup>-</sup> , in cmol l <sup>-1</sup>	NA
SblHCO3	Orilayers	1	Num double	cmol/l	Soluble HCO3	Content of soluble HCO <sub>3</sub> <sup>-</sup> , in cmol l <sup>-1</sup>	NA
SblCl	Orilayers	1	Num double	cmol/l	Soluble Cl	Content of soluble Cl <sup>-</sup> , in cmol l <sup>-1</sup>	NA
SblSO4	Orilayers	1	Num double	cmol/l	Soluble SO4	Content of soluble SO <sub>4</sub> <sup>-</sup> , in cmol l <sup>-1</sup>	NA



Attr Code	Attr Table	Attr Soil	Attr DType	Attr Unit	AttrDescrS (description short)	AttrDescrL (description long)	Standard
SlbIN03	OriLayers	1	Num double	cmo/l	Soluble NO3	Content of soluble NO <sub>3</sub> <sup>-</sup> , in cmo l <sup>-1</sup>	NA
SlbIF	OriLayers	1	Num double	cmo/l	Soluble F	Content of soluble F <sup>-</sup> , in cmo l <sup>-1</sup>	NA
ExCaMg	OriLayers	1	Num double	cmo/kg	Exchangeable Ca & Mg	Sum of exchangeable Ca and Mg, in cmoic kg-1 (= meq/100 g)	NA
ExCa	Layers	1	Num double	cmo/kg	Exchangeable Ca	Exchangeable Ca, in cmoic kg-1 (= meq/100 g)	eSOTER2012
ExMg	Layers	1	Num double	cmo/kg	Exchangeable Mg	Exchangeable Mg, in cmoic kg-1 (= meq/100 g)	eSOTER2012
ExNa	Layers	1	Num double	cmo/kg	Exchangeable Na	Exchangeable Na, in cmoic kg-1 (= meq/100 g)	eSOTER2012
ExK	Layers	1	Num double	cmo/kg	Exchangeable K	Exchangeable K, in cmoic kg-1 (= meq/100 g)	eSOTER2012
ExBases	Layers	1	Num double	cmo/kg	Exchangeable bases	Sum of exchangeable bases, in cmoic kg-1 (= meq/100 g)	NA
ExH	Layers	1	Num double	cmo/kg	Exchangeable H	Exchangeable H, in cmoic kg-1	NA
ExAl	Layers	1	Num double	cmo/kg	Exchangeable Al	Exchangeable Al, in cmoic kg-1	eSOTER2012
ExAcid	Layers	1	Num double	cmo/kg	Exchangeable acidity	Exchangeable acidity (H + Al), in cmoic kg-1	eSOTER2012
Ecec	Layers	1	Num double	cmo/kg	Effective CEC	Effective cation exchange capacity of the soil (is sum of exbases and exacidity), in cmoic kg-1	NA
CecSoil	Layers	1	Num double	cmo/kg	CEC soil	Cation exchange capacity of the soil, in cmoic kg-1	eSOTER2012
CecSoil2	Layers	1	Num double	cmo/kg	CEC soil, 2nd measurement	Cation exchange capacity of the soil, 2nd measurement (other method), in cmoic kg-1	NA
CecMin	OriLayers	0	Num double	cmo/kg	CecMin	Calculated minimum value for CEC, assuming that CEC is function of CEC-clay and CEC-organic carbon, with CEC-clay = 1.5 cmoic kg-1 and CEC-organic carbon = 100 cmoic kg-1	NA
CecMax	OriLayers	0	Num double	cmo/kg	CecMax	Calculated maximum value for CEC, assuming that CEC is function of CEC-clay and CEC-organic carbon, with CEC-clay = 150 cmoic kg-1 and CEC-organic carbon = 600 cmoic kg-1	NA
Bsat	Layers	1	Num double	%	Base saturation	Base saturation or sum of exchangeable bases relative to CEC, expressed as %	NA
Bsat2	Layers	1	Num double	%	Base saturation, 2nd measurement	Base saturation or sum of exchangeable bases relative to CEC, 2nd measurement (other method), expressed as %	NA
CaSO4	Layers	1	Num double	g/kg	Gypsum	Gypsum content, in g kg-1 or promille (‰)	eSOTER2012
CaCO3	Layers	1	Num double	g/kg	Carbonate equivalent	Content of carbonate equivalents, in g kg-1 or promille (‰)	eSOTER2012
InOrgC	Layers	1	Num double	g/kg	Inorganic carbon	Content of inorganic carbon (C), in g kg-1 or promille (‰).	NA
TotC	Layers	1	Num double	g/kg	Total carbon	Content of total carbon (C, including both inorganic and organic carbon), in g kg-1 or promille (‰). Note that the measured content of total carbon doesn't necessarily exceed the measured contents of inorganic and/or organic carbon, as measuring methods	eSOTER2012

Attr Code	Attr Table	Attr Soil	Attr DType	Attr Unit	AttrDescrS (description short)	AttrDescrL (description long)	Standard
OrgC	Layers	1	Num double	g/kg	Organic carbon	Content of organic carbon (C), in g kg <sup>-1</sup> or promille (‰)	eSOTER2012
TotalN	Layers	1	Num double	g/kg	Total nitrogen	Content of total nitrogen (N), in g kg <sup>-1</sup> or promille (‰)	eSOTER2012
CN	Layers	1	Num double	-	C/N ratio	Ratio of organic carbon over total nitrogen (C/N)	NA
TotalP	Layers	1	Num double	mg/kg	Total P	Content of total phosphorus (P), in mg kg <sup>-1</sup> or ppm	eSOTER2012
AvailP	Orilayers	1	Num double	mg/kg	Available P	Content of -assumed- available phosphorus (P), in mg kg <sup>-1</sup> , (is not P205 content).	eSOTER2012
AvailP2	Orilayers	1	Num double	mg/kg	Available P, 2nd measurement	Content of -assumed- available phosphorus (P), 2nd measurement, in mg kg <sup>-1</sup> , (is not P205 content).	eSOTER2012
RetentP	Orilayers	1	Num double	g/100g	P retention	Phosphorus (P) retention, in weight %	NA
Poros	Orilayers	1	Num double	v %	Porosity	Total porosity, in volume %	NA
VMCpF00	Layers	1	Num double	v %	Volumetric moisture content at pF 0.0	Volumetric soil moisture content at a matric suction of pF 0.0 (or -0.1 kPa), expressed in volume %	eSOTER2012
VMCpF05	Layers	1	Num double	v %	Volumetric moisture content at pF 0.5	Volumetric soil moisture content at a matric suction of pF 0.5 (or -0.33 kPa), expressed in volume %	NA
VMCpF10	Layers	1	Num double	v %	Volumetric moisture content at pF 1.0	Volumetric soil moisture content at a matric suction of pF 1.0 (or -1 kPa), expressed in volume %	NA
VMCpF15	Layers	1	Num double	v %	Volumetric moisture content at pF 1.5	Volumetric soil moisture content at a matric suction of pF 1.5 (or -3.3 kPa), expressed in volume %	NA
VMCpF17	Layers	1	Num double	v %	Volumetric moisture content at pF 1.7	Volumetric soil moisture content at a matric suction of pF 1.7 (or -5 kPa), expressed in volume %	NA
VMCpF18	Layers	1	Num double	v %	Volumetric moisture content at pF 1.8	Volumetric soil moisture content at a matric suction of pF 1.8 (or -6.6 kPa), expressed in volume %	NA
VMCpF20	Layers	1	Num double	v %	Volumetric moisture content at pF 2.0	Volumetric soil moisture content at a matric suction of pF 2.0 (or -10 kPa), expressed in volume % (field capacity)	eSOTER2012
VMCpF22	Layers	1	Num double	v %	Volumetric moisture content at pF 2.2	Volumetric soil moisture content at a matric suction of pF 2.2 (or -16 kPa), expressed in volume %	NA
VMCpF23	Layers	1	Num double	v %	Volumetric moisture content at pF 2.3	Volumetric soil moisture content at a matric suction of pF 2.3 (or -20 kPa), expressed in volume %	eSOTER2012
VMCpF24	Layers	1	Num double	v %	Volumetric moisture content at pF 2.4	Volumetric soil moisture content at a matric suction of pF 2.4 (or -25 kPa), expressed in volume %	NA
VMCpF25	Layers	1	Num double	v %	Volumetric moisture content at pF 2.5	Volumetric soil moisture content at a matric suction of pF 2.5 (or -33 kPa), expressed in volume % (field capacity)	eSOTER2012
VMCpF27	Layers	1	Num double	v %	Volumetric moisture content at pF 2.7	Volumetric soil moisture content at a matric suction of pF 2.7 (or -50 kPa), expressed in volume %	eSOTER2012

Attr Code	Attr Table	Attr Soil	Attr DType	Attr Unit	AttrDescrS (description short)	AttrDescrL (description long)	Standard
VMCpF28	Layers	1	Num double	v %	Volumetric moisture content at pF 2.8	expressed in volume % Volumetric soil moisture content at a matric suction of pF 2.8 (or -66 kPa), expressed in volume %	NA
VMCpF29	Layers	1	Num double	v %	Volumetric moisture content at pF 2.9	Volumetric soil moisture content at a matric suction of pF 2.9 (or -80 kPa), expressed in volume %	NA
VMCpF30	Layers	1	Num double	v %	Volumetric moisture content at pF 3.0	Volumetric soil moisture content at a matric suction of pF 3.0 (or -100 kPa), expressed in volume %	eSOTER2012
VMCpF33	Layers	1	Num double	v %	Volumetric moisture content at pF 3.3	Volumetric soil moisture content at a matric suction of pF 3.3 (or -200 kPa), expressed in volume %	NA
VMCpF34	Layers	1	Num double	v %	Volumetric moisture content at pF 3.4	Volumetric soil moisture content at a matric suction of pF 3.4 (or -250 kPa), expressed in volume %	NA
VMCpF35	Layers	1	Num double	v %	Volumetric moisture content at pF 3.5	Volumetric soil moisture content at a matric suction of pF 3.5 (or -330 kPa), expressed in volume %	eSOTER2012
VMCpF36	Layers	1	Num double	v %	Volumetric moisture content at pF 3.6	Volumetric soil moisture content at a matric suction of pF 3.6 (or -400 kPa), expressed in volume %	NA
VMCpF37	Layers	1	Num double	v %	Volumetric moisture content at pF 3.7	Volumetric soil moisture content at a matric suction of pF 3.7 (or -500 kPa), expressed in volume %	NA
VMCpF40	Layers	1	Num double	v %	Volumetric moisture content at pF 4.0	Volumetric soil moisture content at a matric suction of pF 4.0 (or -1000 kPa), expressed in volume %	NA
VMCpF42	Layers	1	Num double	v %	Volumetric moisture content at pF 4.2	Volumetric soil moisture content at a matric suction of pF 4.2 (or -1500 kPa), expressed in volume % (permanent wilting point)	eSOTER2012
VMCpF50	Layers	1	Num double	v %	Volumetric moisture content at pF 5.0	Volumetric soil moisture content at a matric suction of pF 5.0 (or -10000 kPa), expressed in volume %	NA
VMCpF58	Layers	1	Num double	v %	Volumetric moisture content at pF 5.8	Volumetric soil moisture content at a matric suction of pF 5.8 (or -66000 kPa), expressed in volume %	NA
VolAWC	Layers	1	Num double	v %	Available volumetric water content	Volumetric content of water or soil moisture assumed available for uptake by reference plant, defined as the difference in soil moisture content at field capacity and at permanent wilting point. Expressed in volume % (m <sup>3</sup> / 100 m <sup>3</sup> )	NA
WghtAWC	Orilayers	1	Num double	g/100g	Available weight-based water content	Weight-based water or soil moisture content, assumed available for uptake by reference plant, defined as the difference in soil moisture content at field capacity and at permanent wilting point. Expressed in weight % (g/100 g)	NA
Extr1Fe	Orilayers	1	Num double	g/100g	Extractable Fe - free	Fe fraction, in weight %, extractable in dithionite citrate (is not Fe2O3 fraction)	eSOTER2012
Extr2Fe	Orilayers	1	Num double	g/100g	Extractable Fe - active	Fe fraction, in weight %, extractable in oxalate acid (is not Fe2O3 fraction)	eSOTER2012

Attr Code	Attr Table	Attr Soil	Attr DType	Attr Unit	AttrDescrS (description short)	AttrDescrL (description long)	Standard
Extr3Fe	Orilayers	1	Num double	g/100g	Extractable Fe - organic bound	Fe fraction, in weight %, extractable in pyrophosphate (is not Fe2O3 fraction)	NA
Extr1Fe	Orilayers	1	Num double	g/100g	Extractable Fe - total	Total Fe, in weight %, extractable (is not Fe2O3 fraction)	NA
Extr1Al	Orilayers	1	Num double	g/100g	Extractable Al - free	Al fraction, in weight %, extractable in dithionite citrate (is not Al2O3 fraction)	NA
Extr2Al	Orilayers	1	Num double	g/100g	Extractable Al - active	Al fraction, in weight %, extractable in oxalate acid (is not Al2O3 fraction)	eSOTER2012
Extr3Al	Orilayers	1	Num double	g/100g	Extractable Al - organic bound	Al fraction, in weight %, extractable in pyrophosphate (is not Al2O3 fraction)	NA
AvailK	Orilayers	1	Num double	mg/kg	Available K	-Assumed- available potassium, in mg kg-1 or ppm	NA
TotalK	Orilayers	1	Num double	mg/kg	Total K	Total potassium, in mg kg-1 or ppm	NA
Fe	Orilayers	1	Num double	mg/kg	Fe micro nutrient	Micro nutrient Iron, expressed in mg/kg or ppm	NA
Mn	Orilayers	1	Num double	mg/kg	Mn micro nutrient	Micro nutrient Manganese, expressed in mg/kg or ppm	NA
Zn	Orilayers	1	Num double	mg/kg	Zn micro nutrient	Micro nutrient Zinc, expressed in mg/kg or ppm	NA
Cu	Orilayers	1	Num double	mg/kg	Cu micro nutrient	Micro nutrient Copper, expressed in mg/kg or ppm	NA
B	Orilayers	1	Num double	mg/kg	B micro nutrient	Micro nutrient Borium, expressed in mg/kg or ppm	NA
S	Orilayers	1	Num double	mg/kg	S micro nutrient	Micro nutrient Sulfur, expressed in mg/kg or ppm	NA
OrgMat	Orilayers	1	Num double	g/kg	Organic matter	Organic matter, expressed in g kg-1 or promille (é).	NA
TotHumC	Orilayers	1	Num double	g/kg	Total humic C	Total humic carbon (a fraction of organic carbon), expressed in g kg-1 or promille (é).	NA
HumAcidC	Orilayers	1	Num double	g/kg	Humic acid C	Humic acid carbon (a fraction of total humic carbon), expressed in g kg-1 or promille (é).	NA
FulAcidC	Orilayers	1	Num double	g/kg	Fulvic acid C	Fulvic acid carbon (a fraction of total humic carbon), expressed in g kg-1 or promille (é).	NA
LabTxtr	Layers	1	Text	-	Lab derived texture	Particle size class of the fine earth (texture class), derived from particle size fractions as measured at the laboratory	eSOTER2012
ClyMinera	Layers	1	Text	-	Clay mineralogy	Dominant type of mineral in the clay size fraction, expressed as class code	eSOTER2012
FullDescr	Orilayers	0	Text	-	Full horizon description	Full horizon description	NA
FID	GeoPoints	0	Num integer	-	In-shapefile geofeature ID	Identifier of the in-shapefile spatial feature	NA
Shape	GeoPoints	0	Text	-	Geofeature type	Type of the spatial feature (point)	NA
LayerID00	GeoPoints	0	Text	-	AFSP 00th layer point subfeature ID	Identifier of the soil profile's 00th layer point subfeature (is similar to LayerID for LayerNr = 0)	NA
LayerID99	GeoPoints	0	Text	-	AFSP 99th layer point subfeature ID	Identifier of the soil profile's 99th layer point subfeature (is similar to LayerID for LayerNr = 99)	NA
oProfileID	Oriprofiles	0	Text	-	AFSP profile ID	Identifier of the soil profile feature (is similar to ProfileID)	NA
oLayerID	Orilayers	0	Text	-	AFSP profile layer ID	Identifier of the soil profile layer subfeature (is similar to LayerID)	NA
mMethodKey	AttrMethods	0	Text	-	AFSP-key to methods	Key (is similar to MethodKey) to collection of methods (codes) applied to assess	NA

Attr Code	Attr Table	Attr Soil	Attr DType	Attr Unit	AttrDescrS (description short)	AttrDescrL (description long)	Standard
mMethdYN	AttrMethods	0	Text	-	Boolean for inclusion of methods	feature-attribute-values	NA
uUnitKey	AttrUnits	0	Text	-	AFSP:key to units of expression	Indicates whether Method codes have been specified (Y) or not (N) Key (is similar to UnitKey) to collection of units to express feature-attribute-values	NA
aAttr	Attrs	0	Text	-	AFSP:key to attributes	Key (is similar to AttrKey) to collection of attributes (codes), including soil properties, observed or measured	NA



## Annex 3b Dictionary of attribute codes, corresponding to the column headings applied in the db dictionary tables

Attr Code	Attr Table	Attr Soil	Attr DType	Attr Unit	Attr DescrS (short)	Attr DescrL (long)	Standard
DbAvail	DictioSrcDBases	0	Num integer	-	Dataset availability	Indicator (boolean) of the availability with the compiler of the digital dataset (1 =yes, 0=no)	NA
SrcDb_ID	DictioSrcDBases	0	Text	-	AFSP-ID of source dataset	Identifier of the digital source dataset	NA
DbDescr	DictioSrcDBases	0	Text	-	Dataset description	Description or title of the database or digital dataset	eSOTER2012
DbHolder	DictioSrcDBases	0	Text	-	Dataset holder and owner	Name of the holder and owner, institute or organisation, of the dataset	eSOTER2012
DbPublYr	DictioSrcDBases	0	Num integer	-	Dataset publication year	Year of publication of the dataset	eSOTER2012
DbAuthor	DictioSrcDBases	0	Text	-	Dataset author	Name of the author(s) of the dataset. Where applicable, this can be an institute or organisation	eSOTER2012
DbUrl	DictioSrcDBases	0	Hyper link	-	Dataset online access	URL link to online dataset or online metadata with the dataset	NA
DbIP	DictioSrcDBases	0	Text	-	IP or Copy rights of source dataset	Indicator of IP rights and/or copy rights on the source dataset	NA
SrcRep_ID	DictioSrcReports	0	Text	-	AFSP-ID source report	Identifier of the report, book or publication. Where possible, the identifier is harmonised by using the unique ISRIC library identifier (ISN).	NA
PrshAFSP	DictioSrcReports	0	Num integer	-	Quantity of soil profiles captured from report	Number of soil profiles actually captured from report into AFSP database	NA
RepAuthor	DictioSrcReports	0	Text	-	Report author	Name of the author(s) of the report, book or publication. Where applicable, this can be an institute or organisation	eSOTER2012
RepPubYr	DictioSrcReports	0	Num integer	-	Report publication year	Year of publication of the report, book or publication	eSOTER2012
RepTitle	DictioSrcReports	0	Text	-	Report title	Title of the report, book or publication	eSOTER2012
RepSerie	DictioSrcReports	0	Text	-	Report serie	Serie (plus serie number)of which the report, book or publication is part	NA
RepPublshr	DictioSrcReports	0	Text	-	Report publisher	Publisher of the report, book or publication	eSOTER2012
RepIP	DictioSrcReports	0	Text	-	IP or Copy rights of source report	Indicator of IP rights and/or copy rights on the source report	NA

Attr Code	Attr Table	Attr Soil	Attr DType	Attr Unit	Attr DescrS (short)	Attr DescrL (long)	Standard
Lab_ID	DictioLabs	0	Text	-	AFSP laboratory ID	Identifier of the soil laboratory where the soil samples were analyzed, with -if available- the laboratory manual	eSOTER2012
LabDescr	DictioLabs	0	Text	-	Laboratory description	Description or name of the laboratory, with -if available, the laboratory manual	eSOTER2012
MethodCode	DictioLabMethods	0	Text	-	Method code	Code for the method applied to assess the value for feature properties	eSOTER2012
MethodDescr	DictioLabMethods	0	Text	-	Method description	Short description of the method, including references if possible. To be standardised	eSOTER2012
MethodGrp	DictioLabMethods	0	Text	-	Method group	Group of methods, expressed as targeted soil property	NA
PropertyCod	DictioClassValues	0	Text	-	Soil property code	Coding for soil property	eSOTER2012
ValueCode	DictioClassValues	0	Text	-	Value class code	Class code for categorical soil property value	NA
ValueDescr	DictioClassValues	0	Text	-	Value class description	Description of the significance of the class code for categorical soil property value	NA
RefCode	DictioRefs	0	Text	-	Reference code	Coding for reference to standard definitions of attributes as associated value domains (= Standard)	NA
RefDescr	DictioRefs	0	Text	-	Reference description	Reference to standard definitions of attributes and associated value domains (= Standard)	NA
AttrCode	DictioAttributes	0	Text	-	Attribute code or DB column heading	Coding for database attribute or column heading (maximally 10 characters)	NA
AttrTable	DictioAttributes	0	Text	-	DB table	Table in the DB wherein the attribute or column is	NA
AttrSoil	DictioAttributes	0	Text	-	Attribute indicator	Attribute indicator, expressed as boolean (0= DB attribute, 1=soil property)	NA
AttrDType	DictioAttributes	0	Text	-	Data type	Format type of the data with the attribute (text, real, integer)	NA
AttrUnit	DictioAttributes	0	Text	-	Unit of expression	Unit to express the value of the attribute	NA
AttrDescrS	DictioAttributes	0	Text	-	Short description (this field)	Short description of the attribute, including references if possible.	NA
AttrDescrL	DictioAttributes	0	Text	-	Long description	Long description or definition of the attribute, including references if possible (this field)	NA
Standard	DictioAttributes	0	Text	-	Reference to standard	Coding for reference to the standard definition of the attribute concerned, and -in most cases- to the associated standard value domain	NA
Standard2	DictioAttributes	0	Text	-	2nd reference to standard	Coding for 2nd reference to the standard definition of the attribute concerned, and -in most cases- to the associated standard value domain	NA
GeoPoints	DictioAttributes	0	Text	-	Headings GeoPoints table	Column headings GeoPoints table, associated with the attribute concerned	NA
Profiles	DictioAttributes	0	Text	-	Headings Profiles table	Column headings Profiles table, associated with the attribute concerned	NA
Layers	DictioAttributes	0	Text	-	Headings Layers table	Column headings Layers table, associated with the attribute concerned	NA
OriProfile	DictioAttributes	0	Text	-	Headings OriProfiles table	Column headings OriProfiles table, associated with the attribute concerned	NA



Attr Code	Attr Table	Attr Soil	Attr DType	Attr Unit	Attr DescrS (short)	Attr DescrL (long)	Standard
OriLayers	DictioAttributes	0	Text	-	Headings OriLayers table	Column headings OriLayers table, associated with the attribute concerned	NA
AttrMethods	DictioAttributes	0	Text	-	Headings AttrMethods table	Column headings AttrMethods table, associated with the attribute concerned	NA
AttrUnits	DictioAttributes	0	Text	-	Headings AttrUnits table	Column headings AttrUnits table, associated with the attribute concerned	NA
Attrs_123	DictioAttributes	0	Text	-	Headings Attrs table(s)	Column headings Attrs tables (Attrs_1Profiles, Attrs_2LayerFid, Attrs_3LayerLab), associated with the attribute concerned	NA
AbbrAfSP2	DictioAttributes	0	Text	-	AFSP2 attribute code	Coding for database attribute or column heading as applied in earlier version (2) of the AFSP database	NA
AbbrSoter	DictioAttributes	0	Text	-	SOTER attribute code	Coding for database attribute or column heading as applied in the SOTER databases	NA
AbbrWise3	DictioAttributes	0	Text	-	WISE3 attribute code	Coding for database attribute or column heading as applied in the WISE3 database	NA



## Annex 4 Dictionary of (analytical) method codes

Method group	Method code	Method description
MethdGrp	MethdCode	MethdDescr
AlExtractable	AL-	Not measured
AlExtractable	AL01	Al, dithionite-citrate extraction ('free aluminium')
AlExtractable	AL02	Al, acid oxalate extraction ('active')
AlExtractable	AL03	Al, pyrophosphate extraction (organic bound Al)
AlExtractable	AL99	Unspecified methods
bulkDensity	BD-	Not measured (Bulk density)
bulkDensity	BD01	Core sampling (pF rings)
bulkDensity	BD02	Clod samples
bulkDensity	BD02.1	Clod samples, at air dry
bulkDensity	BD02.2	Clod samples, at 0.33 bar / pF2.5
bulkDensity	BD03	Replacement method (with spherical plastic balls; Avery & Bascomb, 1974)
bulkDensity	BD04	Auger-hole method (Zwarich & Shaykewich, 1969)
bulkDensity	BD05	Clod samples, oven-dry (USDA method 4A1h)
bulkDensity	BD06	db: drying and weighting of 100-ml sample (Schlichting et al. 1995)
bulkDensity	BD07	Unspecified, air dry
bulkDensity	BD08	Grossman and Reinsch, 2002 (In: Dane JH and Topp Gc (eds.) Soil Sci. Soc. Am. book series 5, part 4, pp 201-228.)
bulkDensity	BD99	Unspecified methods
Base saturation	BS-	Not measured
Base saturation	BS01	Sum of bases as percentage of CEC (method specified with CEC)
Base saturation	BS99	Unspecified methods
CarbonateEquivalent	CA-	Not measured (CaCO <sub>3</sub> )
CarbonateEquivalent	CA01	Method of Scheibler (volumetric)
CarbonateEquivalent	CA02	Method of Wesemael
CarbonateEquivalent	CA03	Method of Piper (HCl)
CarbonateEquivalent	CA04	Calcimeter method (volumetric after adition of dilute acid)
CarbonateEquivalent	CA04.1	CO <sub>2</sub> measurement by calcimeter Scheibler-Finkener
CarbonateEquivalent	CA05	Gravimetric (USDA Agr. Hdbk 60; method Richards et al., 1954)
CarbonateEquivalent	CA06	H <sub>3</sub> PO <sub>4</sub> acid at 80C, conductometric in NaOH (Schlichting & Blume, 1966)
CarbonateEquivalent	CA07	Pressure calcimeter (Nelson, 1982)
CarbonateEquivalent	CA08	Bernard calcimeter (Total CaCO <sub>3</sub> )
CarbonateEquivalent	CA09	Carbonates: H <sub>3</sub> PO <sub>4</sub> treatment at 80 deg. C and CO <sub>2</sub> measurement like TOC (OC13), transformation into CaCO <sub>3</sub> (Schlichting et al. 1995)
CarbonateEquivalent	CA10	CaCO <sub>3</sub> Equivalent, CO <sub>2</sub> evolution after HCl treatment. Gravimetric
CarbonateEquivalent	CA11	Black, 1965-HCl
CarbonateEquivalent	CA12	Treatment with H <sub>2</sub> SO <sub>4</sub> N/2 acid followed by titration with NaOH N/2 in presence of an indicator
CarbonateEquivalent	CA99	Unspecified methods
effectiveCec	CE-	Not measured (CEC, sum of bases)
effectiveCec	CE01	Sum of exch. Ca, Mg, K and Na, plus exchangeable aluminium (in 1M KCl) *
effectiveCec	CE02	Sum of exch. Ca, Mg, K and Na, plus exchangeable Al (according to method EA02)
effectiveCec	CE03	Sum of exch. Ca, Mg, K and Na, plus exchangeable H+Al (in 1M KCl)
effectiveCec	CE04	Sum of exch. Ca, Mg, K and Na (in NH <sub>4</sub> Cl at pH 7/0), plus exchangeable H+Al (in 1M KCl)

Method group	Method code	Method description
MethdGrp	MethdCode	MethdDescr
effectiveCec	CE05	CEC and exchangeable cations with BaCl2 (after extracting water soluble cations, measurement by AAS); Schlichting et al. 1995
effectiveCec	CE06	Sum of exch. Ca, Mg, K and Na, plus exchangeable H
effectiveCec	CE07	Sum of exch bases plus exch acidity
effectiveCec	CE99	Unspecified methods
Coarse Fragments	CF-	Coarse Fragments
Coarse Fragments	CF01	Particles with 2 to 75 mm diameter are reported as a volume percent on a whole soil at 1/3 bar water tension base.
Coarse Fragments	CF02	Coarse Fragments derived from laboratory and from field (class values), with priority given to laboratory values
Coarse Fragments	CF03	Particles >2 mm measured in laboratory (sieved after light pounding). May include concretions and very hard aggregates
Coarse Fragments	CF03.1	Particles >2 mm measured in laboratory (sieved after light pounding). May include concretions and very hard aggregates. Expressed in w%
Coarse Fragments	CF04	Coarse Fragments observed in the field (class values or v%)
Coarse Fragments	CF99	Unspecified methods
cecSoil	CS-	Not measured (CEC soil)
cecSoil	CS01	CEC in 1M NH4OAc buffered at pH 7
cecSoil	CS01.1	CEC in 1M NH4OAc buffered at pH 7, with ExCa=ExMg= 0.5* ExCa&Mg if ExCa=-9999 and ExMg = -9999
cecSoil	CS02	CEC in 1M BaCl2 buffered at pH 8.1
cecSoil	CS02.1	CEC in BaCl2-TEA buffered at pH 8.1
cecSoil	CS03	CEC in 1M NH4OAc buffered at pH 8.2 (Bascomb)
cecSoil	CS04	CEC in 1M NaOAc buffered at pH 8.2
cecSoil	CS05	CEC in Silver Thiourea (AgTU)
cecSoil	CS06	CEC as sum of bases (NH4OAc at pH 7) + extr. acidity in BaCl2-TEA at pH 8.2
cecSoil	CS07	CEC determined in 0.5 M LiCl buffered at pH 8 with TEA (after Peech, 1965)
cecSoil	CS08	CEC in 1 M KCl at pH of soil
cecSoil	CS09	Sum of exch. cations (Brasil)
cecSoil	CS10	CEC in Li-EDTA at pH7; treat. with K-EDTA solution at pH 10
cecSoil	CS11	CEC in 1M BaCl2 at pH 8.4
cecSoil	CS12	CEC by saturation with NH4OAc and percolation with 10% NaCl + 4 cc conc. HCl/L
cecSoil	CS13	CEC determined in 0.2 M NH4Cl at approximately field pH (Rusell, 1973)
cecSoil	CS14	CEC determined in 0.5N BaOAc at pH 8.2-8.4 after washing
cecSoil	CS15	CEC determined according to Oosterbeek (NL) method (NH4 acetate?)
cecSoil	CS16	CEC Mehlich; Ba2+ retained from BaCl2, TEA at pH 8.2
cecSoil	CS17	CEC with 0.1 M Li-EDTA, buffered at pH 8.0
cecSoil	CS18	CEC acc. Schollenberger/Shmuck/Pfeffer dep. on initial pH and salt content
cecSoil	CS19	CEC in NH4OAc at pH7 and NaOAc at pH 8.2 dep. on initial pH and salt content
cecSoil	CS20	CEC in 1M Na-acetate (after Hermann 2005)
cecSoil	CS21	NH4OAc, pH?
cecSoil	CS22	NH4OAc. BaCl2 unbuffered percolation
cecSoil	CS23	NH4OAc (Stahlberg et. al., 1978)
cecSoil	CS24	Ca++ used to saturate complex, followed by 'washing', and replacement of Ca by NH4 (NH4Cl). CEC = Tca
cecSoil	CS25	CECmaxWithCECclaylsMax150andInclOCwith_1gramOCis600)
cecSoil	CS26	CECminWithCECclaylsMin1andInclOCwith_1gramOCis100)
cecSoil	CS88	Estimated (synthetic)
cecSoil	CS98	Other methods (buffered at pH of about 8)
cecSoil	CS99	Other methods (buffered at pH of about 7)
exchAcidity	EA-	Not measured (Exchangeable acidity)
exchAcidity	EA01	Exchangeable acidity (H+Al) in 1 M KCl

Method group	Method code	Method description
MethdGrp	MethdCode	MethdDescr
exchAcidity	EA02	Exch. acidity in 1 M KCl estimated from soluble Al in 2:1 v/v 0.02 M CaCl <sub>2</sub>
exchAcidity	EA03	Extractable acidity in NH <sub>4</sub> OAc, formaldehyde and BaCl <sub>2</sub> ; acid. by titration at pH 11 (Mados, 1943)
exchAcidity	EA03.1	Exchangeable H, in 0.2 M NH <sub>4</sub> OH, followed by formaldehyde and BaCl <sub>2</sub> . Method of Mados, modified.
exchAcidity	EA04	Ca-acetate 1 M at pH 7 (Brasil)
exchAcidity	EA05	Exch. acidity in 0.1 N NH <sub>4</sub> Cl extract
exchAcidity	EA06	Extractable acidity in 1 M BaCl <sub>2</sub> and TEA (at pH 8.2)
exchAcidity	EA07	Exch. acidity in NaCl extract
exchAcidity	EA08	Exchangeable H and Al (pH measurement in in Ca-acetate pH 7.2); Schlichting et al. 1995
exchAcidity	EA09	McLean, 1965
exchAcidity	EA10	Exchangeable acidity (H+Al)
exchAcidity	EA99	Unspecified methods
electroConductivity	EL-	Not measured (Electro-conductivity)
electroConductivity	EL01	Elec. conductivity at 1:1 soil/water ratio
electroConductivity	EL02	Elec. conductivity at 1:2.5 soil/water ratio
electroConductivity	EL03	Elec. conductivity at 1:5 soil/water ratio
electroConductivity	EL04	Elec. conductivity in saturated paste (ECe)
electroConductivity	EL05	Elec. conductivity at 1:2 soil/water ratio
electroConductivity	EL06	Elec. conductivity at 1:10 soil/water ratio
electroConductivity	EL07	Elec. conductivity at soil/water ratio varying from 1:1 to 1:2
electroConductivity	EL99	Unspecified methods
exchangeableBases	EX-	Not measured (Exchangeable bases)
exchangeableBases	EX01	Various methods with no apparent differences in results
exchangeableBases	EX01.1	AAS (Atomic Absorption Spectrometry)
exchangeableBases	EX01.2	FP (Flame Photometry)
exchangeableBases	EX01.3	EDTA titration
exchangeableBases	EX01.4	Methode test HCl N/20 (Gedroiz-Schofield)
exchangeableBases	EX88	Estimated (synthetic)
exchangeableBases	EX99	Unspecified methods
FeExtractable	FE-	Not measured
FeExtractable	FE01	Fe, dithionite-citrate extraction, 'free iron' (or 'total iron')
FeExtractable	FE01.1	Fe <sub>2</sub> O <sub>3</sub> , 'total iron'
FeExtractable	FE02	Fe, acid oxalate extraction ('active')
FeExtractable	FE03	Fe, pyrophosphate extraction (organic bound Fe)
gypsum	GY-	Not measured (Gypsum)
gypsum	GY01	Dissolved in water and precipitated by acetone
gypsum	GY02	Differ. between Ca-conc. in sat. extr. and Ca-conc. in 1/50 s/w solution
gypsum	GY03	Calculated from conductivity of successive dilutions
gypsum	GY04	In 0.1 M Na <sub>3</sub> -EDTA; turbidimetric (Begheijn, 1993)
gypsum	GY05	Gravimetric after dissolution in 0.2 N HCl (USSR-method)
gypsum	GY06	Total-S, using LECO furnace, minus easily soluble MgSO <sub>4</sub> and Na <sub>2</sub> SO <sub>4</sub>
gypsum	GY07	Schleiff method, electrometric
gypsum	GY99	Unspecified methods
HydrConductivity	HC-	Not measured (Hydraulic conductivity)
HydrConductivity	HC01	Double ring method
HydrConductivity	HC02	Bore hole method
HydrConductivity	HC03	Inverse bore hole method
HydrConductivity	HC04	Permeability in cm/hr determined in column filled with fine earth fraction
HydrConductivity	HC99	Unspecified methods
Available potassium	KA-	Not measured (available K)
Available potassium	KA01	Available K

Method group	Method code	Method description
MethdGrp	MethdCode	MethdDescr
Available potassium	KA99	Unspecified methods
Moisture content	MC-	Not measured (Moisture content)
Moisture content	MC01	sand/silt baths and porous plates, undisturbed samples (pF rings)
Moisture content	MC02	ceramic plate extractors, dist. samples in 10x50mm rings; after L.A. Richards 1965
Moisture content	MC03	Pressure-plate extraction, disturbed -clod- samples (wt%) * density (USDA-NRCS method 4B1 * 4A1d)
Moisture content	MC03	Separate measurements in the field of humidity (by neutron meter) and of tension (by tensiometer)
Moisture content	MC04	Pressure-plate extraction, disturbed -clod- samples (wt%) * density (USDA-NRCS method 4B2 * 4A1h * 4B5)
Moisture content	MC05	pressure plate extractor & compressor
Moisture content	MC06	Pressure membrane press & compressor
Moisture content	MC07	membrane
Moisture content	MC08	pressure membrane and pressure plate extractor. Klute, 1986. pF4.2-pF2
Moisture content	MC09	Richard's apparatus
Moisture content	MC10	Pressure plate, undisturbed core samples,
Moisture content	MC99	Unspecified methods
MicroNutrients	MN-	Not measured (Micro nutrients)
MicroNutrients	MN01	DiEthyleneTriAminePentaAcetic acid (DTPA) method for Fe, Mn, Zn, Cu
MicroNutrients	MN02	Nitric/perchloric acid mixture, leached by hydrochloric acid
MicroNutrients	MN99	Unspecified methods
Organic carbon	OC-	Not measured (Total Organic Carbon)
Organic carbon	OC01	Method of Walkley-Black (Total OC = OC * 1.3 (rec.fr. = 77% has been applied) and Org. matter = T Org. C x 1.72)
Organic carbon	OC01.1	OC01; with fr.=1
Organic carbon	OC01.2	OC01; with rec.fr.= 77% included (TOC = OC*1.3)
Organic carbon	OC01.3	OC01; Walkley & Black modified, wet combustion, with rec.fr. = 80% included (TOC= OC*1.25)
Organic carbon	OC01.4	Chromate wet oxidation of Jackson, 1958. Chromic acid digestion
Organic carbon	OC01.5	OC01; with rec.fr.= 85% included (TOC = OC * 1.18), and Org. matter = TOC x 1.72)
Organic carbon	OC02	Loss on ignition (NL) is Total OC
Organic carbon	OC03	Method of Allison
Organic carbon	OC04	Method of Kurmies (=OC16, Wet oxidation, K <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub> +H <sub>2</sub> SO <sub>4</sub> )
Organic carbon	OC05	Method of furnace combustion (e.g., LECO analyzer)
Organic carbon	OC06	Method of Kalemra and Jenkinson (1973); acid dichromate; Org. matter = Org. C x 1.72
Organic carbon	OC07	Wet oxidation according to Tinsley (1950)
Organic carbon	OC08	Wet oxidation according to Anne (Org. matter = Org. C x 1.7)
Organic carbon	OC09	Method of Tiurin (oxid. with K-dichr.)
Organic carbon	OC10	Wet oxidation by Chromic acid and gravimetric determination of CO <sub>2</sub> (Knopp)
Organic carbon	OC11	Total carbon (no-carbonates present) using VarioEL CNS-analyzer
Organic carbon	OC12	Dry combustion using a CN-corder and cobalt oxide or copper oxide as an oxidation accelerator (Tanabe and Araragi, 1970)
Organic carbon	OC13	Dry combustion at 1200 deg. C and coulometric CO <sub>2</sub> measurement (Schlichting et al. 1995)
Organic carbon	OC14	Organic Carbon, acid dichromate digestion, FeSO <sub>4</sub> titration, automatic titrator (USDA-NRCS method 6A1c)
Organic carbon	OC15	calorimetric, oxidation by acidified dichromate
Organic carbon	OC16	Wet oxidation, K <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub> +H <sub>2</sub> SO <sub>4</sub> (=OC4, Method of Kurmies)
Organic carbon	OC17	Org Carbon by Combustion at 840 C
Organic carbon	OC18	Wet oxidation/digestion according to Nelson and Sommers, 1996. (In: Sparks DL (ed.). Soil Sci. Soc. Am. book series 5, part 3, pp 961-1010)
Organic carbon	OC18.1	Modified Walkley and Black procedure (Nelson and Sommers, 1982)

Method group	Method code	Method description
MethdGrp	MethdCode	MethdDescr
Organic carbon	OC19	Dry combustion at 500 C (total C?)
Organic carbon	OC99	Unspecified methods
Org. matter fraction	OM-	Not measured (Organic Matter fractioning)
Org. matter fraction	OM01	Organic Matter, Total Humic Matter, Humic Acid fraction, Fulvic Acid fraction
Org. matter fraction	OM99	Unspecified methods
AvailablePhosphorus	PA-	Not measured (P-available)
AvailablePhosphorus	PA02	Method of Bray I (dilute HCl/NH4F)
AvailablePhosphorus	PA02.01	Murphy and Riley, 1962. Method of Bray I (dilute HCl/NH4F)
AvailablePhosphorus	PA03	Method of Olsen (0.5 M Sodium bicarbonate extraction at pH 8.5)
AvailablePhosphorus	PA03.1	Olsen (NaHCO3-pH8.2)
AvailablePhosphorus	PA04	Method of Truog (dilute H2SO4)
AvailablePhosphorus	PA05	Method of Morgan (Na-acetate/acetic acid)
AvailablePhosphorus	PA06	Method of Saunders and Metelerkamp (anion-exch. resin)
AvailablePhosphorus	PA07	Method of Bray II (dilute HCl/NH4F)
AvailablePhosphorus	PA08	Modified after ISFEI method, A.H. Hunter (1975)
AvailablePhosphorus	PA09	Method of Nelson (dilute HCl/H2SO4)
AvailablePhosphorus	PA10	ADAS method (NH4 acetate/acetic acid)
AvailablePhosphorus	PA11	Spectrometer (Brasil)
AvailablePhosphorus	PA12	North Carolina (0.05 M HCl, 0.025 N H2SO4)
AvailablePhosphorus	PA13	0.02 colorimetric in N H2SO4 extract, molybd. blue method
AvailablePhosphorus	PA14	Method of Olsen, modified by Dabin (ORSTOM)
AvailablePhosphorus	PA15	Method of Kurtz-Bray I (0.025 M HCl + 0.03 M NH4F)
AvailablePhosphorus	PA15.1	Bray&Kurtz I, if pHH2O <= 7
AvailablePhosphorus	PA15.2	Method of Kurtz-Bray II
AvailablePhosphorus	PA16	Complexation with citric acid (van Reeuwijk)
AvailablePhosphorus	PA17	NH4-lactate extraction method (KU-Leuven)
AvailablePhosphorus	PA18	Bray-I (acid soils) resp. Olsen (other soils)
AvailablePhosphorus	PA18.1	Olsen, if pHH2O >7
AvailablePhosphorus	PA19	Ambic1 method (ammonium bicarbonate) (South Africa)
AvailablePhosphorus	PA20	soluble in water (mg/kg filtrate)
AvailablePhosphorus	PA21	CaPO4
AvailablePhosphorus	PA99	Unspecified methods
pH - CaCl2	PC-	Not measured (pH_CaCl2)
pH - CaCl2	PC01	pH in 1:1 soil/1 M CaCl2 solution
pH - CaCl2	PC02	pH in 1:2.5 soil/1 M CaCl2 solution
pH - CaCl2	PC03	pH in 1:5 soil/1 M CaCl2 solution
pH - CaCl2	PC04	pH in 1:2 soil/0.01 M CaCl2 solution
pH - CaCl2	PC05	pH in 1:2.5 soil/0.01 M CaCl2 solution
pH - CaCl2	PC06	pH in 1:2.5 soil/0.1 M CaCl2 solution
pH - CaCl2	PC07	pH in 1:5 (w/v) soil/0.01 M CaCl2 solution for mineral soils; 1/10 for organic soils
pH - CaCl2	PC08	pH in 1:5 soil/ 0.02 M CaCl2 solution
pH - CaCl2	PC09	pH in 0.01 M CaCl2 solution on a saturated sample
pH - CaCl2	PC99	Unspecified methods
pH - H2O	PH-	Not measured (pH-water)
pH - H2O	PH01	pH in 1:1 soil/water solution
pH - H2O	PH02	pH 1:2.5 soil/water solution
pH - H2O	PH03	pH 1:5 soil/water solution
pH - H2O	PH04	pH in 1:2 soil/water solution
pH - H2O	PH05	pH in water saturated extract
pH - H2O	PH88	Estimated (synthetic)
pH - H2O	PH99	Unspecified methods
pH - KCl	PK-	Not measured (pH-KCl)

Method group	Method code	Method description
MethdGrp	MethdCode	MethdDescr
pH - KCl	PK01	pH in 1:1 soil/ 1 M KCl solution
pH - KCl	PK02	pH in 1:2.5 soil/ 1 M KCl solution
pH - KCl	PK03	pH in 1:5 soil/ M KCl solution
pH - KCl	PK04	pH in 1:2 soil/0.01 M KCl solution
pH - KCl	PK99	Unspecified methods
pH - X	PX01	pH in NaF solution
pH - X	PX01.1	pH in 1M NaF solution
pH - X	PX02	pH in HexamineCobalt TriChloride
Soluble salts	SS-	Not measured (soluble salts)
Soluble salts	SS01	Na, flame photometry
Soluble salts	SS02	Ca , precipitation Ca oxalate (Hdb 60)
Soluble salts	SS03	Ca , EDTA titration
Soluble salts	SS04	Ca , Atomic absorption spectrophotometry (AAS)
Soluble salts	SS05	Mg, precipitation Mg ammonium phosphate
Soluble salts	SS06	Mg, Atomic absorption spectrophotometry (AAS)
Soluble salts	SS07	K, flame photometry
Soluble salts	SS08	Cl, titration with AgNO3 (Hdb60)
Soluble salts	SS09	Cl, colorimetric by Clor-O-counter Cl titrator
Soluble salts	SS10	Cl, ion chromatography
Soluble salts	SS11	SO4, precipitation Ca sulphate (Hdb60)
Soluble salts	SS12	SO4, precipitation Ba sulphate with turbidimetry
Soluble salts	SS13	SO4, ion chromatography
Soluble salts	SS14	SO4, other
Soluble salts	SS15	HCO2 and CO3, titration with acid (Hdb60)
Soluble salts	SS16	HCO2 and CO3, potentiometric titration with HCl (=SS15?)
Soluble salts	SS17	As described by Van Beek and Kamphorst, 1973
Soluble salts	SS99	Unspecified methods
Soluble salts	SS99.1	Unspecified, mmol/kg
Soluble salts	SS99.2	Unspecified, cmol/kg
Total carbon	TC-	Not measured (Total Carbon)
Total carbon	TC01	Total Carbon (USDA-NRCS method 6A2d)
Total carbon	TC02	Total Carbon (USDA-NRCS method 6A), LECO analyzer at 1140 C
Total carbon	TC99	Unspecified methods
Texture	TE-	Not measured (texture)
Texture	TE01	Pipette method, with appropriate dispersion treatment (c<0.002<si<0.05<sa<2mm)
Texture	TE01.1	pipette, McKeague 1976
Texture	TE01.2	method of Robinson, dispersion with NH4. Fine sand<0.2 mm<Coarse sand
Texture	TE01.3	TE01; method of Robinson, dispersion with NH4
Texture	TE01.4	Pipette method, with appropriate dispersion treatment (c<0.002<si<0.05<sa<2mm, WITH C = C+SI, si=0)
Texture	TE01.5	Pipette method, with appropriate dispersion treatment (c<0.002<si<0.05<sa<2mm) AND SILT FRACTION ADAPTED TO SUM UP TO 100%
Texture	TE01.6	Pipette method, with appropriate dispersion treatment (c<0.002<si<0.05<sa<2mm), with fractions rounded to 5%
Texture	TE01.7	Pipette method, with appropriate dispersion treatment (c<0.002<si<0.05<sa<2mm), with humidity fraction added to clay fraction
Texture	TE01.8	Pipette method, with appropriate dispersion treatment (c<0.002<si<0.05<sa<1.7mm), with fraction 16-50 um estimated.
Texture	TE01.9	Pipette method, with appropriate dispersion treatment (c<0.002<si<0.05<sa<2mm), with 0.02-0.05 originally in sand fraction, transferred to silt fraction
Texture	TE02	Pipette method, without dispersion treatment (c<0.002<si<0.05<sa<2mm)
Texture	TE03	Hydrometer method, with dispersion treatment (c<0.002<si<0.05<sa<2mm)



Method group	Method code	Method description
MethdGrp	MethdCode	MethdDescr
Texture	TE03.1	Bouyoucos, 1951. Hydrometer method, with dispersion treatment (c<0.002<si<0.05<sa<2mm)
Texture	TE03.2	Hydrometer method, with dispersion treatment (c<0.002<si<0.05<sa<2mm), with fsa<0.2mm<csa AND SILT FRACTION ADAPTED TO SUM UP TO 100%
Texture	TE03.3	Hydrometer method, with dispersion treatment (c<0.002<si<0.05<sa<2mm), with fraction 0.02-0.05 originally in sand, moved to silt
Texture	TE04	Hydrometer, without dispersion treatment (c<0.002<si<0.05<sa<2mm)
Texture	TE05	Pipette method, with appropriate dispersion treatment (c<0.002<si<0.02<sa<2mm)
Texture	TE06	Pipette method, without dispersion treatment (c<0.002<si<0.02<sa<2mm)
Texture	TE07	Hydrometer method, with dispersion treatment (c<0.002<si<0.02<sa<2mm)
Texture	TE07.0	Hydrometer method, with dispersion treatment (c<0.002<si<0.02<sa<2mm, WITH SPLIT FRACTIONS)
Texture	TE07.1	TE07; Fine sand= 50% of 0.02-0.2mm
Texture	TE07.2	TE07; Sand= 0.2-2mm plus 50% of 0.02-0.2mm
Texture	TE07.3	TE07; Silt = 0.002-0.02mm plus 50% of 0.02-0.2mm
Texture	TE07.4	TE07; Bouyoucos. Fine sand= 50% of 0.02-0.2mm
Texture	TE07.5	TE07; Bouyoucos. Sand= 0.2-2mm plus 50% of 0.02-0.2mm
Texture	TE07.6	TE07; Bouyoucos. Silt = 0.002-0.02mm plus 50% of 0.02-0.2mm
Texture	TE07.7	Bouyoucos
Texture	TE08	Hydrometer, without dispersion treatment (c<0.002<si<0.02<sa<2mm)
Texture	TE09	Pipette method, with appropriate dispersion treatment (c<0.002<si<0.06<sa<2mm)
Texture	TE09.1	sieving, 0.6-2 mm
Texture	TE09.2	sieving, 0.06-0.6 mm
Texture	TE09.3	sieving, 0.06-2 mm
Texture	TE10	Pipette method, without dispersion treatment (c<0.002<si<0.06<sa<2mm)
Texture	TE11	Hydrometer method, with dispersion treatment (c<0.002<si<0.06<sa<2mm)
Texture	TE12	Hydrometer, without dispersion treatment (c<0.002<si<0.06<sa<2mm)
Texture	TE13	Hydrometer method, with dispersion treatment (c<0.005<si<0.05<sa<1mm)
Texture	TE14	Beaker method of sedimentation, with dispersion treatment (c<0.002<si<0.06<sa<2mm)
Texture	TE14.2	Beaker method of sedimentation, with dispersion treatment (c<0.002<si<0.02<sa<2mm, with c=c&si, si=0, sa=fsa&csa, with fsa=0.02-0.2 mm and csa=0.2-2 mm)
Texture	TE15	Pipette method, full dispersion (c<.001<si<0.05<sa<1mm; USSR method)
Texture	TE16	Sieve and pipette method after H2O2 extraction, and dispersion (Schlichting et al. 1995)
Texture	TE17	Sieving and sedimentation method, with appropriate dispersion treatment (c<0.002<si<0.05<sa<2 mm)
Texture	TE95	Hydrometer method, with dispersion treatment (c<0.002<si<0.05<sa<2mm OR c<0.002<si<0.02<sa<2mm), with fsa<0.2<csa
Texture	TE96	Other methods (c<0.002<si<0.02<sa<2mm, with fsa 0.02-0.2 and csa 0.2-2 mm)
Texture	TE96.1	Other methods (c&si<0.02<sa<2mm, with fsa 0.02-0.2 and csa 0.2-2 mm)
Texture	TE97	Other methods (c<0.002<si<0.06<sa<2mm)
Texture	TE98	Other methods (c<0.002<si<0.05<sa<2mm)
Texture	TE98.1	fine sand<0.3 mm
Texture	TE98.2	Derived from field estimated particle size class
Texture	TE99	Unspecified methods
Total nitrogen	TN-	Not measured (Total N)
Total nitrogen	TN01	Method of Kjeldahl
Total nitrogen	TN01.1	Kjeldahl, and ammonia distillation
Total nitrogen	TN02	Element analyzer (LECO analyzer), DRY COMBUSTION
Total nitrogen	TN03	Total N (Bremner, 1965, p. 1162-1164)
Total nitrogen	TN04	Dry combustion using a CN-corder and cobalt oxide or copper oxide as an oxidation accelerator (Tanabe and Araragi, 1970)
Total nitrogen	TN05	H2SO4

Method group	Method code	Method description
MethdGrp	MethdCode	MethdDescr
Total nitrogen	TN06	Continuous flow analyser after digestion with H2SO4/salicylic acid/H2O2/Se
Total nitrogen	TN07	Nelson and Sommers, 1980
Total nitrogen	TN08	Sample digested by sulphuric acid, distillation of released ammonia, back titration against sulphuric acid
Total nitrogen	TN98	OC * 1.72 / 20 (gives C/N=11.6009)
Total nitrogen	TN99	Unspecified methods
Total phosphorus	TP-	Not measured (Total-P)
Total phosphorus	TP01	Total P; colorimetric in H2SO4-Se-Salicylic acid digest
Total phosphorus	TP02	COLORIMETRIC VANADATE MOLYBDATE
Total phosphorus	TP03	Reagent of Baeyens. Precipitation in form of Phosphomolybdate
Total phosphorus	TP04	acid fleischman
Total phosphorus	TP05	HCl extraction
Total phosphorus	TP05.1	8 M HCl extraction
Total phosphorus	TP05.2	Perchloric acid percolation
Total phosphorus	TP99	Unspecified methods
Total phosphorus	TP99.01	P205

## Annex 5a Dictionary of class value codes

Attribute code	Value code	Value description
ProprtyCod	ValueCode	ValueDescr
CfFldCls	N	None (0%)
CfFldCls	V	Very few (0-2%)
CfFldCls	F	Few (2-5%)
CfFldCls	C	Common (5-15%)
CfFldCls	M	Many (15-40%)
CfFldCls	A	Abundant (40-80%)
CfFldCls	D	Dominant ( $\geq 80\%$ )
CfFldCls	S	Stone line (any content, but concentrated at a distinct depth)
CfNature	N	not known
CfNature	M	manganese (manganiferous)
CfNature	U	sulphur (sulphurous)
CfNature	S	salt (saline)
CfNature	R	residual rock fragments
CfNature	F	iron (ferruginous)
CfNature	K	carbonates (calcareous)
CfNature	I	Iron-manganese (sesquioxides)
CfNature	G	gypsum (gypsiferous)
CfNature	Q	silica (siliceous)
ClyMinera	AL	Allophane
ClyMinera	CH	Chloritic
ClyMinera	IL	Illitic
ClyMinera	IN	Interstratified or mixed
ClyMinera	KA	Kaolinitic
ClyMinera	MO	Montmorilonitic
ClyMinera	SE	Sesquioxidic
ClyMinera	VE	Vermiculitic
Drain	E	Excessively well drained
Drain	S	Somewhat excessively well drained
Drain	W	Well drained
Drain	M	Moderately well drained
Drain	I	Imperfectly drained
Drain	P	Poorly drained
Drain	V	Very poorly drained
FA074	A	Acrisols
FA074	Af	Ferric Acrisols
FA074	Ag	Gleyic Acrisols
FA074	Ah	Humic Acrisols
FA074	Ao	Orthic Acrisols
FA074	Ap	Plinthic Acrisols
FA074	B	Cambisols
FA074	Bc	Chromic Cambisols
FA074	Bd	Dystric Cambisols
FA074	Be	Eutric Cambisols
FA074	Bf	Ferralic Cambisols
FA074	Bg	Gleyic Cambisols

Attribute code	Value code	Value description
ProprtyCod	ValueCode	ValueDescr
FA074	Bh	Humic Cambisols
FA074	Bk	Calcic Cambisols
FA074	Bv	Vertic Cambisols
FA074	Bx	Gelic Cambisols
FA074	C	Chernozems
FA074	Cg	Glosic Chernozems
FA074	Ch	Haplic Chernozems
FA074	Ck	Calcic Chernozems
FA074	Cl	Luvic Chernozems
FA074	D	Podzoluvisols
FA074	Dd	Dystric Podzoluvisols
FA074	De	Eutric Podzoluvisols
FA074	Dg	Gleyic Podzoluvisols
FA074	E	Rendzinas
FA074	F	Ferralsols
FA074	Fa	Acric Ferralsols
FA074	Fh	Humic Ferralsols
FA074	Fo	Orthic Ferralsols
FA074	Fp	Plinthic Ferralsols
FA074	Fr	Rhodic Ferralsols
FA074	Fx	Xanthic Ferralsols
FA074	G	Gleysols
FA074	Gc	Calcaric Gleysols
FA074	Gd	Dystric Gleysols
FA074	Ge	Eutric Gleysols
FA074	Gh	Humic Gleysols
FA074	Gm	Mollic Gleysols
FA074	Gp	Plinthic Gleysols
FA074	Gx	Gelic Gleysols
FA074	H	Phaeozems
FA074	Hc	Calcaric Phaeozems
FA074	Hg	Gleyic Phaeozems
FA074	Hh	Haplic Phaeozems
FA074	Hi	Luvic Phaeozems
FA074	I	Lithosols
FA074	J	Fluvisols
FA074	Jc	Calcaric Fluvisols
FA074	Jd	Dystric Fluvisols
FA074	Je	Eutric Fluvisols
FA074	Jt	Thionic Fluvisols
FA074	K	Kastanozems
FA074	Kh	Haplic Kastanozems
FA074	Kk	Calcic Kastanozems
FA074	Kl	Luvic Kastanozems
FA074	L	Luvisols
FA074	La	Albic Luvisols
FA074	Lc	Chromic Luvisols
FA074	Lf	Ferric Luvisols
FA074	Lg	Gleyic Luvisols
FA074	Lk	Calcic Luvisols
FA074	Lo	Orthic Luvisols
FA074	Lp	Plinthic Luvisols

Attribute code	Value code	Value description
ProprtyCod	ValueCode	ValueDescr
FA074	Lv	Vertic Luvisols
FA074	M	Greyzems
FA074	Mg	Gleyic Greyzem
FA074	Mo	Orthic Greyzem
FA074	N	Nitosols
FA074	Nd	Dystric Nitosols
FA074	Ne	Eutric Nitosols
FA074	Nh	Humic Nitosols
FA074	O	Histosols
FA074	Od	Dystric Histosols
FA074	Oe	Eutric Histosols
FA074	Ox	Gelic Histosols
FA074	P	Podzols
FA074	Pf	Ferric Podzols
FA074	Pg	Gleyic Podzols
FA074	Ph	Humic Podzols
FA074	Pl	Leptic Podzols
FA074	Po	Orthic Podzols
FA074	Pp	Placic Podzols
FA074	Q	Arenosols
FA074	Qa	Albic Arenosols
FA074	Qc	Cambic Arenosols
FA074	Qf	Ferralic Arenosols
FA074	Ql	Luvic Arenosols
FA074	R	Regosols
FA074	Rc	Calcaric Regosols
FA074	Rd	Dystric Regosols
FA074	Re	Eutric Regosols
FA074	Rx	Gelic Regosols
FA074	S	Solonetz
FA074	Sg	Gleyic Solonetz
FA074	Sm	Mollic Solonetz
FA074	So	Orthic Solonetz
FA074	T	Andosols
FA074	Th	Humic Andosols
FA074	Tm	Mollic Andosols
FA074	To	Ochric Andosols
FA074	Tv	Vitric Andosols
FA074	U	Rankers
FA074	V	Vertisols
FA074	Vc	Chromic Vertisols
FA074	Vp	Pellic Vertisols
FA074	W	Planosols
FA074	Wd	Dystric Planosols
FA074	We	Eutric Planosols
FA074	Wh	Humic Planosols
FA074	Wm	Mollic Planosols
FA074	Ws	Sodic Planosols
FA074	Wx	Gelic Planosols
FA074	X	Xerosols
FA074	Xh	Haplic Xerosols
FA074	Xk	Calcic Xerosols

Attribute code	Value code	Value description
ProprtyCod	ValueCode	ValueDescr
FA074	XI	Luvic Xerosols
FA074	Xy	Gypsic Xerosols
FA074	Y	Yermosols
FA074	Yh	Haplic Yermosols
FA074	Yk	Calcic Yermosols
FA074	Yl	Luvic Yermosols
FA074	Yt	Takyric Yermosols
FA074	Yy	Gypsic Yermosols
FA074	Z	Solonchaks
FA074	Zg	Gleyic Solonchaks
FA074	Zm	Mollic Solonchaks
FA074	Zo	Orthic Solonchaks
FA074	Zt	Takyric Solonchaks
FA088	AC	Acrisols
FA088	ACf	Ferric Acrisols
FA088	ACg	Gleyic Acrisols
FA088	ACh	Haplic Acrisols
FA088	ACp	Plinthic Acrisols
FA088	ACu	Humic Acrisols
FA088	AL	Alisols
FA088	ALf	Ferric Alisols
FA088	ALg	Gleyic Alisols
FA088	ALh	Haplic Alisols
FA088	ALj	Stagnic Alisols
FA088	ALp	Plinthic Alisols
FA088	ALu	Humic Alisols
FA088	AN	Andosols
FA088	ANg	Gleyic Andosols
FA088	ANh	Haplic Andosols
FA088	ANi	Gelic Andosols
FA088	ANm	Mollic Andosols
FA088	ANu	Umbric Andosols
FA088	ANz	Vitric Andosols
FA088	AR	Arenosols
FA088	ARa	Albic Arenosols
FA088	ARb	Cambic Arenosols
FA088	ARc	Calcaric Arenosols
FA088	ARg	Gleyic Arenosols
FA088	ARh	Haplic Arenosols
FA088	ARl	Luvic Arenosols
FA088	ARo	Ferralic Arenosols
FA088	AT	Anthrosols
FA088	Ata	Aric Anthrosols
FA088	ATc	Cumulic Anthrosols
FA088	ATf	Fimic Anthrosols
FA088	ATu	Urbic Anthrosols
FA088	CH	Chernozems
FA088	CHg	Gleyic Chernozems
FA088	CHh	Haplic Chernozems
FA088	CHk	Calcic Chernozems
FA088	CHI	Luvic Chernozems
FA088	CHw	Glosic Chernozems

Attribute code	Value code	Value description
ProprtyCod	ValueCode	ValueDescr
FA088	CL	Calcisols
FA088	CLh	Haplic Calcisols
FA088	CLI	Luvic Calcisols
FA088	CLp	Petric Calcisols
FA088	CM	Cambisols
FA088	CMc	Calcaric Cambisols
FA088	CMd	Dystric Cambisols
FA088	CMe	Eutric Cambisols
FA088	CMg	Gleyic Cambisols
FA088	CMi	Gelic Cambisols
FA088	CMo	Ferralic Cambisols
FA088	CMu	Humic Cambisols
FA088	CMv	Vertic Cambisols
FA088	CMx	Chromic Cambisols
FA088	FL	Fluvisols
FA088	FLc	Calcaric Fluvisols
FA088	FLd	Dystric Fluvisols
FA088	FLe	Eutric Fluvisols
FA088	FLm	Mollic Fluvisols
FA088	FLs	Salic Fluvisols
FA088	FLt	Thionic Fluvisols
FA088	FLu	Umbric Fluvisols
FA088	FR	Ferralsols
FA088	FRg	Geric Ferralsols
FA088	FRh	Haplic Ferralsols
FA088	FRp	Plinthic Ferralsols
FA088	FRr	Rhodic Ferralsols
FA088	FRu	Humic Ferralsols
FA088	FRx	Xanthic Ferralsols
FA088	GL	Gleysols
FA088	GLa	Andic Gleysols
FA088	GLd	Dystric Gleysols
FA088	GLE	Eutric Gleysols
FA088	GLi	Gelic Gleysols
FA088	GLk	Calcic Gleysols
FA088	GLm	Mollic Gleysols
FA088	GLt	Thionic Gleysols
FA088	GLu	Umbric Gleysols
FA088	GR	Greyzems
FA088	GRg	Gleyic Greyzems
FA088	GRh	Haplic Greyzems
FA088	GY	Gypsisols
FA088	GYh	Haplic Gypsisols
FA088	GYk	Calcic Gypsisols
FA088	GYl	Luvic Gypsisols
FA088	GYp	Petric Gypsisols
FA088	HS	Histosols
FA088	HSf	Fibric Histosols
FA088	HSi	Gelic Histosols
FA088	HSI	Folic Histosols
FA088	HS	Terric Histosols
FA088	HSt	Thionic Histosols

Attribute code	Value code	Value description
ProprtyCod	ValueCode	ValueDescr
FA088	KS	Kastanozems
FA088	KSh	Haplic Kastanozems
FA088	KSk	Calcic Kastanozems
FA088	KSI	Luvic Kastanozems
FA088	KSy	Gypsic Kastanozems
FA088	LP	Leptosols
FA088	LPd	Dystric Leptosols
FA088	LPe	Eutric Leptosols
FA088	LPi	Gelic Leptosols
FA088	LPk	Rendzic Leptosols
FA088	LPm	Mollic Leptosols
FA088	LPq	Lithic Leptosols
FA088	LPu	Umbric Leptosols
FA088	LV	Luvisols
FA088	LVa	Albic Luvisols
FA088	LVf	Ferric Luvisols
FA088	LVg	Gleyic Luvisols
FA088	LVh	Haplic Luvisols
FA088	LVj	Stagnic Luvisols
FA088	LVk	Calcic Luvisols
FA088	LVv	Vertic Luvisols
FA088	LVx	Chromic Luvisols
FA088	LX	Lixisols
FA088	LXa	Albic Lixisols
FA088	LXf	Ferric Lixisols
FA088	LXg	Gleyic Lixisols
FA088	LXh	Haplic Lixisols
FA088	LXj	Stagnic Lixisols
FA088	LXp	Plinthic Lixisols
FA088	NT	Nitisols
FA088	NTh	Haplic Nitisols
FA088	NTr	Rhodic Nitisols
FA088	NTu	Humic Nitisols
FA088	PD	Podzoluvisols
FA088	PDd	Dystric Podzoluvisols
FA088	PDe	Eutric Podzoluvisols
FA088	PDg	Gleyic Podzoluvisols
FA088	PDi	Gelic Podzoluvisols
FA088	PDj	Stagnic Podzoluvisols
FA088	PH	Phaeozems
FA088	PHc	Calcaric Phaeozems
FA088	PHg	Gleyic Phaeozems
FA088	PHh	Haplic Phaeozems
FA088	PHj	Stagnic Phaeozems
FA088	PHI	Luvic Phaeozems
FA088	PL	Planosols
FA088	PLd	Dystric Planosols
FA088	PLe	Eutric Planosols
FA088	PLi	Gelic Planosols
FA088	PLm	Mollic Planosols
FA088	PLu	Umbric Planosols
FA088	PT	Plinthosols



Attribute code	Value code	Value description
ProprtyCod	ValueCode	ValueDescr
FA088	PTa	Albic Plinthosols
FA088	PTd	Dystric Plinthosols
FA088	PTe	Eutric Plinthosols
FA088	PTu	Humic Plinthosols
FA088	PZ	Podzols
FA088	PZb	Cambic Podzols
FA088	PZc	Carbic Podzols
FA088	PZf	Ferric Podzols
FA088	PZg	Gleyic Podzols
FA088	PZh	Haplic Podzols
FA088	PZi	Gelic Podzols
FA088	RG	Regosols
FA088	RGc	Calcaric Regosols
FA088	RGd	Dystric Regosols
FA088	RGe	Eutric Regosols
FA088	RGi	Gelic Regosols
FA088	RGu	Umbric Regosols
FA088	RGy	Gypsic Regosols
FA088	SC	Solonchaks
FA088	SCg	Gleyic Solonchaks
FA088	SCh	Haplic Solonchaks
FA088	SCi	Gelic Solonchaks
FA088	SCK	Calcic Solonchaks
FA088	SCm	Mollic Solonchaks
FA088	SCn	Sodic Solonchaks
FA088	SCy	Gypsic Solonchaks
FA088	SN	Solonetz
FA088	SNg	Gleyic Solonetz
FA088	SNh	Haplic Solonetz
FA088	SNj	Stagnic Solonetz
FA088	SNk	Calcic Solonetz
FA088	SNm	Mollic Solonetz
FA088	SNy	Gypsic Solonetz
FA088	VR	Vertisols
FA088	VRd	Dystric Vertisols
FA088	VRe	Eutric Vertisols
FA088	VRk	Calcic Vertisols
FA088	VRy	Gypsic Vertisols
FldTxtr	S	Sand
FldTxtr	LS	Loamy sand
FldTxtr	SL	Sandy loam
FldTxtr	SIL	Silty loam
FldTxtr	SI	Silt
FldTxtr	L	Loam
FldTxtr	SCL	Sandy clay loam
FldTxtr	CL	Clay loam
FldTxtr	SICL	Silty clay loam
FldTxtr	SC	Sandy clay
FldTxtr	SIC	Silty clay
FldTxtr	C	Clay
FldTxtr	HC	Heavy clay

Attribute code	Value code	Value description
PrpertyCod	ValueCode	ValueDescr
FrqFlood	N	None
FrqFlood	D	Daily
FrqFlood	W	Weekly
FrqFlood	M	Monthly
FrqFlood	A	Annually
FrqFlood	B	Biennially
FrqFlood	F	Once every 2-5 years
FrqFlood	T	Once every 5-10 years
FrqFlood	R	Rare (less than once in every 10 years)
FrqFlood	U	Unknown
HorDes	H	H horizon/layer
HorDes	O	O horizon/layer
HorDes	A	A horizon
HorDes	E	E horizon
HorDes	B	B horizon
HorDes	C	C horizon/layer
HorDes	R	R layer
HorDes	I	I Layer
HorDes	L	L Layer
HorDes	W	Water Layer
LndCov	I	Closed forest
LndCov	IA	Mainly evergreen forest
LndCov	IA1	Tropical ombrophilous forest (tropical rain forest)
LndCov	IA2	Tropical and subtropical evergreen seasonal forest
LndCov	IA3	Tropical and subtropical semi-deciduous forest
LndCov	IA4	Subtropical ombrophilous forest
LndCov	IA5	Mangrove forest
LndCov	IA6	Temperate and subpolar evergreen ombrophilous forest
LndCov	IA7	Temperate evergreen seasonal broad-leaved forest
LndCov	IA8	Winter-rain evergreen broad-leaved sclerophyllous forest
LndCov	IA9	Tropical and subtropical evergreen needle-leaved forest
LndCov	IA10	Temperate and subpolar evergreen needle-leaved forest
LndCov	IB	Mainly deciduous forest
LndCov	IB1	Tropical and subtropical drought-deciduous forest
LndCov	IB2	Cold-deciduous forest with evergreen trees (or shrubs)
LndCov	IB3	Cold-deciduous forest without evergreen trees
LndCov	IC	Extremely Xeromorphic forest
LndCov	IC1	Sclerophyllous-dominated extremely xeromorphic forest
LndCov	IC2	Thorn forest
LndCov	IC3	Mainly succulent forest
LndCov	II	Woodland
LndCov	IIA	Mainly evergreen woodland
LndCov	IIA1	Evergreen broad-leaved woodland
LndCov	IIA2	Evergreen needle-leaved forest (woodland)
LndCov	IIB	Mainly deciduous woodland
LndCov	IIB1	Drought-deciduous woodland
LndCov	IIB2	Cold-deciduous woodland with evergreen trees
LndCov	IIB3	Cold-deciduous woodland without evergreen trees
LndCov	IIC	Extremely xeromorphic woodland
LndCov	IIC1	Sclerophyllous-dominated extremely xeromorphic woodland
LndCov	IIC2	Thorn woodland
LndCov	IIC3	Mainly succulent woodland

Attribute code	Value code	Value description
ProprtyCod	ValueCode	ValueDescr
LndCov	III	Scrub (shrubland or thicket)
LndCov	IIIA	Mainly evergreen shrub
LndCov	IIIA1	Evergreen broad-leaved shrubland (or thicket)
LndCov	IIIA2	Evergreen needle-leaved and microphyllous shrubland
LndCov	IIIB	Mainly deciduous scrub
LndCov	IIIB1	Drought-deciduous scrub with evergreen woody plants admixed
LndCov	IIIB2	Drought-decid. scrub without evergreen woody plants admixed
LndCov	IIIB3	Cold-deciduous scrub
LndCov	IIIC	Extremely xeromorphic (subdesert) shrubland
LndCov	IIIC1	Mainly evergreen subdesert shrubland
LndCov	IIIC2	Deciduous subdesert shrubland
LndCov	IV	Dwarf-scrub and related communities
LndCov	IVA	Mainly evergreen dwarf-scrub
LndCov	IVA1	Evergreen dwarf-scrub thicket
LndCov	IVA2	Evergreen dwarf-shrubland
LndCov	IVA3	Mixed evergreen dwarf-shrub and herbaceous formation
LndCov	IVB	Mainly deciduous dwarf-scrub
LndCov	IVB1	Facultatively drought-deciduous dwarf-thicket
LndCov	IVB2	Obligatory, drought-deciduous dwarf-thicket
LndCov	IVB3	Cold-deciduous dwarf-thicket (or dwarf-shrubland)
LndCov	IVC	Extremely xeromorphic dwarf-shrubland
LndCov	IVC1	Mainly evergreen subdesert dwarf-shrubland
LndCov	IVC2	Deciduous subdesert dwarf-shrubland
LndCov	IVD	Tundra
LndCov	IVD1	Mainly bryophyte tundra
LndCov	IVD2	Mainly lichen tundra
LndCov	IVE	Mossy bog formations with dwarf-shrub
LndCov	IVE1	Raised bog
LndCov	IVE2	Non-raised bog
LndCov	V	Herbaceous vegetation
LndCov	VA	Tall graminoid vegetation
LndCov	VA1	Tall grassland with a tree synusia covering 10-40%
LndCov	VA2	Tall grassland with a tree synusia covering less than 10%
LndCov	VA3	Tall grassland with a synusia of shrubs
LndCov	VA4	Tall grassland with a woody synusia of mainly tuft plants
LndCov	VA5	Tall grassland practically without woody synusia
LndCov	VB	Medium tall grassland
LndCov	VB1	Medium tall grassland with a tree synusia covering 10-40%
LndCov	VB2	Medium tall grassland with tree synusia cover less than 10%
LndCov	VB3	Medium tall grassland with a synusia of shrubs
LndCov	VB4	Medium tall grassland with an open synusia of tuft plants
LndCov	VB5	Medium tall grassland practically without woody synusia
LndCov	VC	Short grassland
LndCov	VC1	Short grassland with a tree synusia covering 10-40%
LndCov	VC2	Short grassland with a tree synusia covering less than 10%
LndCov	VC3	Short grassland with a synusia of shrubs
LndCov	VC4	Short grassland with an open synusia of tuft plants
LndCov	VC5	Short grassland practically without woody synusia
LndCov	VC6	Short to medium tall mesophytic grassland
LndCov	VC7	Graminoid tundra
LndCov	VD	Forb vegetation
LndCov	VD1	Tall forb communities

Attribute code	Value code	Value description
ProprtyCod	ValueCode	ValueDescr
LndCov	VD2	Low forb communities
LndCov	VE	Hydromorphic fresh-water vegetation
LndCov	VE1	Rooted fresh-water communities
LndCov	VE2	Free floating fresh-water communities
LndCov	VI	Barren
LndCov	VIB	Non-vegetated or very sparse vegetation less than 5%
LndForm	L	level land (<10%)
LndForm	LP	plain
LndForm	LL	plateau
LndForm	LD	depression
LndForm	LF	low gradient footslope
LndForm	LV	valley floor
LndForm	S	sloping land (10-30%)
LndForm	SE	medium-gradient escarpment zone
LndForm	SH	medium-gradient hill
LndForm	SM	medium-gradient mountain
LndForm	SP	dissected plain
LndForm	SV	medium-gradient valley
LndForm	T	steep land (>30%)
LndForm	TE	high-gradient escarpment zone
LndForm	TH	high-gradient hill
LndForm	TM	high-gradient mountain
LndForm	TV	high-gradient valleys
LndUse	S	Residential, industrial use
LndUse	SR	Residential use, cities
LndUse	SI	Industrial use
LndUse	ST	Transport (roads, railways etc.)
LndUse	SC	Recreation
LndUse	SX	Excavations, quarries
LndUse	A	Land used for cultivation of crops
LndUse	AA	Annual field cropping
LndUse	AA1	Shifting cultivation
LndUse	AA2	Fallow system cultivation
LndUse	AA3	Ley system cultivation
LndUse	AA4	Rainfed arable cultivation
LndUse	AA5	Wet rice cultivation
LndUse	AA6	Irrigated cultivation
LndUse	AP	Perennial field cropping
LndUse	AP1	Non-irrigated perennial field cropping
LndUse	AP2	Irrigated perennial field cropping
LndUse	AT	Tree and shrub cropping
LndUse	AT1	Non-irrigated tree crop cultivation
LndUse	AT2	Irrigated tree crop cultivation
LndUse	AT3	Non-irrigated shrub crop cultivation
LndUse	AT4	Irrigated shrub crop cultivation
LndUse	H	Animal husbandry
LndUse	HE	Extensive grazing
LndUse	HE1	Nomadism
LndUse	HE2	Semi-nomadism
LndUse	HE3	Ranching
LndUse	HI	Intensive grazing
LndUse	HI1	Intensive grazing - animal production

Attribute code	Value code	Value description
PrpertyCod	ValueCode	ValueDescr
LndUse	HI2	Intensive grazing - dairying
LndUse	F	Forestry
LndUse	FN	Exploitation of natural forest and woodland
LndUse	FN1	Selective felling
LndUse	FN2	Clear felling
LndUse	FP	Plantation forestry
LndUse	M	Mixed farming
LndUse	MF	Agro-forestry
LndUse	MP	Agro-pastoralism
LndUse	E	Extraction of products from the environment
LndUse	EV	Exploitation of natural vegetation
LndUse	EH	Hunting and fishing
LndUse	P	Nature protection
LndUse	PN	Nature and game preservation
LndUse	PN1	Reserves
LndUse	PN2	Parks
LndUse	PN3	Wildlife management
LndUse	PD	Degradation control
LndUse	PD1	Degradation control - non-interference
LndUse	PD2	Degradation control - interference
LndUse	U	Not used and not managed
Mottling	Y	Presence of mottles
Mottling	N	No presence of mottles
ParMat	M	M metamorphic rocks
ParMat	MA	MA acid metamorphic rocks
ParMat	MA1	MA1 quartzite
ParMat	MA2	MA2 gneiss
ParMat	MA3	MA3 phyllite, slate
ParMat	MA4	MA4 granulite
ParMat	MA5	MA5 migmatite
ParMat	MB	MB basic metamorphic rocks
ParMat	MB1	MB1 slate, phyllite
ParMat	MB2	MB2 (mica-) schist
ParMat	MB3	MB3 (green-) schist
ParMat	MB4	MB4 gneiss rich in ferro-magnesian minerals
ParMat	MB5	MB5 amphibolite
ParMat	MB6	MB6 eclogite
ParMat	MB7	MB7 skarn
ParMat	MC	MC calcareous metamorphic rocks
ParMat	MC1	MC1 metamorphic limestone(marble)
ParMat	MU	MU metasomatic and hydrothermal rocks
ParMat	MU1	MU1 serpentine
ParMat	MU2	MU2 iron ore
ParMat	P	P plutonic rocks
ParMat	PA	PA acid
ParMat	PA1	PA1 granite
ParMat	PA2	PA2 tonalite (quartz-diorite)
ParMat	PA3	PA3 granodiorite
ParMat	PA4	PA4 aplite
ParMat	PA5	PA5 quartz-rich granitoids, quartzolite
ParMat	PB	PB basic plutonic rocks
ParMat	PB1	PB1 gabbro

Attribute code	Value code	Value description
ProprtyCod	ValueCode	ValueDescr
ParMat	PI	PI intermediate
ParMat	PI1	PI1 diorite
ParMat	PQ	PQ acid to intermediate
ParMat	PQ1	PQ1 foid-bearing syenite
ParMat	PU	PU ultrabasic plutonic rocks
ParMat	PU1	PU1 peridotite
ParMat	PU2	PU2 pyroxenite
ParMat	PU3	PU3 horblendite
ParMat	PW	PW intermediate to basic
ParMat	PW1	PW1 syenite
ParMat	PW2	PW2 monzonite
ParMat	S	S sedimentary rocks (consolidated)
ParMat	SA	SA psammite or arenite
ParMat	SA1	SA1 sandstone
ParMat	SE	SE evaporites
ParMat	SE1	SE1 anhydrite, gypsum
ParMat	SE2	SE2 halite, sylvite
ParMat	SI	SI ironstone
ParMat	SI1	SI1 ironstone
ParMat	SL	SL pelite or lutite
ParMat	SL1	SL1 siltstone
ParMat	SL2	SL2 claystone
ParMat	SL3	SL3 shale
ParMat	SL4	SL4 mudstone
ParMat	SL5	SL5 diamictite
ParMat	SO	SO calcareous rocks
ParMat	SO1	SO1 limestone, chalk, dolomite and other carbonate rocks
ParMat	SO2	SO2 marl, marlstone, and other mixtures
ParMat	SP	SP psephite or rudite
ParMat	SP1	SP1 conglomerate
ParMat	SP2	SP2 breccia
ParMat	SQ	SQ organic-rich rocks
ParMat	SQ1	SQ1 coal, bitumen & related rocks
ParMat	SS	SS siliceous rock
ParMat	SS1	SS1 chert, hornstone, flint, diatomite, radiolarite
ParMat	SX	SX phosphorites
ParMat	SX1	SX1 guano
ParMat	U	U unconsolidated deposits
ParMat	U0	U0 group unknown
ParMat	U000	U000 subgroup and type unknown
ParMat	U00CF	U00CF subgroup unknown collo-fluvial
ParMat	U00F	U00F subgroup unknown fluvial
ParMat	UA	UA anthropogenic/ technogenic
ParMat	UAI	UAI industrial/artisanal deposits
ParMat	UAN	UAN redeposited natural materials
ParMat	UI	UI iron-sediment
ParMat	UL	UL lime-sediment
ParMat	UO	UO peat & organic rich sediments
ParMat	U01	U01 rainwater fed peat
ParMat	U02	U02 groundwater fed peat
ParMat	U03	U03 sapropel
ParMat	UP	UP phosphate-sediment

Attribute code	Value code	Value description
ProprtyCod	ValueCode	ValueDescr
ParMat	UQ	UQ gravelly
ParMat	UQ0C	UQ0C colluvial, unspecified
ParMat	UQ0F	UQ0F fluvial, unspecified
ParMat	UQ0G	UQ0G glaciofluvial, unspecified
ParMat	UQ0M	UQ0M marine and estuarine, unspecified
ParMat	UQ0T	UQ0T glacial till, unspecified
ParMat	UQ1C	UQ1C colluvial, not calcareous
ParMat	UQ1F	UQ1F fluvial, not calcareous
ParMat	UQ1G	UQ1G glaciofluvial, not calcareous
ParMat	UQ1M	UQ1M marine and estuarine, not calcareous
ParMat	UQ1T	UQ1T glacial till, not calcareous
ParMat	UQ2C	UQ2C colluvial, calcareous
ParMat	UQ2F	UQ2F fluvial, calcareous
ParMat	UQ2G	UQ2G glaciofluvial, calcareous
ParMat	UQ2M	UQ2M marine and estuarine, calcareous
ParMat	UQ2T	UQ2T glacial till, calcareous
ParMat	UR	UR weathering residuum
ParMat	UR1	UR1 bauxite
ParMat	US	US sandy
ParMat	US0C	US0C colluvial, unspecified
ParMat	US0E	US0E eolian, unspecified
ParMat	US0F	US0F fluvial, unspecified
ParMat	US0G	US0G glaciofluvial, unspecified
ParMat	US0L	US0L lacustrine, unspecified
ParMat	US0M	US0M marine and estuarine, unspecified
ParMat	US0T	US0T glacial till, unspecified
ParMat	US1C	US1C colluvial, not calcareous
ParMat	US1E	US1E eolian, not calcareous
ParMat	US1F	US1F fluvial, not calcareous
ParMat	US1G	US1G glaciofluvial, not calcareous
ParMat	US1L	US1L lacustrine, not calcareous
ParMat	US1M	US1M marine and estuarine, not calcareous
ParMat	US1T	US1T glacial till, not calcareous
ParMat	US2C	US2C colluvial, calcareous
ParMat	US2E	US2E eolian, calcareous
ParMat	US2F	US2F fluvial, calcareous
ParMat	US2G	US2G glaciofluvial, calcareous
ParMat	US2L	US2L lacustrine, calcareous
ParMat	US2M	US2M marine and estuarine, calcareous
ParMat	US2T	US2T glacial till, calcareous
ParMat	UT	UT silty, loamy
ParMat	UT0C	UT0C colluvial, unspecified
ParMat	UT0E	UT0E eolian, unspecified
ParMat	UT0F	UT0F fluvial, unspecified
ParMat	UT0L	UT0L lacustrine, unspecified
ParMat	UT0M	UT0M marine and estuarine, unspecified
ParMat	UT0T	UT0T glacial till, unspecified
ParMat	UT1C	UT1C colluvial, not calcareous
ParMat	UT1E	UT1E eolian, not calcareous
ParMat	UT1F	UT1F fluvial, not calcareous
ParMat	UT1L	UT1L lacustrine, not calcareous
ParMat	UT1M	UT1M marine and estuarine, not calcareous

Attribute code	Value code	Value description
ProprtyCod	ValueCode	ValueDescr
ParMat	UT1T	UT1T glacial till, not calcareous
ParMat	UT2C	UT2C colluvial, calcareous
ParMat	UT2E	UT2E eolian, calcareous
ParMat	UT2F	UT2F fluvial, calcareous
ParMat	UT2L	UT2L lacustrine, calcareous
ParMat	UT2M	UT2M marine and estuarine, calcareous
ParMat	UT2T	UT2T glacial till, calcareous
ParMat	UU	UU diamicton (unsorted)
ParMat	UU0C	UU0C colluvial, unspecified
ParMat	UU0F	UU0F fluvial, unspecified
ParMat	UU0G	UU0G glaciofluvial, unspecified
ParMat	UU0L	UU0L lacustrine, unspecified
ParMat	UU0M	UU0M marine and estuarine, unspecified
ParMat	UU0T	UU0T glacial till, unspecified
ParMat	UU1C	UU1C colluvial, not calcareous
ParMat	UU1F	UU1F fluvial, not calcareous
ParMat	UU1G	UU1G glaciofluvial, not calcareous
ParMat	UU1L	UU1L lacustrine, not calcareous
ParMat	UU1M	UU1M marine and estuarine, not calcareous
ParMat	UU1T	UU1T glacial till, not calcareous
ParMat	UU2C	UU2C colluvial, calcareous
ParMat	UU2F	UU2F fluvial, calcareous
ParMat	UU2G	UU2G glaciofluvial, calcareous
ParMat	UU2L	UU2L lacustrine, calcareous
ParMat	UU2M	UU2M marine and estuarine, calcareous
ParMat	UU2T	UU2T glacial till, calcareous
ParMat	UX	UX siliceous-ooze
ParMat	UY	UY clayey
ParMat	UY0C	UY0C colluvial, unspecified
ParMat	UY0E	UY0E eolian, unspecified
ParMat	UY0F	UY0F fluvial, unspecified
ParMat	UY0L	UY0L lacustrine, unspecified
ParMat	UY0M	UY0M marine and estuarine, unspecified
ParMat	UY0T	UY0T glacial till, unspecified
ParMat	UY1C	UY1C colluvial, not calcareous
ParMat	UY1E	UY1E eolian, not calcareous
ParMat	UY1F	UY1F fluvial, not calcareous
ParMat	UY1L	UY1L lacustrine, not calcareous
ParMat	UY1M	UY1M marine and estuarine, not calcareous
ParMat	UY1T	UY1T glacial till, not calcareous
ParMat	UY2C	UY2C colluvial, calcareous
ParMat	UY2E	UY2E eolian, calcareous
ParMat	UY2F	UY2F fluvial, calcareous
ParMat	UY2L	UY2L lacustrine, calcareous
ParMat	UY2M	UY2M marine and estuarine, calcareous
ParMat	UY2T	UY2T glacial till, calcareous
ParMat	V	V volcanic rocks
ParMat	VA	VA acid
ParMat	VA1	VA1 rhyolite
ParMat	VA2	VA2 dacite
ParMat	VB	VB basic volcanic rocks
ParMat	VB1	VB1 basalt



Attribute code	Value code	Value description
PropertyCod	ValueCode	ValueDescr
ParMat	VI	VI intermediate
ParMat	VI1	VI1 andesite, trachyandesite
ParMat	VJ	VJ acid to basic
ParMat	VJ1	VJ1 phonolite
ParMat	VP	VP pyroclastic rocks (tephra)
ParMat	VP1	VP1 tuff, tuffstone, tuffite, pumice
ParMat	VP2	VP2 scoria
ParMat	VP3	VP3 pyroclastic-breccia
ParMat	VP4	VP4 volcanic ash
ParMat	VP5	VP5 ignimbrite
ParMat	VP6	VP6 lappilstone
ParMat	VQ	VQ acid to intermediate
ParMat	VQ1	VQ1 trachyte, trachydacite
ParMat	VU	VU ultrabasic volcanic rocks
ParMat	VU1	VU1 picrobasalt
ParMat	VU2	VU2 basanite
ParMat	VW	VW intermediate to basic
ParMat	VW1	VW1 basaltic-trachyandesit,
ParMat	VW2	VW2 phono-thephrite, tephri-phonolite
Regolith	R	Residuum
Regolith	U	Unknown
Regolith	M	Mixed origin
Regolith	T	Transported
Reliab	1	Reference profile description, high reliability
Reliab	2	Routine profile description, moderately high reliability
Reliab	3	Incomplete description, moderately low reliability
Reliab	4	Other descriptions, low reliability
Roots	Y	Presence of roots
Roots	N	No presence of roots (at most very few)
RtblDpth	V	Very shallow (<30 cm)
RtblDpth	S	Shallow (30-50 cm)
RtblDpth	M	Moderately deep (50-100 cm)
RtblDpth	D	Deep (100-150 cm)
RtblDpth	X	Very deep (≥ 150 cm)
SaltAlkl	Y	Notable presence of Salt or Alkali
SaltAlkl	N	No notable presence of Salt or Alkali
SlpForm	U	Uniform slope
SlpForm	C	Concave, lower slope with decreasing gradient downslope
SlpForm	V	Convex, upper slope with decreasing gradient upslope
SlpForm	T	Terraced
SlpForm	I	Irregular (complex) slope
SlpPosit	H	High
SlpPosit	M	Middle
SlpPosit	L	Low
SlpPosit	D	Lowest
SlpPosit	A	All
SrfCrck	Y	Presence of Surface Cracks
SrfCrck	N	No presence of Surface Cracks
SrfDrain	V	Very rapid
SrfDrain	R	Rapid
SrfDrain	W	Well

Attribute code	Value code	Value description
ProprtyCod	ValueCode	ValueDescr
SrfDrain	M	Moderately well
SrfDrain	S	Slow
SrfDrain	E	Extremely slow
SrfSeal	Y	Notable presence of Surface Sealing / Crust
SrfSeal	N	No notable presence of Surface Sealing / Crust
SrfStone	N	None (0%)
SrfStone	V	Very few (0-2%)
SrfStone	F	Few (2-5%)
SrfStone	C	Common (5-15%)
SrfStone	M	Many (15-40%)
SrfStone	A	Abundant (40-80%)
SrfStone	D	Dominant (≥ 80%)
Sticknss	NST	Non-sticky
Sticknss	SST	Slightly sticky
Sticknss	ST	Sticky
Sticknss	VST	Very sticky
StrGrade	N	Structureless
StrGrade	W	Weak
StrGrade	M	Moderate
StrGrade	S	Strong
StrSize	V	Very fine
StrSize	F	Fine
StrSize	M	Medium
StrSize	C	Coarse
StrSize	X	Very coarse
StrSize	E	Extremely coarse
StrType	P	Platy
StrType	R	Prismatic
StrType	C	Columnar
StrType	A	Angular blocky
StrType	S	Subangular blocky
StrType	G	Granular
StrType	B	Crumb
StrType	M	Massive
StrType	N	Single grain
StrType	W	Wedge shaped
StrType	K	Rock structure
StrType	BL	Blocky
Topogrph	W0	0-0.5% flat, wet
Topogrph	F0	0.5-2% flat
Topogrph	G0	2-5% gently undulating
Topogrph	U0	5-10% undulating
Topogrph	R0	10-15% rolling
Topogrph	S0	15-30% moderately steep
Topogrph	T0	30-45% steep
Topogrph	V0	45-60% very steep
Topogrph	E0	>60% extremely steep
Transitn	A	Abrupt (0-2 cm)
Transitn	C	Clear (2-5 cm)
Transitn	G	Gradual (5-15 cm)
Transitn	D	Diffuse (≥ 15 cm)

## Annex 5b Classification of soil parent material (after eSOTER2012, intermediate version)

Major class	Group	Type
P plutonic rocks	PA acid	PA1 granite
		PA2 tonalite (quartz-diorite)
		PA3 granodiorite
		PA4 aplite
		PA5 quartz-rich granitoids, quartzolite
	PQ acid to intermediate	PQ1 foid-bearing syenite
	PI intermediate	PI1 diorite
	PW intermediate to basic	PW1 syenite
		PW2 monzonite
	PB basic plutonic rocks	PB1 gabbro
PU ultrabasic plutonic rocks	PU1 peridotite	
	PU2 pyroxenite	
	PU3 hornblende	
V volcanic rocks	VA acid	VA1 rhyolite
		VA2 dacite
	VQ acid to intermediate	VQ1 trachyte, trachydacite
	VI intermediate	VI1 andesite, trachyandesite
	VW intermediate to basic	VW1 basaltic-trachyandesite,
		VW2 phonothephrite, tephri-phonolite
	VJ acid to basic	VJ1 phonolite
	VB basic volcanic rocks	VB1 basalt
	VU ultrabasic volcanic rocks	VU1 picrobasalt
		VU2 basanite
	VP pyroclastic rocks (tephra)	VP1 tuff, tuffstone, tuffite, pumice
		VP2 scoria
		VP3 pyroclastic-breccia
VP4 volcanic ash		
VP5 ignimbrite		
VP6 lapillistone		
M metamorphic rocks	MA acid metamorphic rocks	MA1 quartzite
		MA2 gneiss
		MA3 phyllite, slate
		MA4 granulite
		MA5 migmatite
	MB basic metamorphic rocks	MB1 slate, phyllite
		MB2 (mica-) schist
		MB3 (green-) schist
		MB4 gneiss rich in ferro-magnesian minerals
		MB5 amphibolite
		MB6 eclogite
		MB7 skarn
	MC calcareous metamorphic rocks	MC1 metamorphic limestone(marble)
	MU metasomatic and hydrothermal rocks	MU1 serpentine
MU2 iron ore		

<b>Major class</b>	<b>Group</b>	<b>Type</b>				
<b>S</b> sedimentary rocks (consolidated)	<b>SP</b> psephite or rudite	<b>SP1</b> conglomerate <b>SP2</b> breccia				
	<b>SA</b> psammite or arenite	<b>SA1</b> sandstone				
	<b>SL</b> pelite or lutite	<b>SL1</b> siltstone <b>SL2</b> claystone <b>SL3</b> shale <b>SL4</b> mudstone <b>SL5</b> diamictite				
	<b>SO</b> calcareous rocks	<b>SO1</b> limestone, chalk, dolomite and other carbonate rocks <b>SO2</b> marl, marlstone, and other mixtures				
	<b>SE</b> evaporites	<b>SE1</b> anhydrite, gypsum <b>SE2</b> halite, sylvite				
	<b>SQ</b> organic-rich rocks	<b>SQ1</b> coal, bitumen & related rocks				
	<b>SS</b> siliceous rock	<b>SS1</b> chert, hornstone, flint, diatomite, radiolarite				
	<b>SX</b> phosphorites	<b>SX1</b> guano				
	<b>SI</b> ironstone	<b>SI1</b> ironstone				
	<b>U</b> unconsolidated deposits (alluvium, slope deposits, glacial drift)	<b>UQ</b> gravelly	<b>UQxF</b> fluvial <b>UQxM</b> marine and estuarine <b>UQxC</b> colluvial <b>UQxG</b> glaciofluvial <b>UQxT</b> glacial till			
<b>US</b> sandy			<b>USxF</b> fluvial <b>USxL</b> lacustrine <b>USxM</b> marine and estuarine <b>USxC</b> colluvial <b>USxG</b> glaciofluvial <b>USxT</b> glacial till <b>USxE</b> eolian			
			<b>UT</b> silty, loamy	<b>UTxF</b> fluvial <b>UTxL</b> lacustrine <b>UTxM</b> marine and estuarine <b>UTxC</b> colluvial <b>UTxT</b> glacial till <b>UTxE</b> eolian		
				<b>UY</b> clayey	<b>UYxF</b> fluvial <b>UYxL</b> lacustrine <b>UYxM</b> marine and estuarine <b>UYxC</b> colluvial <b>UYxT</b> glacial till <b>UYxE</b> eolian	
					<b>UU</b> diamicton (unsorted)	<b>UUxF</b> fluvial <b>UUxL</b> lacustrine <b>UUxM</b> marine and estuarine <b>UUxC</b> colluvial <b>UUxG</b> glaciofluvial <b>UUxT</b> glacial till
		<b>UO</b> group unknown				<b>U000</b> subgroup and type unknown <b>U00F</b> subgroup unknown fluvial <b>U00CF</b> subgroup unknown collo-fluvial
						<b>UA</b> anthropogenic/ technogenic
			<b>UL</b> lime-sediment			<b>UAI</b> industrial/artisanal deposits
<b>UP</b> phosphate-sediment						
<b>UI</b> iron-sediment						

<b>Major class</b>	<b>Group</b>	<b>Type</b>
	<b>UX</b> siliceous-ooze	
	<b>UO</b> peat & organic rich sediments	<b>UO1</b> rainwater fed peat <b>UO2</b> groundwater fed peat <b>UO3</b> sapropel
	<b>UR</b> weathering residuum	<b>UR1</b> bauxite

Groups of unconsolidated deposits are subgrouped, with the subgroup indicated as 'x' in Type column. The 'x' is to be replaced by subgroup indicator 0, 1 or 2, for not specified, non calcareous or calcareous, respectively.



## Annex 6 Criteria applied for routine quality control

- 1) Referential integrity.
- 2) Data types.
- 3) Geo-location.
  - a) Exclude: Identify, and subsequently check, profiles for which the geo-location (lat-lon) is unknown (0, 0) or not within the spatial domain of the profile's ISO country code. Correct coordinates, if possible, or exclude profile.
- 4) Layer upper and lower depths and sequential layer numbering.
  - a) Identify profile layers with upper depth equal to- or exceeding lower; correct depths and update sequential numbering of layers.
  - b) Identify sample layers with depth interval fitting within the depth interval of the associated horizon; adjust layer depths to horizon depths.
  - c) Identify sample layers with depth interval not fitting within the depth interval of the associated horizon; adjust layer depths to sampled depths and update sequential numbering of layers.
- 5) Depth of profile observation.
  - a) No routine controls applied.
- 6) Coarse fragment content (v%).
  - a) Identify Coarse fragment content values outside the range of 0-100%, and correct or exclude value.
- 7) Coarse and fine sand.
  - a) Identify values for the Sum of coarse and fine sand contents exceeding the Total sand content, permitting an inaccuracy of 1 %, and correct or exclude values for coarse and fine sand.
- 8) Fine earth fractions.
  - a) Identify Sand content values outside the range of 0-100%, and correct or exclude values.
  - b) Identify Silt content values outside the range of 0-100%, and correct or exclude values.
  - c) Identify Clay content values outside the range of 0-100%, and correct or exclude values.
- 9) Sum of fine earth fractions.
  - a) Identify reported values for Sum of sand, silt and clay fractions, different from re-calculated sum of Sand, Silt and Clay fractions, permitting an inaccuracy of  $\pm 0.5\%$ , and correct values.
  - b) Identify values for the Sum of sand, silt and clay fractions outside the range of 90-110%, and correct or exclude values (of sand, silt, clay and sum).
  - c) Subsequently, identify values for the sum of Sand, silt and clay outside the range of 98-102%, and flag values (699/37862)

- 10) Bulk density (BlkDens).
  - a) Identify Bulk density values outside the range of 0.1-2.7 kg/dm<sup>3</sup>, and correct or exclude values.
  - b) Identify Bulk density values outside the range of 0.5-2.0 kg/dm<sup>3</sup>, and flag values (64/6736).
  
- 11) Saturated hydraulic conductivity (KSat).
  - a) Identify Saturated hydraulic conductivity values < 0 dS/m, and correct or exclude values.
  
- 12) pH.
  - a) Identify pHH<sub>2</sub>O, pHKCl and/or pHCaCl<sub>2</sub> values outside the range of 2-12, and correct or exclude values.
  - b) Identify pHKCl and/or pHCaCl<sub>2</sub> values exceeding pHH<sub>2</sub>O values, permitting an inaccuracy of 0.1 while excepting layers of profiles classified as having geric property, and flag values (17/16600 for pHKCl and 16/5864 for pHCaCl<sub>2</sub>).
  - c) Flag pH value for layers for which base saturation value is flagged.
  
- 13) Electrical conductivity.
  - a) Identify Electrical conductivity values < 0 dS/m, and correct or exclude values.
  - b) Identify Electrical conductivity values exceeding 30 dS/m (89/18923) while pHH<sub>2</sub>O < 7.5 or pHKCl < 7 or pHCaCl<sub>2</sub> < 7, and flag values (27/18789).
  - c) Identify Electrical conductivity values exceeding 0 dS/m (89/18923) while pHH<sub>2</sub>O < 6.5 or pHKCl < 6 or pHCaCl<sub>2</sub> < 6, and flag values.
  
- 14) Soluble cations and anions.
  - a) Identify Soluble cation and anion values outside the range of 0-2600 cmol/l, and correct or exclude values.
  - b) Identify Soluble cation and anion values exceeding 0.1 cmol/l while pHH<sub>2</sub>O < 7.5 or pHKCl < 7 or pHCaCl<sub>2</sub> < 7, and flag values (94/387)
  
- 15) Exchangeable bases.
  - a) Identify Exchangeable calcium, magnesium, sodium or potassium values, of version 1 data outside the range of 0-200, 0-50, 0-200 and 0-20 cmol/kg, respectively, and of version 2 data outside the range of 0-100, 0-25, 0-100 and 0-10 cmol/kg, and correct or exclude values. If the data source is LREP then correct or exclude values by batch (district). Upper limits are based on visual outlier analysis.
  - b) Identify Exchangeable calcium, magnesium, sodium or potassium values exceeding 100, 50, 100 and 20 cmol/kg, respectively, and flag values (6/34474, 2/32635, 4/29912, 4/33779, for Ca, Mg, Na, K, respectively).
  - c) Identify Sum of Exchangeable bases values exceeding 150 cmol/kg, and flag values (6/33202). The sum of exchangeable bases is defined here as the sum of minimally 3 out of 4 bases.
  
- 16) Exchangeable acidity.
  - a) Identify Exchangeable acidity values exceeding 50 cmol/kg, and flag values (3/28187).
  - b) Identify Exchangeable acidity values where Exchangeable hydrogen value exceeds 0.1 cmol/kg (729/1166) while pHH<sub>2</sub>O > 6.5 or pHKCl > 6 or pHCaCl<sub>2</sub> > 6, and flag values (74/729).
  - c) Identify Exchangeable acidity values where Exchangeable aluminum or the sum of Exchangeable aluminum and hydrogen exceeds 0.1 cmol/kg (2877/8968) while pHH<sub>2</sub>O > 5.5 or pHKCl > 5 or pHCaCl<sub>2</sub> > 5, and flag values (393/2877).



17) Effective Cation Exchange Capacity.

- a) Identify eCEC values (mineral soils) exceeding 150 cmol/kg and flag values (7/26931).
- b) Identify eCEC values exceeding 4 times CEC value, and flag values (369/25694).
- c) Flag eCEC values for layers for which the base saturation value or the exchangeable acidity value is flagged.

18) Cation Exchange Capacity.

- a) Identify Soil CEC values outside the range of 0-150 cmol/kg, and correct or exclude values for version 1 and 2 data. If the data source is LREP then correct or exclude values by batch (district). Upper limits are based on visual outlier analysis (often associated with peat soils).
- b) Identify Soil CEC values less than 1 cmol/kg, and flag values (377/35777).
- c) Identify Soil CEC values exceeding 120 cmol/kg, and flag values (6/35777).
- d) Identify Soil CEC values outside the range as determined by type and content of clay and organic carbon, and correct or exclude values for version 1 data. Lower limit is defined as  $[\text{clay} (\%) * 1 (\text{cmol/kg}) / 100] + [\text{OrgC} (\%) * 100 (\text{cmol/kg}) / 1000] * 1/a$ , and upper limit as  $[\text{clay} (\%) * 150 (\text{cmol/kg}) / 100] + [\text{OrgC} (\%) * 600 (\text{cmol/kg}) / 1000] * a$ , with  $a = 1.5$ . Soil CEC values less than a lower limit of maximally 2.5 cmol/kg are maintained.
- e) Identify Soil CEC values outside the range as determined by type and content of clay and organic carbon, and flag values. Lower limit (94/29636) is defined as  $[\text{clay} (\%) * 1 (\text{cmol/kg}) / 100] + [\text{OrgC} (\%) * 100 (\text{cmol/kg}) / 1000] * 1/a$ , and upper limit (614/29636) as  $[\text{clay} (\%) * 150 (\text{cmol/kg}) / 100] + [\text{OrgC} (\%) * 600 (\text{cmol/kg}) / 1000] * a$ , with  $a = 1$ .

19) Base saturation.

- a) Identify values for the ratio of Exchangeable calcium/CEC, magnesium/CEC, sodium/CEC or potassium/CEC outside the range of 0-5, 0-2, 0-5 and 0-1, respectively, and flag values (176/32940, 26/31143, 17/28721 and 11/32259, respectively). Upper limits are based on visual outlier analysis.
- b) Identify values for  $\text{ExCa} > 0.5$  cmol/kg (28521/32462) and  $< \text{ExMg}$ , and flag values (2100/28521).
- c) Identify values for  $\text{ExNa} > 0.5$  cmol/kg (6728/29307) and  $< \text{ExK}$  (1008/6728), and flag values.
- d) Identify base (over-) saturation values exceeding 300%, and flag values (540/31861).
- e) Identify base saturation values exceeding 60%, while  $\text{pHH}_2\text{O} < 5.5$  or  $\text{pHKCl} < 5$  or  $\text{pHCaCl}_2 < 5$ , or base saturation values less than 40%, while  $\text{pHH}_2\text{O} > 5.5$  or  $\text{pHKCl} > 5$  or  $\text{pHCaCl}_2 > 5$  and flag values (9629/31175). Flagged values indicate possible inconsistencies in the values for ExCa, ExMg, ExNa, ExK, ExBases, eCEC, CEC, clay content, organic carbon content, pHH<sub>2</sub>O, pHKCl and/or pHCaCl<sub>2</sub>.
- f) Identify base saturation values exceeding 99%, while  $\text{pHH}_2\text{O} < 6.5$  or  $\text{pHKCl} < 6$  or  $\text{pHCaCl}_2 < 6$ , or base saturation values less than 99%, while  $\text{pHH}_2\text{O} > 6.5$  or  $\text{pHKCl} > 6$  or  $\text{pHCaCl}_2 > 6$  and flag values (9668/31271). Flagged values indicate possible inconsistencies in the values for ExCa, ExMg, ExNa, ExK, ExBases, eCEC, CEC, clay content, organic carbon content, pHH<sub>2</sub>O, pHKCl and/or pHCaCl<sub>2</sub>.

20) Free gypsum and lime.

- a) Identify CaSO<sub>4</sub> and CaCO<sub>3</sub> values outside the range of 0-1000 g/kg, and correct or exclude values.
- b) Identify CaSO<sub>4</sub> values exceeding 0.1 g/kg (1630/8361), while  $\text{pHH}_2\text{O} < 6.5$  or  $\text{pHKCl} < 6$  or  $\text{pHCaCl}_2 < 6$ , and flag values (569/1630).
- c) Identify CaCO<sub>3</sub> values exceeding 0.1 g/kg (4540/11791), while  $\text{pHH}_2\text{O} < 6.5$  or  $\text{pHKCl} < 6$  or  $\text{pHCaCl}_2 < 6$ , and flag values (1042/4540).

- 21) Total carbon and inorganic carbon.
  - a) Identify Total or Inorganic Carbon values outside the range of 0-1000 g/kg, and correct or exclude values.
  - b) Identify Total carbon values exceeding organic carbon values, with >0.1 g/kg, while  $pH_{H2O} < 6.5$  or  $pH_{KCl} < 6$  or  $pH_{CaCl2} < 6$ , and flag values (211/526)
  - c) Identify Inorganic carbon values exceeding 0.1 g/kg while  $pH_{H2O} < 6.5$  or  $pH_{KCl} < 6$  or  $pH_{CaCl2} < 6$ , and flag values (877/10423)
  - d) Identify Organic carbon values exceeding Total carbon values, and flag values (141/526).
  
- 22) Organic carbon and total nitrogen.
  - a) Identify Organic carbon values outside the range of 0-580 g/kg (with ISRIC datasets as reference), and correct or exclude values.
  - b) Identify Organic carbon values exceeding 140 g/kg, flag values (65/32610)
  - c) Identify Total nitrogen values outside the range of 0-40 g/kg (with ISRIC datasets as reference), and correct or exclude values.
  - d) Identify Total nitrogen values exceeding 12 g/kg, and flag values (23/22457)
  - e) Identify C/N ratio values outside the range of 1-110, and correct or exclude values (of organic carbon and total nitrogen).
  - f) Identify C/N ratio values outside the range of 4-45, and flag values (659/22109).
  
- 23) Total phosphorus.
  - a) Identify Total P values outside the range of 0-1,000,000 mg/kg, and correct or exclude values.
  - b) Identify Total P values exceeding 1000 mg/kg and flag values (31/2727).
  
- 24) Available phosphorus.
  - a) Identify Available P values outside the range of 0-1,000,000 mg/kg, and correct or exclude values.
  
- 25) Volumetric moisture content at suctions from pF 0.0 – pF 5.8.
  - a) Identify volumetric moisture content values outside the range of 0-98 %, and correct or exclude values (with values exceeding 98% set at 98%).
  - b) Identify Volumetric moisture content values exceeding volumetric moisture content values at lower suction (VMCpF00 >10 >15 >20 >23 >25 >28 >29 >30 >37 >42 >VMCpF58), and correct or exclude value.

Note that the routine criteria applied on multiple attributes (e.g. inorganic carbon and pH, or base saturation and pH) are (too) simple. The criteria include cut off points (e.g. base saturation exceeding 60% while  $pH < 5.5$ ), yielding 'squared corner' selections out of clouds of data points. It is better, where the values of 2 attributes show some correlation, to assess the relationship ( $Y = aX$ ) and to define the permitted inaccuracy or confidence interval as (user

## **Annex 7 Definition of key soil properties, inclusive of specific method of observation or measurement, according to GlobalSoilMap specifications**

For GlobalSoilMap specifications, version 1, release 2.1 (July 2011), see: [http://www.globalsoilmap.net/system/files/GlobalSoilMap\\_net\\_specifications\\_v2\\_0\\_edited\\_draft\\_Sept\\_2011\\_RAM\\_V12.pdf](http://www.globalsoilmap.net/system/files/GlobalSoilMap_net_specifications_v2_0_edited_draft_Sept_2011_RAM_V12.pdf)

Depth to rock

Depth in cm to a lithic or paralithic contact

Reference: SSS, 1993. USDA soil survey manual. Chapter 1, page 5.

Effective depth

Lower limit of soil, normally being the lower limit of biological activity, generally coinciding with the common rooting depth of native perennial plants.

The root restricting depth, in cm, is where root penetration is strongly inhibited because of physical and/or chemical characteristics, meaning the incapability (of the soil) to support more than few fine or very fine roots. The restriction may be below where plant roots normally occur.

Reference: SSS, 1993. USDA soil survey manual. Chapter 3, page 60.

Organic carbon

Mass fraction (g/kg) of carbon in the fine earth material (<2 mm) as determined by dry combustion at 900 C.

Reference: ISO 10694

pH

Soil reaction, as determined in a 1:5 soil: water mixture

Reference: ISO 10390

Clay

Mass fraction (g/kg) of particles of size 0-2 um in the fine earth material, as determined by using the pipette method

Reference: Burt, 2004. USDA soil survey laboratory methods manual. Page 347.

Silt

Mass fraction (g/kg) of particles of size 2-50 um in the fine earth material, as determined by using the pipette method

Reference: Burt, 2004. USDA soil survey laboratory methods manual. Page 347.

Sand

Mass fraction (g/kg) of particles of size 50-2000 um in the fine earth material, as determined by using the pipette method

Reference: Burt, 2004. USDA soil survey laboratory methods manual. Page 347.

#### Coarse fragments

Mass fraction (vol % ???) of particles of size >2000  $\mu\text{m}$

Reference: Burt, 2004. USDA soil survey laboratory methods manual. Page 36.

#### Effective cation exchange capacity

Cations, extracted using  $\text{BaCl}_2$ , plus exchangeable H + Al, expressed as mmol/kg

Reference: ISO 11260

#### Bulk density

Bulk density of the whole soil, including coarse fragments and fine earth material, in kg/l or kg/dm<sup>3</sup>, as determined by a method equivalent to the core method using a pedotransfer function

Reference: ISO 11272

#### Bulk density

Bulk density of the fine earth material, in kg/l or kg/dm<sup>3</sup>, as determined by a method equivalent to the core method using a pedotransfer function

Reference: ISO 11272

#### Available water capacity

Available water capacity (mm) computed over a depth interval using a specified pedotransfer function that references the values estimated for organic carbon, clay, silt, sand, coarse fragments and bulk density.

Reference: Burt, 2004. USDA soil survey laboratory methods manual. Page 137.

#### Electrical conductivity

Electrical conductivity (mS/m), as determined in 1: 1 saturated paste.

## Annex 8a Statistics of profile attribute values, by country (including 11 duplicate profiles, later identified and excluded)

	AF	AO	BF	BI	BJ	BW	CD	CF	CG	CI	CM	ET	GA	GH	GN	KE	LR	LS	MG
<b>Profiles</b>	12585	242	626	36	733	901	381	89	46	144	120	524	25	34	6	423	17	33	54
<b>Map ID</b>	5426	0	486	2	8	0	0	8	0	0	52	4	0	0	0	57	0	0	0
<b>Map unit ID</b>	2189	0	304	0	0	0	0	0	0	0	0	280	0	0	0	0	0	0	0
<b>X lon DD</b>	12585	242	626	36	733	901	381	89	46	144	120	524	25	34	6	423	17	33	54
Min	-17.2	12.0	-4.9	29.1	1.2	21.0	12.4	14.8	11.7	-7.5	8.9	35.6	10.3	-2.5	-14.0	34.0	-11.4	27.2	44.5
Max	49.1	23.6	2.4	30.5	2.8	28.9	31.1	24.7	15.4	-4.1	15.0	43.1	14.1	0.8	-14.0	40.0	-9.5	29.3	49.1
Ave (average value)	22.0	15.5	-1.1	29.6	2.3	25.0	23.6	18.8	13.4	-6.3	10.6	38.2	12.6	-1.0	-14.0	37.0	-10.9	27.7	47.5
SD (std deviation)	15.6	2.5	1.5	0.4	0.3	1.6	6.2	2.0	0.7	1.5	1.5	0.9	1.2	0.8	0.0	1.6	0.5	0.5	0.8
<b>Y lat DD</b>	12585	242	626	36	733	901	381	89	46	144	120	524	25	34	6	423	17	33	54
Min	-34.3	-17.8	9.6	-4.2	6.3	-25.7	-11.8	3.7	-4.7	5.3	3.9	3.6	-2.4	5.1	10.2	-4.5	6.4	-29.8	-22.9
Max	17.6	-4.6	14.8	-2.7	10.8	-17.8	4.0	10.5	4.5	9.7	12.6	14.2	0.5	9.4	10.2	4.0	7.9	-28.9	-12.5
Ave	-4.1	-11.1	12.7	-3.3	7.2	-20.8	-2.6	6.7	-4.2	7.8	5.8	8.2	-1.0	6.9	10.2	-0.8	7.0	-29.4	-19.0
SD	13.1	3.2	1.0	0.4	0.5	2.2	4.2	1.7	1.3	1.8	1.5	3.1	1.0	0.9	-	1.7	0.4	0.3	3.1
<b>XY accuracy</b>	9711	36	338	32	172	889	369	89	46	144	120	517	25	17	6	337	17	26	54
Min	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.02	0.02	0.00
Max	1.00	1.00	0.10	0.02	1.00	0.02	1.00	0.09	0.20	0.02	0.05	0.40	0.02	0.05	0.02	0.04	0.02	1.00	1.00
Ave	0.03	0.29	0.01	0.01	0.94	0.00	0.02	0.03	0.02	0.01	0.01	0.02	0.01	0.02	0.02	0.01	0.02	0.05	0.03
SD	0.14	0.45	0.01	0.01	0.24	0.00	0.05	0.03	0.03	0.01	0.01	0.04	0.01	0.02	0.00	0.01	0.00	0.19	0.13
<b>Year</b>	11611	242	551	36	511	894	380	89	46	143	113	521	25	34	6	298	17	33	34
Min	1938	1951	1968	1951	1965	1955	1954	1960	1968	1966	1938	1973	1975	1971	1968	1972	1974	1967	1965
Max	2010	1991	2002	1984	1999	1990	2005	1978	1998	1997	1989	2008	1984	2009	1969	2003	1980	1982	1979
Ave	1986	1964	1984	1975	1993	1986	1966	1969	1970	1992	1971	2004	1980	1991	1969	1981	1979	1974	1974
SD	11	10	13	11	9	3	13	6	5	5	10	7	4	15	0	6	1	7	7

	AF	AO	BF	BI	BJ	BW	CD	CF	CG	CI	CM	ET	GA	GH	GN	KE	LR	LS	MG
<b>Depth observed</b>	12559	242	625	36	733	901	381	89	46	144	120	524	25	34	6	423	17	33	54
Min	8	32	10	39	20	20	10	18	40	20	10	10	100	60	90	15	42	9	40
Max	2000	205	770	240	240	600	2000	1350	600	585	400	500	300	320	130	750	200	205	400
Ave	126	143	116	162	107	126	165	216	192	81	158	154	147	158	105	138	154	134	163
SD	63	36	58	54	27	45	110	192	105	64	59	77	43	53	15	66	37	50	61
<b>WRB ref group</b>	5980	242	19	34	733	901	257	32	7	49	66	177	25	34	6	380	17	33	54
<b>FAO 88</b>	7673	242	108	34	733	901	257	39	26	49	66	232	25	34	6	418	17	33	54
<b>FAO 74</b>	4507	36	10	30	733	891	154	32	8	26	56	11	25	27	6	321	17	26	54
<b>USDA</b>	1804	23	42	28	1	56	94	2	0	32	35	29	3	8	0	74	17	15	20
<b>CPCS</b>	681	0	280	0	3	0	0	49	38	15	10	0	0	0	0	0	0	0	0

	ML	MR	MW	MZ	NA	NE	NG	RW	SD	SL	SN	SO	SZ	TD	TG	TZ	UG	ZA	ZM	ZW
<b>Profiles</b>	626	11	2990	164	62	457	1141	96	112	12	116	68	14	0	9	1303	12	649	87	222
<b>Map ID</b>	269	0	2972	0	0	0	798	0	16	0	0	0	0	0	0	754	0	0	0	0
<b>Map unit ID</b>	81	0	0	0	0	0	768	0	0	0	0	0	0	0	0	756	0	0	0	0
<b>X lon DD</b>	626	11	2990	164	62	457	1141	96	112	12	116	68	14	0	9	1303	12	649	87	222
Min	-10.5	-15.8	32.7	32.0	13.6	1.0	2.8	28.9	24.2	-13.2	-17.2	42.8	31.1	-	0.4	30.4	30.0	16.6	23.1	25.6
Max	0.5	-11.2	35.9	40.5	21.4	7.2	14.4	30.7	36.1	-11.5	-11.7	45.3	32.1	-	1.3	40.4	32.6	32.3	31.9	33.0
Ave	-6.2	-13.0	34.4	35.2	17.1	2.2	8.0	29.8	32.0	-12.1	-16.0	43.7	31.4	-	1.1	35.5	32.2	27.3	27.8	30.7
SD	1.9	1.4	0.8	2.8	1.7	0.8	3.5	0.5	4.1	0.4	1.1	0.6	0.3	-	0.3	2.6	1.0	3.6	2.7	1.6
<b>Y lat DD</b>	626	11	2990	164	62	457	1141	96	112	12	116	68	14	0	9	1303	12	649	87	222
Min	11.3	14.8	-17.1	-26.8	-28.2	11.8	4.4	-2.7	10.0	7.9	12.5	0.3	-27.1	-	9.5	-11.0	-1.3	-34.3	-17.5	-22.3
Max	16.5	17.6	-9.5	-12.6	-17.4	14.4	13.6	-1.2	16.9	9.4	16.5	10.6	-25.9	-	10.3	-1.5	0.5	-22.3	-8.8	-15.8
Ave	13.3	16.1	-13.7	-20.0	-21.2	13.4	9.2	-1.9	13.0	8.9	14.1	7.8	-26.5	-	9.7	-4.9	0.2	-28.5	-13.1	-18.7
SD	1.2	0.9	1.9	5.2	3.0	0.6	2.2	0.3	1.9	0.3	1.0	3.7	0.3	-	0.3	2.1	0.7	3.0	2.1	1.5
<b>XY accuracy</b>	464	11	2980	17	10	453	973	66	112	12	109	60	0	0	8	1028	12	40	86	36
Min	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.00	0.00	-	-	0.02	0.00	0.00	0.00	0.02	0.00
Max	0.08	0.02	0.01	0.02	0.02	0.02	1.00	0.02	0.02	0.02	0.02	0.02	-	-	0.02	0.10	0.02	0.02	0.02	0.02
Ave	0.02	0.02	0.01	0.02	0.01	0.00	0.07	0.00	0.02	0.02	0.01	0.00	-	-	0.02	0.01	0.00	0.01	0.02	0.01
SD	0.02	0.00	0.00	0.00	0.01	0.00	0.16	0.01	0.00	0.00	0.01	0.01	-	-	0.00	0.01	0.01	0.01	0.00	0.01
<b>Year</b>	626	11	2963	164	62	20	1136	96	112	12	107	68	14	0	9	1268	12	649	87	222
Min	1955	1983	1987	1961	1973	1986	1942	1963	1960	1968	1956	1979	1992	-	1985	1964	1988	1941	1972	1961
Max	2001	1983	1998	1996	2000	1997	2009	1993	1981	1986	2003	2006	1996	-	1997	2010	1988	2001	1983	1998
Ave	1988	1983	1989	1984	1995	1990	1978	1983	1970	1970	1983	2001	1994	-	1986	1991	1988	1981	1979	1987
SD	8	0	1	12	10	4	9	4	7	5	12	10	2	-	4	11	0	9	5	7
<b>Depth observed</b>	601	11	2990	164	62	457	1141	96	112	12	116	68	14	0	9	1303	12	649	87	222
Min	8	46	10	15	10	20	16	37	45	64	30	20	30	-	100	10	102	10	70	18
Max	500	120	1220	670	140	300	1120	400	470	188	235	200	550	-	200	405	274	250	310	358
Ave	103	77	111	143	81	116	158	157	170	151	132	136	205	-	157	117	192	101	153	132
SD	43	23	48	88	37	51	66	55	63	34	33	41	134	-	43	64	43	36	44	52
<b>WRB ref group</b>	21	11	360	164	62	453	288	96	71	12	114	68	14	0	8	202	12	649	87	222
<b>FAO 88</b>	126	11	1004	164	62	453	581	96	97	12	114	68	14	0	8	619	12	649	87	222
<b>FAO 74</b>	51	11	8	56	46	453	655	82	97	12	109	23	0	0	8	199	12	40	87	95
<b>USDA</b>	59	10	0	4	4	17	508	66	103	11	9	5	9	0	0	368	12	26	83	31
<b>CPCS</b>	275	0	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0

	AF	AO	BF	BI	BJ	BW	CD	CF	CG	CI	CM	ET	GA	GH	GN	KE	LR	LS	MG
<b>Altitude</b>	7304	227	117	34	482	549	285	76	34	35	106	304	23	28	2	373	15	30	43
Min	0	13	238	750	0	122	0	350	25	15	15	700	80	2	1	0	8	1495	435
Max	4958	1890	465	2160	500	1914	2900	1240	600	435	2134	3460	640	255	5	4958	550	2670	2200
Ave	847	886	305	1532	147	991	852	514	296	270	764	1904	383	164	3	1196	108	1734	1358
SD	625	515	31	457	54	145	552	163	149	100	567	456	148	86	3	748	145	243	438
<b>Slope</b>	5270	19	313	12	1	22	122	31	5	29	68	204	21	17	0	70	9	19	33
Min	0	1	0	1	2	0	0	0	10	0	0	0	0	0	-	0	1	1	0
Max	100	25	45	75	2	5	60	25	30	10	33	65	30	12	-	40	12	16	65
Ave	5.1	6.9	2.4	17.0	2.0	1.2	9.4	5.1	24.0	3.5	6.2	6.3	8.0	2.9	-	5.4	2.6	5.4	19.1
SD	7.9	7.3	4.3	21.4	0.0	1.4	11.8	5.3	8.9	2.4	6.8	9.7	8.5	3.1	-	8.7	3.6	3.8	21.7
<b>Topography</b>	5648	0	330	9	15	28	145	0	18	7	68	207	6	20	0	65	0	0	0
<b>Landform</b>	7273	29	335	16	23	690	245	37	44	23	112	191	25	30	6	74	16	15	39
<b>Slope form</b>	3088	0	231	4	15	23	22	0	0	16	0	4	2	8	0	43	0	1	0
<b>Slope position</b>	5477	9	355	11	20	428	211	34	33	112	67	188	16	24	1	63	12	6	7
<b>Frequency flooding</b>	2277	0	293	4	12	21	6	4	2	16	2	72	6	14	0	57	0	0	0
<b>Parent material</b>	5197	0	290	5	15	25	211	6	40	110	66	201	6	21	0	65	0	8	0
<b>Lithology</b>	776	0	53	0	0	0	0	0	10	0	8	31	0	7	0	0	0	0	0
<b>Regolith</b>	3631	0	16	1	15	25	90	0	1	7	3	4	6	21	0	65	0	3	0
<b>Land cover</b>	1459	0	41	5	1	12	107	0	29	12	36	29	6	16	0	59	0	1	0
<b>Land use</b>	3000	27	84	11	23	583	85	31	2	13	86	207	23	29	6	139	17	14	53
<b>Drainage</b>	10601	242	392	35	733	892	377	40	44	49	120	217	24	33	6	395	17	33	54
<b>Surface drainage</b>	1055	0	222	4	14	21	7	0	0	7	51	14	6	14	0	65	0	0	0
<b>Surface stoniness</b>	1985	0	287	4	12	22	37	0	0	26	9	188	6	7	0	64	0	0	0
<b>Surface salt</b>	1196	0	42	7	12	28	47	0	2	7	56	4	6	20	0	65	0	14	0
<b>Rooted depth</b>	3494	0	124	7	15	26	92	8	2	7	13	8	6	20	0	48	0	14	0
Min	0	-	0	185	17	82	10	10	250	100	15	50	100	30	-	25	-	40	-
Max	400	-	220	220	240	200	220	178	250	151	210	133	300	210	-	260	-	180	-
Ave	101	-	84	201	97	147	104	72	250	137	146	99	167	102	-	125	-	134	-
SD	50	-	47	12	48	32	46	58	0	22	62	30	68	50	-	45	-	39	-
<b>Rootable depth</b>	1399	0	35	0	0	0	0	0	0	0	0	4	0	4	0	0	0	1	0
<b>Rock depth</b>	1915	0	125	0	0	0	0	0	2	3	4	36	0	7	0	0	0	1	0



	ML	MR	MW	MZ	NA	NE	NG	RW	SD	SL	SN	SO	SZ	TD	TG	TZ	UG	ZA	ZM	ZW
<b>Altitude</b>	247	0	834	130	60	446	610	96	90	11	8	23	14	0	7	1022	12	644	68	219
Min	225	-	0	0	100	150	0	910	350	5	1	0	107	-	300	0	1122	22	500	240
Max	767	-	2440	1325	1800	298	1495	4500	600	90	25	200	1399	-	700	2900	2448	2150	1800	2020
Ave	354	-	1129	237	1210	213	321	1876	479	75	16	105	675	-	480	1079	1378	1022	1247	1037
SD	140	-	436	249	333	29	249	561	68	23	8	91	355	-	157	624	481	468	241	397
<b>Slope</b>	39	11	2750	7	3	16	541	22	68	10	0	14	0	0	1	647	12	33	50	51
Min	0	1	0	0	0	0	0	1	0	1	-	0	-	-	46	0	1	1	0	0
Max	10	7	100	3	1	6	30	92	24	12	-	1	-	-	46	55	12	33	5	21
Ave	1.3	3.7	5.6	1.4	0.3	1.3	3.6	23.3	4.4	4.1	-	0.5	-	-	46.0	3.4	5.5	6.9	1.1	2.4
SD	1.6	1.8	8.1	1.1	0.6	1.5	3.6	24.0	7.5	3.4	-	0.5	-	-	0.0	4.7	3.4	7.7	1.0	3.0
<b>Topography</b>	598	1	2674	9	10	11	534	33	57	0	5	13	0	0	0	700	8	16	30	31
<b>Landform</b>	608	4	2947	9	10	9	665	44	112	12	17	23	0	0	8	669	11	39	86	50
<b>Slope form</b>	77	1	1951	9	10	0	28	25	21	0	0	1	0	0	0	528	12	16	12	28
<b>Slope position</b>	376	1	2274	10	10	11	327	37	38	7	2	15	0	0	1	645	6	37	59	24
<b>Frequency flooding</b>	225	2	705	6	8	6	144	32	3	0	4	7	0	0	0	536	11	14	29	36
<b>Parent material</b>	334	5	2194	9	10	11	689	35	52	0	4	5	0	0	0	695	5	15	24	41
<b>Lithology</b>	142	0	0	0	0	0	129	0	0	0	0	0	0	0	0	396	0	0	0	0
<b>Regolith</b>	194	4	2206	9	10	3	124	35	7	0	0	11	0	0	0	678	5	15	30	43
<b>Land cover</b>	205	2	0	8	9	2	262	13	26	0	0	4	0	0	0	534	2	10	12	16
<b>Land use</b>	167	5	16	19	10	16	254	31	71	9	16	13	0	0	8	763	11	30	75	53
<b>Drainage</b>	492	5	2839	163	59	451	719	94	112	12	116	23	14	0	8	848	12	643	87	201
<b>Surface drainage</b>	129	2	4	9	9	11	20	33	42	0	0	13	0	0	0	257	12	16	29	44
<b>Surface stoniness</b>	151	0	346	9	10	3	98	36	35	0	5	13	0	0	0	533	6	13	30	35
<b>Surface salt</b>	38	11	10	9	10	11	105	37	42	0	6	13	0	0	0	488	12	16	30	48
<b>Rooted depth</b>	419	10	1492	9	7	10	350	37	38	0	12	0	0	0	0	617	12	14	30	47
Min	0	15	0	58	40	61	10	0	5	-	42	-	-	-	0	0	81	22	60	59
Max	200	104	300	230	120	211	282	400	160	-	175	-	-	-	300	195	140	140	310	230
Ave	71	63	101	144	70	159	94	168	68	-	115	-	-	-	113	140	85	167	153	153
SD	41	29	46	47	31	46	49	68	44	-	39	-	-	-	47	36	33	39	39	45
<b>Rootable depth</b>	204	0	351	0	0	0	85	0	1	0	4	0	0	0	0	710	0	0	0	0
<b>Rock depth</b>	518	0	123	0	0	0	332	0	17	0	5	0	0	0	0	742	0	0	0	0



## Annex 8b Statistics of profile layer attribute values, by country (including 11 duplicate profiles, later identified and excluded)

	AF	AO	BF	BI	BJ	BW	CD	CF	CG	CI	CM	ET	GA	GH	GN	KE	LR	LS	MG
<b>Profiles</b>	12585	242	626	36	733	901	381	89	46	144	120	524	25	34	6	423	17	33	54
<b>Layer numbers</b>	50163	1266	2215	186	2930	3554	2152	434	209	505	535	2023	113	213	22	1947	81	169	248
<b>Ave</b>	4.0	5.2	3.5	5.2	4.0	3.9	5.6	4.9	4.5	3.5	4.5	3.9	4.5	6.3	3.7	4.6	4.8	5.1	4.6
<b>Upper depth</b>	12585	242	626	36	733	901	381	89	46	144	120	524	25	34	6	423	17	33	54
<b>Layers</b>	50163	1266	2215	186	2930	3554	2152	434	209	505	535	2023	113	213	22	1947	81	169	248
<b>Min</b>	-30	0	0	-3	0	0	-10	0	-30	0	0	0	0	0	0	0	0	0	0
<b>Max</b>	1900	175	640	200	180	400	1900	1100	425	480	300	480	235	271	95	700	156	180	300
<b>Ave</b>	42	44	36	53	32	41	51	78	59	29	47	58	33	52	34	46	42	53	54
<b>SD</b>	47	41	42	51	30	43	67	133	77	41	51	66	39	53	32	47	45	45	54
<b>Lower depth</b>	12585	242	626	36	733	901	381	89	46	144	120	524	25	34	6	423	17	33	54
<b>Layers</b>	50163	1266	2215	186	2930	3554	2152	434	209	505	535	2023	113	213	22	1947	81	169	248
<b>Min</b>	0	2	1	0	2	1	0	2	0	1	3	5	3	4	15	1	7	5	5
<b>Max</b>	2000	205	770	240	240	600	2000	1350	600	585	400	500	300	320	130	750	200	205	400
<b>Ave</b>	73	71	68	84	58	73	81	122	101	52	82	96	65	78	63	76	75	79	90
<b>SD</b>	59	52	56	62	39	52	87	161	98	53	66	72	59	63	36	61	59	51	66
<b>HorizonDesign</b>	7476	145	372	36	733	896	381	75	44	24	73	165	25	34	6	420	17	33	54
<b>Color</b>	7522	238	284	34	23	900	174	32	7	23	54	123	25	31	6	415	17	32	23
<b>Mottles</b>	3948	0	279	7	15	28	14	0	1	7	4	8	6	21	0	122	0	14	0
<b>StructureType</b>	4081	72	101	25	15	88	103	0	1	7	4	8	6	21	0	379	0	30	0
<b>Stickiness</b>	889	0	248	7	2	28	2	0	2	7	4	58	6	15	0	65	14	14	0
<b>SaltAlkali</b>	2214	0	34	7	15	28	14	0	2	7	7	59	6	16	0	65	0	14	0
<b>Roots</b>	2053	0	288	0	0	0	80	8	2	0	9	55	0	4	0	0	0	0	0
<b>Field Texture</b>	6168	204	399	27	15	88	107	0	1	7	4	8	6	21	0	323	0	28	0
<b>Fld Crs:fragments</b>	6463	208	363	23	12	32	99	3	1	10	14	64	3	17	0	319	0	26	0

	AF	AO	BF	BI	BJ	BW	CD	CF	CG	CI	CM	ET	GA	GH	GN	KE	LR	LS	MG
<b>Coarse fragments</b>	7465	226	483	28	22	41	313	63	8	36	67	64	12	28	2	322	13	29	20
<b>Layers</b>	28470	1116	1643	128	105	210	1753	251	31	138	238	226	37	151	4	1272	43	144	128
Min	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	3	0	0
Max	100	90	95	90	90	93	95	100	32	95	95	90	90	90	2	90	86	90	80
Ave	8	3	16	4	22	10	5	18	5	36	15	9	13	17	2	6	57	6	3
SD	19	10	26	13	27	22	16	25	8	28	23	21	23	24	1	16	20	16	9

	ML	MR	MW	MZ	NA	NE	NG	RW	SD	SL	SN	SO	SZ	TD	TG	TZ	UG	ZA	ZM	ZW
<b>Profiles</b>	626	11	2990	164	62	457	1141	96	112	12	116	68	14	0	9	1303	12	649	87	222
<b>Layer numbers</b>	1965	43	10322	627	216	1850	5420	515	615	51	475	273	68	0	38	5201	88	2005	516	1073
Ave	3.1	3.9	3.5	3.8	3.5	4.0	4.8	5.4	5.5	4.3	4.1	4.0	4.9	0	4.2	4.0	7.3	3.1	5.9	4.8
<b>Upper depth</b>	626	11	2990	164	62	457	1141	96	112	12	116	68	14	0	9	1303	12	649	87	222
<b>Layers</b>	1965	43	10322	627	216	1850	5420	515	615	51	475	273	68	0	38	5201	88	2005	516	1073
Min	0	0	0	0	0	0	-13	-3	0	0	0	0	0	-	0	0	0	0	0	0
Max	375	90	242	600	110	230	430	215	375	137	175	180	200	-	160	260	244	220	300	348
Ave	29	27	33	46	29	39	52	62	62	41	37	42	60	-	43	43	72	35	48	48
SD	35	23	34	63	30	42	52	54	59	37	37	41	55	-	45	43	59	35	47	47
<b>Lower depth</b>	626	11	2990	164	62	457	1141	96	112	12	116	68	14	0	9	1303	12	649	87	222
<b>Layers</b>	1965	43	10322	627	216	1850	5420	515	615	51	475	273	68	0	38	5201	88	2005	516	1073
Min	1	3	2	3	4	1	0	0	1	10	1	10	15	-	8	2	10	1	3	2
Max	500	120	1220	670	140	300	1120	400	470	188	235	200	550	-	200	405	274	250	310	358
Ave	60	46	65	84	53	68	85	91	92	77	69	75	102	-	80	72	97	68	74	75
SD	47	27	48	80	36	52	66	60	68	53	50	52	92	-	61	54	65	41	58	55
<b>HorizonDesign</b>	21	11	1008	135	62	452	719	96	105	12	51	23	14	0	8	261	12	649	87	217
<b>Color</b>	131	11	2934	162	61	16	126	92	69	12	95	23	14	0	8	367	12	646	87	215
<b>Mottles</b>	121	11	2985	9	10	11	105	33	17	0	1	13	0	0	0	0	12	16	30	48
<b>StructureType</b>	39	11	1635	117	59	11	99	82	17	0	87	13	14	0	0	211	12	620	30	164
<b>Stickiness</b>	41	11	6	8	9	11	67	19	17	0	0	4	0	0	0	129	12	16	26	41
<b>SaltAlkali</b>	41	11	1419	9	10	11	65	33	17	0	1	13	0	0	0	204	12	16	30	48
<b>Roots</b>	0	0	1495	0	0	0	73	4	25	0	0	0	0	0	0	10	0	0	0	0
<b>Field Texture</b>	124	11	2940	153	61	11	312	81	33	0	88	13	14	0	0	218	12	625	30	204
<b>Fld Crs.fragments</b>	349	2	2975	150	58	7	203	78	39	0	18	8	12	0	0	583	12	602	11	162
<b>Coarse fragments</b>	401	11	2976	150	60	15	417	88	68	9	19	9	12	0	9	611	12	609	30	182
<b>Layers</b>	1277	43	10262	518	188	94	2011	450	339	27	67	37	53	0	29	2648	86	1796	152	775
Min	0	0	0	0	0	0	0	0	0	1	0	0	0	-	0	0	0	0	0	0
Max	95	3	95	90	90	54	95	90	90	81	90	90	90	-	70	95	90	90	66	90
Ave	6	0	7	3	9	3	15	7	8	28	21	14	6	-	16	8	10	3	2	9
SD	17	1	17	13	18	8	22	19	19	28	29	26	16	-	19	20	20	8	8	17

	AF	AO	BF	BI	BJ	BW	CD	CF	CG	CI	CM	ET	GA	GH	GN	KE	LR	LS	MG
<b>Sand</b>	9941	238	432	36	718	895	379	89	46	143	112	510	25	34	6	416	17	29	53
<b>Layers</b>	37865	1212	1522	177	2815	2934	2049	390	160	390	430	1928	112	200	22	1788	79	139	241
Min	0	7	2	1	1	1	0	3	3	10	1	1	4	3	1	1	3	7	1
Max	100	100	98	95	98	98	98	98	98	98	95	85	100	87	86	98	83	85	97
Ave	54	67	53	40	62	70	44	49	38	49	40	32	43	48	26	40	52	44	48
SD	25	24	21	23	22	24	26	22	30	19	24	19	25	19	29	24	22	18	25
<b>Clay</b>	9941	238	432	36	718	895	379	89	46	143	112	510	25	34	6	416	17	29	53
<b>Layers</b>	37864	1212	1521	177	2815	2934	2049	390	161	390	430	1928	112	200	22	1787	79	139	241
Min	0	0	0	1	1	1	0	1	1	1	1	1	0	0	10	0	9	5	1
Max	97	84	80	82	94	87	93	88	78	65	84	88	79	68	78	96	64	67	69
Ave	30	25	27	39	23	22	40	30	36	32	38	42	41	30	52	41	32	31	27
SD	20	19	16	24	18	19	21	19	21	15	22	20	22	17	21	22	14	16	19
<b>Sum fractions</b>	9941	238	432	36	718	895	379	89	46	143	112	510	25	34	6	416	17	29	53
<b>Layers</b>	37863	1212	1521	177	2815	2934	2049	390	160	390	430	1928	112	200	22	1787	79	139	241
Min	90	95	93	90	99	94	97	96	100	91	100	98	100	100	100	90	100	99	100
Max	110	101	108	110	101	106	102	100	100	101	101	102	100	101	100	110	100	100	100
Ave	100	100	99	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
SD	1	0	1	2	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
<b>Bulk density</b>	1781	2	43	10	21	66	12	1	1	9	6	190	4	16	6	274	4	14	2
<b>Layers</b>	6736	8	120	56	75	266	54	6	2	23	29	536	14	67	22	1057	17	86	8
Min	0.16	1.36	1.12	0.70	1.20	0.54	1.24	1.02	1.80	1.27	0.47	0.59	1.05	1.24	0.75	0.16	1.10	1.16	0.31
Max	2.67	1.48	2.26	1.84	2.05	2.17	1.97	1.25	1.92	1.80	1.60	1.87	1.53	2.07	1.53	2.08	1.60	1.94	1.27
Ave	1.39	1.39	1.74	1.26	1.53	1.55	1.55	1.14	1.86	1.53	1.04	1.23	1.31	1.62	1.01	1.32	1.35	1.51	0.94
SD	0.24	0.04	0.22	0.29	0.20	0.24	0.17	0.09	0.08	0.16	0.43	0.17	0.14	0.19	0.23	0.20	0.15	0.17	0.41
<b>pH H2O</b>	9555	238	409	36	720	898	381	86	44	144	115	512	23	31	6	417	17	30	54
<b>Layers</b>	36244	1204	1379	176	2856	3036	2061	375	156	394	469	1960	99	189	22	1803	80	143	246
Min	2.4	4.0	4.6	4.1	3.2	3.5	3.4	3.9	3.9	4.2	3.9	4.0	3.3	4.2	3.8	3.6	4.0	4.3	3.6
Max	11.0	9.6	9.4	10.3	9.4	10.8	10.9	9.5	8.9	8.0	10.3	10.5	6.1	8.9	8.5	11.0	5.9	9.1	8.2
Ave	6.3	6.0	6.5	6.0	6.4	6.8	5.4	5.7	5.5	5.6	5.6	6.9	4.8	5.9	5.9	6.4	5.0	6.1	5.1
SD	1.2	1.1	0.9	1.4	0.8	1.3	1.0	0.9	1.0	0.7	0.8	1.2	0.6	1.2	1.6	1.3	0.4	1.0	0.8
<b>pH KCl</b>	4381	216	314	26	404	28	72	71	1	126	15	61	16	9	0	399	6	28	0
<b>Layers</b>	17556	1097	1080	119	1745	167	401	323	5	329	79	237	74	51	0	1725	29	136	0
Min	2.0	3.5	3.4	3.4	3.6	3.2	2.3	3.5	3.1	3.4	3.3	3.9	3.2	3.7	-	3.3	3.7	3.7	-
Max	10.7	8.8	8.0	7.2	7.8	9.7	7.3	8.6	4.9	7.4	5.9	10.0	5.2	6.5	-	10.5	4.5	8.2	-
Ave	5.0	4.9	5.2	4.7	5.5	5.6	4.2	4.9	3.9	4.5	4.7	5.3	4.0	4.3	-	5.4	4.1	4.9	-
SD	1.0	1.0	0.9	0.9	0.7	1.5	0.6	0.8	0.7	0.7	0.6	1.0	0.4	0.7	-	1.2	0.2	0.9	-

	ML	MR	MW	MZ	NA	NE	NG	RW	SD	SL	SN	SO	SZ	TD	TG	TZ	UG	ZA	ZM	ZW
<b>Sand</b>	602	11	811	147	61	456	1120	91	111	12	109	68	13	0	9	1181	12	645	86	218
<b>Layers</b>	1852	43	2335	549	181	1785	5034	473	572	50	376	270	61	0	38	4348	85	1719	500	1006
Min	2	27	18	0	16	1	0	0	1	4	1	0	4	-	15	0	17	2	4	4
Max	99	97	96	98	97	98	100	91	98	81	99	92	93	-	90	98	73	99	99	100
Ave	47	75	66	57	73	69	58	42	32	52	67	33	37	-	52	51	36	56	50	58
SD	21	22	17	28	18	23	24	18	29	22	26	20	23	-	18	25	14	24	25	25
<b>Clay</b>	602	11	811	147	61	456	1120	91	111	12	109	68	13	0	9	1181	12	645	86	218
<b>Layers</b>	1852	43	2335	549	181	1785	5034	473	572	50	376	270	61	0	38	4348	85	1719	500	1006
Min	1	1	1	1	0	1	0	1	1	10	0	2	4	-	4	0	14	0	0	0
Max	80	46	75	88	41	85	88	87	81	61	78	74	90	-	60	97	74	83	82	86
Ave	28	13	27	29	15	18	25	38	48	32	19	45	46	-	31	33	52	27	34	29
SD	17	13	15	21	11	15	19	19	23	15	17	17	21	-	14	20	16	18	20	20
<b>Sum fractions</b>	602	11	811	147	61	456	1120	91	111	12	109	68	13	0	9	1181	12	645	86	218
<b>Layers</b>	1852	43	2335	549	181	1785	5034	473	572	50	376	270	61	0	38	4348	85	1719	500	1006
Min	91	99	100	99	93	100	90	99	99	100	90	96	90	-	100	90	100	91	90	90
Max	109	100	100	110	102	100	110	109	102	100	108	110	101	-	100	110	100	109	101	110
Ave	100	100	100	100	100	100	100	100	100	100	100	100	100	-	100	100	100	99	100	100
SD	1	0	0	1	1	0	1	1	0	0	1	1	1	-	0	1	0	2	0	1
<b>Bulk density</b>	17	0	10	34	9	407	260	25	38	10	5	61	3	0	1	115	12	1	33	59
<b>Layers</b>	68	0	69	89	24	1520	1075	137	129	42	13	86	13	0	4	414	79	5	178	345
Min	0.54	-	1.27	0.95	1.25	0.80	0.73	0.16	1.13	0.80	0.58	1.22	1.00	-	1.51	0.42	1.18	0.90	0.96	0.92
Max	2.04	-	1.93	1.71	1.76	2.02	2.03	2.03	2.27	1.50	1.63	1.80	1.53	-	1.66	1.80	2.12	1.30	2.10	2.67
Ave	1.55	-	1.53	1.31	1.55	1.44	1.31	1.24	1.74	1.24	1.19	1.51	1.32	-	1.56	1.29	1.50	1.17	1.45	1.53
SD	0.23	-	0.15	0.19	0.14	0.18	0.19	0.44	0.21	0.15	0.39	0.14	0.17	-	0.07	0.22	0.18	0.16	0.21	0.20
<b>pH H2O</b>	558	11	851	151	61	406	975	96	111	12	112	68	13	0	9	1184	12	645	59	60
<b>Layers</b>	1613	42	2468	562	181	1536	4596	496	574	51	411	271	61	0	38	4172	86	1732	346	360
Min	4.1	5.0	4.0	3.9	5.0	2.9	3.6	3.4	4.8	2.7	2.4	7.6	4.1	-	4.7	2.5	4.2	4.1	3.6	4.1
Max	10.5	8.8	10.5	9.7	10.4	10.2	10.1	8.7	10.3	5.4	9.2	10.0	8.1	-	8.0	10.8	6.9	10.1	8.5	9.0
Ave	6.1	6.8	6.0	6.4	7.9	5.9	6.1	5.3	7.8	4.7	5.9	8.2	5.6	-	6.5	6.4	5.4	6.5	5.6	6.0
SD	1.1	1.1	0.8	0.8	1.0	1.1	1.1	0.9	1.0	0.5	1.3	0.3	1.1	-	0.9	1.2	0.6	1.2	0.7	1.1
<b>pH KCl</b>	465	0	10	144	10	207	309	93	0	11	39	5	13	0	1	856	0	194	32	200
<b>Layers</b>	1494	0	75	529	60	914	1528	482	0	47	130	28	57	0	5	2950	0	548	198	914
Min	3.2	-	4.0	3.7	4.6	3.0	3.4	3.0	-	3.8	2.9	7.1	4.0	-	4.0	2.0	-	3.6	2.8	3.4
Max	10.0	-	6.1	7.7	7.5	10.7	9.0	7.8	-	5.0	8.5	7.5	7.5	-	4.9	10.1	-	8.1	7.7	9.2
Ave	4.8	-	5.0	5.4	6.2	4.7	5.0	4.4	-	4.2	4.9	7.3	5.0	-	4.4	4.9	-	5.3	4.7	5.3
SD	1.0	-	0.5	0.8	0.8	1.0	1.0	0.8	-	0.2	1.0	0.1	0.9	-	0.4	1.1	-	1.0	0.8	1.0

	AF	AO	BF	BI	BJ	BW	CD	CF	CG	CI	CM	ET	GA	GH	GN	KE	LR	LS	MG
<b>pH CaCl2</b>	1717	0	0	10	0	816	11	1	0	1	66	0	0	18	0	38	0	16	20
<b>Layers</b>	6923	0	0	58	0	2723	67	1	0	6	281	0	0	98	0	192	0	97	122
Min	2.7	-	-	3.4	-	3.2	3.7	2.7	-	3.8	3.4	-	-	3.7	-	3.9	-	4.1	3.6
Max	10.3	-	-	8.5	-	10.3	4.9	2.7	-	5.2	9.3	-	-	8.3	-	8.2	-	7.6	5.8
Ave	5.8	-	-	5.1	-	6.1	4.2	2.7	-	4.1	4.7	-	-	5.5	-	5.4	-	5.5	4.2
SD	1.3	-	-	1.3	-	1.3	0.3	0.0	-	0.5	0.7	-	-	1.2	-	1.0	-	0.8	0.4
<b>EC</b>	5204	54	54	12	602	776	75	30	6	26	52	491	25	16	4	375	17	2	50
<b>Layers</b>	18771	224	184	63	1857	2294	346	117	26	109	229	1908	110	87	16	1579	81	3	234
Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0
Max	776.0	76.6	3.0	36.8	7.0	86.7	9.3	2.1	0.1	0.3	16.5	25.6	0.8	7.4	40.6	105.0	0.1	0.1	0.1
Ave	1.1	3.6	0.2	2.8	0.1	0.6	0.6	0.1	0.1	0.0	0.2	0.6	0.0	0.3	7.1	0.7	0.0	0.1	0.0
SD	14.5	9.9	0.6	7.6	0.2	2.9	1.8	0.2	0.0	0.1	1.5	1.3	0.1	1.2	13.6	5.3	0.0	-	0.0
<b>Soluble cations</b>	100	0	2	2	0	9	10	1	0	0	0	0	0	2	0	4	0	2	0
<b>Layers</b>	391	0	10	16	0	42	39	2	0	0	0	0	0	7	0	15	0	11	0
Min	0.1	-	3.9	2.5	-	3.0	0.8	0.3	-	-	-	-	-	5.9	-	0.1	-	1.6	-
Max	2479.2	-	21.9	876.9	-	1695.2	7.9	2.9	-	-	-	-	-	144.6	-	2479.2	-	3.5	-
Ave	78.4	-	13.2	197.9	-	138.6	4.2	1.6	-	-	-	-	-	65.2	-	578.8	-	2.5	-
SD	251.0	-	7.4	264.0	-	311.4	2.1	1.8	-	-	-	-	-	50.7	-	972.6	-	0.6	-
<b>Exch bases</b>	9036	202	384	32	711	890	210	87	39	142	112	511	15	34	6	415	17	30	42
<b>Layers</b>	33203	903	1291	158	2757	2916	1105	363	120	382	410	1915	45	201	21	1765	58	143	181
Min	0.0	0.0	0.3	0.1	0.5	0.3	0.0	0.1	0.0	0.0	0.2	2.5	0.0	0.0	3.8	0.1	0.3	1.2	0.0
Max	206.1	45.7	142.1	80.5	91.2	145.4	136.0	72.5	26.1	66.8	156.9	112.2	11.0	103.2	33.3	206.1	6.5	62.3	24.0
Ave	12.2	4.5	8.4	9.7	9.5	17.3	5.7	5.3	3.3	3.6	7.3	31.7	1.0	10.0	17.2	16.4	1.2	17.2	1.6
SD	16.4	7.1	10.1	14.1	10.0	19.5	13.5	8.3	5.5	6.6	11.8	18.7	1.8	14.5	8.4	19.8	1.3	17.1	2.9
<b>Exch acidity</b>	8044	226	207	32	714	893	123	47	13	47	92	349	15	34	6	372	17	30	48
<b>Layers</b>	28188	993	545	157	2773	2960	545	139	32	153	345	1160	52	201	22	1602	79	143	195
Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Max	100.0	13.0	4.5	19.5	1.3	3.7	43.8	0.1	0.2	7.9	76.7	0.1	9.0	12.7	0.1	38.5	4.6	17.7	0.1
Ave	0.4	0.6	0.1	1.8	0.0	0.0	1.5	0.0	0.0	0.5	3.4	0.0	2.6	0.8	0.0	1.0	1.4	1.5	0.0
SD	1.9	1.6	0.3	3.6	0.1	0.1	4.1	0.0	0.1	0.9	7.5	0.0	3.0	2.1	0.0	3.4	1.0	3.0	0.0
<b>eCEC</b>	7681	202	189	32	711	890	108	47	10	47	90	349	15	34	6	370	17	30	42
<b>Layers</b>	26932	903	492	154	2757	2916	524	137	23	151	343	1121	45	201	21	1580	58	143	181
Min	0.0	0.0	0.4	0.4	0.5	0.3	0.0	0.3	0.2	0.4	0.3	3.2	0.2	0.5	3.8	0.1	1.0	1.8	0.0
Max	206.1	45.7	142.1	80.5	91.2	145.4	173.2	39.1	25.5	66.9	156.9	112.2	11.1	103.2	33.3	206.1	6.6	62.9	24.0
Ave	13.9	5.2	13.7	11.2	9.6	17.3	10.9	8.0	4.5	5.9	11.1	40.7	3.1	10.9	17.2	18.5	2.9	18.7	1.6
SD	17.4	7.1	13.3	13.6	10.0	19.5	20.3	8.4	7.7	9.9	13.6	17.0	3.2	14.5	8.4	20.4	1.4	17.0	3.0



	ML	MR	MW	MZ	NA	NE	NG	RW	SD	SL	SN	SO	SZ	TD	TG	TZ	UG	ZA	ZM	ZW
<b>pH CaCl2</b>	14	11	10	1	0	11	141	36	69	0	1	5	0	0	0	264	12	21	76	48
<b>Layers</b>	87	42	75	6	0	72	403	212	385	0	5	29	0	0	0	1089	86	63	427	297
Min	3.9	4.6	4.6	4.5	-	3.7	2.8	3.4	4.3	-	5.8	7.5	-	-	-	3.1	3.8	3.5	3.0	4.0
Max	7.9	8.4	6.6	5.6	-	7.7	8.7	7.8	8.9	-	6.7	8.0	-	-	-	9.9	6.7	8.2	8.0	8.1
Ave	4.7	6.5	5.5	5.1	-	4.9	5.6	4.7	7.3	-	6.1	7.7	-	-	-	5.9	4.8	5.7	5.0	5.2
SD	0.8	1.1	0.5	0.4	-	1.0	0.8	0.8	0.8	-	0.4	0.2	-	-	-	1.3	0.7	1.2	0.9	0.9
<b>EC</b>	66	1	89	113	36	364	407	12	78	12	45	68	0	0	5	1016	0	153	44	28
<b>Layers</b>	276	3	226	357	138	1261	1804	63	363	51	161	271	0	0	13	3567	0	347	247	156
Min	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	-	-	0.0	0.0	-	0.0	0.0	0.0
Max	4.6	0.4	185.0	28.0	776.0	22.0	10.0	0.4	33.4	0.1	592.4	10.6	-	-	0.1	62.4	-	102.5	6.2	70.0
Ave	0.1	0.3	7.8	1.1	44.0	0.2	0.2	0.1	1.9	0.0	12.0	1.5	-	-	0.0	0.8	-	3.3	0.1	0.8
SD	0.3	0.1	28.8	3.1	135.8	0.9	0.4	0.1	4.4	0.0	67.7	1.9	-	-	0.0	2.9	-	9.7	0.4	5.8
<b>Soluble cations</b>	0	1	0	1	2	1	0	1	14	0	1	5	0	0	0	10	0	25	1	6
<b>Layers</b>	0	3	0	5	9	6	0	1	54	0	1	28	0	0	0	69	0	41	6	26
Min	-	5.5	-	20.1	32.0	3.9	-	5.3	4.8	-	5.7	4.6	-	-	2.0	-	-	0.2	2.4	0.2
Max	-	6.0	-	53.4	457.0	84.2	-	5.3	225.3	-	5.7	139.8	-	-	335.6	-	-	44.7	83.4	14.7
Ave	-	5.8	-	42.0	206.2	53.7	-	5.3	56.1	-	5.7	46.5	-	-	67.3	-	-	11.9	31.8	5.6
SD	-	0.3	-	13.5	174.1	32.4	-	0.0	62.4	-	0.0	49.6	-	-	101.4	-	-	12.3	38.8	3.1
<b>Exch bases</b>	493	11	405	142	59	378	1081	95	67	12	106	68	13	0	1	1274	12	644	80	216
<b>Layers</b>	1401	42	1200	518	173	1119	4791	478	351	39	348	268	61	0	5	4449	86	1724	423	993
Min	0.1	0.6	0.5	0.3	0.2	0.1	0.0	0.0	0.2	0.4	0.1	3.6	0.3	-	1.2	0.1	0.8	0.0	0.0	0.0
Max	72.1	45.4	26.6	131.9	55.5	164.8	65.9	87.4	120.0	53.0	55.3	131.4	66.5	-	2.7	173.1	28.8	117.7	75.1	116.2
Ave	7.8	8.1	5.8	14.9	13.8	7.4	8.1	9.8	42.5	5.6	6.6	32.6	11.9	-	2.1	15.7	4.9	8.5	4.9	11.2
SD	8.1	11.6	3.6	18.1	11.2	10.1	11.0	15.9	33.6	12.8	9.9	20.8	16.3	-	0.6	18.3	4.5	11.0	9.1	18.5
<b>Exch acidity</b>	358	11	599	146	61	381	621	94	103	12	104	68	13	0	8	1245	12	644	81	218
<b>Layers</b>	917	42	1618	527	181	1172	2265	486	511	51	355	271	61	0	32	4364	86	1724	426	1003
Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0
Max	13.0	0.4	1.5	5.3	0.0	2.6	20.9	47.2	7.2	1.9	2.1	0.0	3.8	-	1.2	21.0	5.4	11.6	2.5	100.0
Ave	0.4	0.0	0.0	0.3	0.0	0.0	0.3	2.8	0.1	0.7	0.0	0.0	0.6	-	0.1	0.2	0.7	0.4	0.2	0.3
SD	1.2	0.1	0.1	0.8	0.0	0.1	1.1	4.7	0.7	0.5	0.1	0.0	0.8	-	0.3	1.0	1.4	1.1	0.4	3.3
<b>eCEC</b>	352	11	405	142	59	378	615	95	59	12	101	68	13	0	1	1229	12	644	80	216
<b>Layers</b>	904	42	1200	518	173	1119	2238	478	308	39	330	268	61	0	5	4273	86	1724	423	993
Min	0.4	0.7	1.0	0.3	0.2	0.4	0.0	0.6	1.1	0.6	0.1	3.6	0.8	-	1.2	0.1	2.0	0.0	0.0	0.0
Max	72.1	45.4	27.1	131.9	55.5	164.8	60.0	99.1	120.0	53.0	55.3	131.4	66.7	-	3.7	173.1	28.8	117.8	75.1	116.2
Ave	8.2	8.1	5.9	15.2	13.8	7.5	11.9	12.6	48.3	6.3	6.9	32.6	12.5	-	2.7	16.2	5.7	8.9	5.1	11.6
SD	9.2	11.6	3.6	18.1	11.2	10.1	13.2	15.6	31.8	12.5	10.1	20.8	16.1	-	1.1	18.4	4.2	10.8	9.0	18.7

	AF	AO	BF	BI	BJ	BW	CD	CF	CG	CI	CM	ET	GA	GH	GN	KE	LR	LS	MG
<b>CEC</b>	9514	230	381	34	719	893	380	84	43	144	112	511	22	27	6	414	15	30	53
<b>Layers</b>	35638	1038	1278	172	2841	3015	2036	363	145	392	423	1919	98	165	21	1762	71	140	237
Min	0.0	0.4	0.5	1.1	0.6	0.1	0.6	0.5	0.1	0.0	0.3	3.0	0.2	1.2	5.4	0.5	3.0	2.7	0.8
Max	179.0	48.1	72.5	109.6	98.0	83.5	179.0	39.2	40.0	70.2	69.8	116.3	25.0	47.7	39.0	88.1	33.7	62.9	98.8
Ave	13.6	8.1	9.6	15.9	12.3	12.1	9.2	8.7	8.4	6.6	15.2	38.0	8.8	11.2	22.3	19.0	8.0	20.4	13.0
SD	13.8	7.5	8.1	13.9	10.7	12.6	9.8	7.7	7.3	6.8	12.5	16.7	5.7	11.0	9.4	12.7	5.4	17.0	12.1
<b>Inorg C</b>	3206	79	53	10	651	514	76	33	7	19	51	200	17	11	5	189	17	10	51
<b>Layers</b>	11794	315	167	53	2385	1286	342	125	29	67	213	789	71	54	15	700	80	21	233
Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Max	990.0	70.7	990.0	16.7	1.4	86.4	99.6	83.5	6.6	0.1	6.0	17.0	0.0	0.1	0.0	52.2	0.0	25.6	0.4
Ave	2.0	4.3	17.5	1.3	0.0	1.1	2.7	1.3	0.5	0.0	0.1	1.4	0.0	0.0	0.0	1.8	0.0	1.9	0.0
SD	16.5	11.5	126.2	2.7	0.1	7.5	12.6	9.8	1.6	0.0	0.5	1.2	0.0	0.0	0.0	5.1	0.0	5.7	0.0
<b>Org C</b>	9713	232	427	34	709	842	381	85	43	144	119	510	25	21	6	408	17	30	54
<b>Layers</b>	32611	983	1443	165	2125	2596	1814	232	106	380	425	1883	105	119	22	1633	79	113	228
Min	0.0	0.1	0.0	0.5	1.0	0.0	0.1	0.3	0.4	0.4	0.4	0.4	0.3	0.4	1.0	0.2	2.2	1.2	0.3
Max	570.0	64.2	40.1	322.4	193.0	81.7	547.4	99.6	163.0	65.0	215.6	120.0	69.2	46.5	68.8	363.0	58.9	55.0	272.1
Ave	8.6	6.9	4.9	24.5	8.8	4.5	13.9	12.7	23.4	9.7	24.3	10.7	13.2	5.8	17.6	11.4	14.5	8.8	30.4
SD	15.6	7.7	4.4	39.4	9.7	6.9	28.0	12.4	26.5	8.7	28.8	8.8	14.6	7.2	17.1	20.4	11.3	9.5	38.3
<b>Total N</b>	7444	207	414	30	713	28	377	85	43	144	106	510	25	34	6	219	12	30	51
<b>Layers</b>	22456	851	1349	116	2129	70	1629	231	103	352	356	1877	90	144	22	464	35	63	213
Min	0.00	0.05	0.00	0.20	0.10	0.10	0.05	0.09	0.02	0.06	0.20	0.03	0.10	0.00	0.20	0.09	0.20	0.20	0.02
Max	29.40	3.77	2.84	29.40	9.50	8.70	14.00	5.60	11.60	7.60	21.80	10.10	4.60	3.10	3.30	16.00	3.50	4.80	19.80
Ave	0.80	0.54	0.41	2.14	0.68	0.80	1.16	0.92	1.58	0.81	2.20	0.96	1.00	0.69	1.16	1.83	1.17	1.00	2.03
SD	1.08	0.51	0.29	3.24	0.56	1.38	1.45	0.76	1.51	0.74	2.32	0.83	0.81	0.66	0.87	2.11	0.75	0.87	2.41
<b>Total P</b>	875	0	322	0	0	0	0	32	1	115	17	0	0	3	0	6	0	0	0
<b>Layers</b>	2727	0	1038	0	0	0	0	77	6	270	40	0	0	13	0	7	0	0	0
Min	0	-	10	-	-	-	-	22	140	15	57	-	-	50	-	21	-	-	-
Max	6035	-	5219	-	-	-	-	1401	240	1410	6035	-	-	300	-	198	-	-	-
Ave	149	-	132	-	-	-	-	289	178	205	1326	-	-	124	-	106	-	-	-
SD	275	-	245	-	-	-	-	279	37	160	1249	-	-	68	-	58	-	-	-
<b>VMC pF 0.0</b>	194	0	1	0	2	28	2	0	0	8	1	0	4	0	0	58	0	0	0
<b>Layers</b>	551	0	3	0	6	84	7	0	0	17	5	0	14	0	0	178	0	0	0
Min	5.0	-	30.3	-	34.5	5.0	37.3	-	-	26.0	58.0	-	40.4	-	-	28.2	-	-	-
Max	85.0	-	37.3	-	61.1	85.0	42.3	-	-	49.9	64.0	-	56.4	-	-	70.0	-	-	-
Ave	42.0	-	34.5	-	48.7	20.6	39.4	-	-	41.1	60.8	-	47.4	-	-	49.4	-	-	-
SD	14.9	-	3.7	-	10.8	17.0	2.1	-	-	6.5	2.6	-	4.4	-	-	8.8	-	-	-

	ML	MR	MW	MZ	NA	NE	NG	RW	SD	SL	SN	SO	SZ	TD	TG	TZ	UG	ZA	ZM	ZW
<b>CEC</b>	491	11	834	132	58	455	957	96	94	12	102	68	13	0	9	1121	12	646	86	219
<b>Layers</b>	1443	42	2408	488	171	1596	4456	485	480	50	343	269	61	0	38	3881	86	1726	495	1004
Min	0.4	0.9	0.3	0.1	0.1	0.5	0.1	0.3	1.0	1.1	0.6	0.6	2.0	-	1.1	0.2	4.3	0.1	0.4	0.1
Max	38.5	32.1	59.8	69.1	38.3	74.0	79.5	141.5	136.0	33.7	52.6	45.3	56.5	-	60.0	118.0	22.4	89.6	53.6	107.8
Ave	9.4	7.6	8.9	14.6	8.5	7.5	11.5	18.8	36.9	8.3	8.3	21.1	12.9	-	19.7	16.5	9.3	10.8	8.4	10.9
SD	7.1	9.6	6.0	14.7	7.9	8.6	11.7	20.3	23.9	7.4	8.9	8.4	13.0	-	15.1	14.3	4.5	9.8	8.3	14.4
<b>Inorg C</b>	47	8	3	53	22	432	150	18	101	12	18	68	0	0	4	189	0	23	32	33
<b>Layers</b>	164	26	4	176	73	1709	646	88	501	51	50	271	0	0	8	729	0	72	155	126
Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	0.0	0.0	-	0.0	0.0	0.0
Max	66.7	0.0	0.0	32.0	73.2	6.0	5.9	103.2	74.4	0.0	62.0	44.8	-	-	0.1	73.4	-	3.5	7.6	68.6
Ave	1.4	0.0	0.0	1.0	9.3	0.0	0.4	3.1	4.3	0.0	6.1	25.7	-	-	0.0	2.9	-	0.4	0.1	3.5
SD	6.5	0.0	0.0	3.1	15.2	0.3	0.5	16.9	7.4	0.0	14.2	9.5	-	-	0.1	6.2	-	1.0	0.7	11.1
<b>Org C</b>	537	11	843	144	61	452	1074	96	111	11	108	68	13	0	9	1269	12	639	87	81
<b>Layers</b>	1566	43	2056	485	180	1494	3712	499	469	47	326	245	59	0	29	4209	86	1716	471	468
Min	0.0	0.4	0.3	0.0	0.2	0.1	0.0	0.3	0.1	2.4	0.1	0.6	0.1	-	1.1	0.0	0.9	0.0	0.5	0.0
Max	48.5	5.5	48.8	76.9	16.9	66.2	111.0	359.1	29.0	50.6	84.9	17.6	47.9	-	17.4	136.0	43.6	326.0	570.0	45.3
Ave	4.1	2.1	8.2	7.2	3.5	3.2	6.2	25.1	5.5	14.4	7.1	5.8	9.7	-	6.0	9.4	9.4	7.8	13.7	4.5
SD	4.2	1.3	7.2	7.4	2.5	5.7	7.3	48.5	3.8	10.9	10.0	3.0	9.3	-	4.3	10.1	10.0	15.7	44.4	6.0
<b>Total N</b>	539	11	780	141	50	383	908	47	49	0	105	68	13	0	5	1158	10	20	61	62
<b>Layers</b>	1384	21	1710	448	112	1085	2782	174	97	0	305	226	51	0	15	3452	31	76	234	159
Min	0.00	0.00	0.10	0.01	0.03	0.00	0.00	0.10	0.10	-	0.01	0.10	0.10	-	0.20	0.00	0.40	0.20	0.10	0.06
Max	4.24	0.60	8.10	7.00	0.97	5.10	11.30	22.40	1.60	-	5.60	1.90	2.40	-	1.00	12.00	3.50	5.60	12.60	3.80
Ave	0.39	0.20	0.80	0.69	0.34	0.38	0.61	2.86	0.47	-	0.55	0.62	0.60	-	0.50	0.81	1.28	0.99	1.02	0.69
SD	0.41	0.14	0.63	0.60	0.20	0.51	0.70	4.45	0.30	0	0.62	0.31	0.46	-	0.23	0.76	0.84	0.81	1.82	0.61
<b>Total P</b>	239	0	0	0	0	0	93	0	0	0	1	0	0	0	0	46	0	0	0	0
<b>Layers</b>	708	0	0	0	0	0	409	0	0	0	6	0	0	0	0	153	0	0	0	0
Min	3	-	-	-	-	-	7	-	-	-	252	-	-	-	-	0	-	-	-	-
Max	974	-	-	-	-	-	700	-	-	-	298	-	-	-	-	31	-	-	-	-
Ave	118	-	-	-	-	-	122	-	-	-	281	-	-	-	-	4	-	-	-	-
SD	75	-	-	-	-	-	86	-	-	-	18	-	-	-	-	4	-	-	-	-
<b>VMC pF 0.0</b>	9	0	0	13	0	9	15	1	5	0	5	0	3	0	1	23	0	0	0	6
<b>Layers</b>	18	0	0	35	0	27	46	5	12	0	9	0	7	0	4	56	0	0	0	18
Min	20.0	-	-	32.8	-	23.0	25.0	58.7	17.3	-	25.0	-	42.0	-	31.6	20.7	-	-	-	32.0
Max	77.5	-	-	64.0	-	56.0	51.6	72.9	56.2	-	32.0	-	61.0	-	38.7	70.3	-	-	-	55.0
Ave	43.5	-	-	47.3	-	38.3	37.7	68.7	36.8	-	29.3	-	50.0	-	36.0	48.9	-	-	-	44.5
SD	13.4	-	-	8.2	-	7.9	5.3	5.7	10.5	-	2.3	-	7.0	-	3.1	13.9	-	-	-	7.3

	AF	AO	BF	BI	BJ	BW	CD	CF	CG	CI	CM	ET	GA	GH	GN	KE	LR	LS	MG
<b>VMC pF 2.0</b>	335	0	9	0	2	19	2	0	0	7	0	0	4	7	0	54	0	0	0
<b>Layers</b>	1157	0	20	0	6	110	7	0	0	15	0	0	14	23	0	168	0	0	0
Min	3.7	-	3.7	-	10.5	5.1	19.2	-	-	21.4	-	-	19.6	7.8	-	10.0	-	-	-
Max	98.0	-	33.9	-	54.3	92.7	25.0	-	-	43.1	-	-	50.5	54.6	-	55.1	-	-	-
Ave	30.9	-	15.9	-	33.7	24.5	22.6	-	-	32.4	-	-	34.1	29.9	-	33.6	-	-	-
SD	16.0	-	9.1	-	20.3	19.7	2.1	-	-	7.0	-	-	10.0	10.2	-	10.6	-	-	-
<b>VMC pF 2.5</b>	1572	164	54	10	0	64	10	0	0	17	4	182	0	14	0	51	6	14	0
<b>Layers</b>	5279	796	171	55	0	260	38	0	0	51	20	516	0	56	0	180	28	86	0
Min	1.0	2.0	1.4	9.1	-	2.0	5.9	-	-	14.0	24.8	17.1	-	6.5	-	4.0	21.0	6.4	-
Max	98.0	63.0	41.1	77.0	-	88.9	32.8	-	-	40.0	62.0	88.6	-	40.3	-	52.1	64.0	52.9	-
Ave	22.9	16.0	15.8	32.9	-	19.3	18.2	-	-	29.2	46.3	43.1	-	20.4	-	30.1	33.7	24.4	-
SD	15.1	9.6	8.6	14.5	-	17.2	6.0	-	-	6.7	11.7	11.9	-	9.3	-	10.6	9.3	11.6	-
<b>VMC pF 4.2</b>	1723	92	96	10	3	64	13	0	0	25	5	182	4	13	6	74	6	14	0
<b>Layers</b>	5878	391	310	56	9	274	74	0	0	68	27	516	14	73	22	243	28	90	0
Min	0.0	1.0	0.8	2.6	1.5	1.0	1.1	-	-	6.0	17.8	9.8	7.8	0.7	5.0	0.3	6.0	1.7	-
Max	83.3	30.0	31.6	47.0	40.4	44.4	31.6	-	-	33.0	50.0	67.0	39.6	27.4	45.0	46.5	18.0	40.0	-
Ave	14.9	10.2	9.1	18.2	17.2	10.7	10.2	-	-	16.8	33.7	29.8	21.1	12.4	23.7	17.8	10.9	15.3	-
SD	10.7	6.7	5.8	8.4	17.5	9.7	7.3	-	-	6.0	8.3	10.2	10.0	6.5	12.0	8.8	3.0	8.9	-

	ML	MR	MW	MZ	NA	NE	NG	RW	SD	SL	SN	SO	SZ	TD	TG	TZ	UG	ZA	ZM	ZW
<b>VMC pF 2.0</b>	7	0	6	15	0	15	52	1	5	0	5	0	0	0	1	88	0	0	5	31
<b>Layers</b>	16	0	30	41	0	56	142	5	12	0	9	0	0	0	4	305	0	0	15	159
Min	7.4	-	9.5	15.7	-	3.7	6.0	42.0	13.5	-	4.5	-	-	-	13.6	7.3	-	-	11.9	4.2
Max	63.8	-	30.9	64.0	-	39.0	98.0	58.6	41.0	-	22.2	-	-	-	24.7	66.0	-	-	36.0	66.0
Ave	32.6	-	22.9	34.6	-	13.2	41.6	53.5	23.8	-	13.9	-	-	-	18.9	36.9	-	-	23.5	21.8
SD	14.7	-	6.7	9.4	-	7.8	20.7	7.1	10.1	-	6.8	-	-	-	6.0	12.5	-	-	8.6	12.3
<b>VMC pF 2.5</b>	69	0	10	42	0	16	51	20	28	11	2	5	3	0	0	49	12	597	27	40
<b>Layers</b>	143	0	68	129	0	67	170	109	83	46	7	27	7	0	0	149	73	1541	158	245
Min	1.1	-	7.9	2.0	-	2.7	4.5	3.5	7.1	9.0	6.8	11.2	30.0	-	-	4.8	15.8	1.0	3.1	3.6
Max	59.8	-	44.0	75.0	-	50.0	98.0	98.0	71.0	43.0	18.0	40.6	40.0	-	-	61.7	32.1	98.0	40.0	62.5
Ave	23.2	-	20.7	24.0	-	15.7	34.6	28.3	36.6	18.8	12.5	34.4	36.6	-	-	30.6	23.9	17.6	17.4	18.6
SD	13.0	-	5.8	16.4	-	12.3	20.8	19.4	15.7	7.9	4.5	6.0	3.6	-	-	13.0	3.9	12.1	7.0	11.4
<b>VMC pF 4.2</b>	83	11	10	51	0	20	62	38	28	11	7	5	3	0	1	97	12	597	33	47
<b>Layers</b>	193	43	75	152	0	99	201	219	152	46	16	29	7	0	4	348	85	1540	180	294
Min	0.5	0.5	2.7	1.0	-	0.5	1.1	0.9	1.2	5.0	2.0	5.2	8.0	-	2.8	0.5	5.5	0.0	0.8	1.1
Max	32.0	14.2	21.7	46.0	-	41.0	66.4	83.3	49.0	29.0	22.1	27.1	35.0	-	14.7	58.0	23.4	60.0	31.0	48.0
Ave	10.7	4.4	13.5	15.1	-	8.9	21.0	17.5	22.4	13.3	9.9	20.3	24.1	-	9.0	20.9	17.2	10.9	12.3	12.8
SD	7.6	4.4	4.6	10.7	-	9.7	13.5	11.5	10.1	6.4	7.8	4.1	9.4	-	6.4	10.5	3.9	8.0	5.7	9.8







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