World Soil Resources Reports 74

ISSN 0532-0488

GLOBAL AND NATIONAL SOILS AND TERRAIN DIGITAL DATABASES (SOTER)

Procedures manual

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

World Soil Resources Reports 74

GLOBAL AND NATIONAL SOILS AND TERRAIN DIGITAL DATABASES (SOTER)

Procedures Manual

UNEP

United Nations Environment Programme

ISSS-AISS-IBG

International Society of Soil Science

ISRIC

International Soil Reference and Information Centre

Food and Agriculture Organization of the United Nations

Land and Water Development Division
Food and Agriculture Organization of the United Nations
1993

M-51
ISBN 92-5-103429-X

Preface

Based on a discussion paper "Towards a Global Soil Resources Inventory at Scale 1:1 million" prepared by Sombroek (1984), the International Society of Soil Science (ISSS) convened a workshop of international experts on soils and related disciplines in January 1986 in Wageningen, the Netherlands, to discuss the "Structure of a Digital International Soil Resources Map annex Data Base" (ISSS, 1986a). Based on the findings and recommendations of this workshop a project proposal was written for SOTER, a World **SO**ils and **TER**rain Digital Data Base at a scale of 1:1 million (ISSS, 1986b).

A small international committee was appointed to propose criteria for a "universal" map legend suitable for compilation of small scale soil-terrain maps, and to include attributes required for a wide range of interpretations such as crop suitability, soil degradation, forest productivity, global soil change, irrigation suitability, agro-ecological zonation, and risk of droughtiness. The committee compiled an initial list of attributes. The SOTER approach received further endorsement at the 1986 ISSS Congress in Hamburg, Germany.

A second meeting, sponsored by the United Nations Environment Programme (UNEP), was held in Nairobi, Kenya, in May 1987 to discuss the application of SOTER for preparing soil degradation assessment maps. Two working groups (legend development and soil degradation assessment) met concurrently during this meeting. The legend working group was charged with the task of developing Guidelines for a World Soils and Terrain Digital Database at a 1:1 million scale, to propose general legend concepts, to prepare an attribute file structure, and to draft an outline for a Procedures Manual (ISSS, 1987).

Following the Nairobi meeting, UNEP formulated a project document: "Global Assessment of Soil Degradation" and asked ISRIC to compile, in close collaboration with ISSS, FAO, the Winand Staring Centre and the International Institute for Aerospace Survey and Earth Sciences (ITC), a global map on the status of human-induced soil degradation at a scale of 1:10 million, and to have this accompanied by a first pilot area at 1:1 million scale in South America where both status and risk of soil degradation would be assessed on the basis of a digital soil and terrain database as envisaged by the SOTER proposal. In this context ISRIC subcontracted the preparation for a first draft of a Procedures Manual for the 1:1 million pilot study area to the Land Resource Research Centre of Agriculture Canada[1].

The first draft of the Procedures Manual (Shields and Coote, 1988) was presented at the First Regional Workshop on a Global Soils and Terrain Digital Database and Global Assessment of Soil Degradation held in March 1988 in Montevideo, Uruguay (ISSS, 1988). The proposed methodology was then tested in a pilot area, covering parts of Argentina, Brazil and Uruguay (LASOTER). Soil survey teams of the participating countries collected soils and terrain data to assess the workability of the procedures as proposed in the draft Manual. During two correlation meetings and field trips minor changes were suggested, while further modifications were recommended at a workshop that concluded the data collection stage. The comments from both workshops were incorporated in the January 1989 version of the Procedures Manual (Shields and Coote, 1989).

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[1] Presently the Centre for Land and Biological Resources Research.

Application of the SOTER methodology in an area along the border between the USA and Canada (NASOTER), revealed additional shortcomings in the second version of the Manual. Also, the first tentative interpretation of the LASOTER data as well as the integration of the attribute data into a Geographic Information System demonstrated the need for further modifications.

A third revised version of the Manual was compiled by the SOTER staff (ISRIC, 1990a) and circulated for comments amongst a broad spectrum of soil scientists and potential users of the database. A workshop on Procedures Manual Revisions was convened at ISRIC, Wageningen, to discuss the revised legend concepts and definitions (ISRIC, 1990b).

Based on the recommendations of this workshop, the proposed modifications were further elaborated, resulting in a fourth draft version of the Procedures Manual (ISRIC, 1991). This Manual consisted of three parts, the first of which dealt with terrain and soil characteristics. The second part treated land use in a summary way in the expectation that a more comprehensive structure for a land use database would become available from other organizations. In the third part information on related files and climatic data needed for SOTER applications were described. In each section definitions and descriptions of the attributes to be coded were given, while in the first section an explanation of the mapping approach was provided.

Unlike the 1st and 2nd versions of the Manual, the later versions did not elaborate upon the soil degradation assessment as this is considered to be an interpretation of the database. Guidelines for this and other interpretations will be subject of separate publications. Technical specifications (e.g. table definitions, primary keys, table constraints etc.) and a user manual for the SOTER database will also be published separately.

A second SOTER workshop organized by UNEP was convened in February 1992 in Nairobi. At this meeting FAO expressed its full support for the SOTER programme and indicated that it was prepared to use the SOTER methodology for storing and updating its own data on world soil and terrain resources. To facilitate the use of SOTER data by FAO it was decided to use the FAO-Unesco Soil Map of the World Revised Legend (FAO, 1990b) as a basis for characterizing the soils component of the SOTER database.

To take account of these decisions a fifth version of the Manual was prepared in 1992 with active participation by FAO. The arrangement of this is similar to the fourth version, but the Manual now consists of three parts, the first one dealing with soils and terrain, the second with land cover and land use, and the third covering databases in which information, including climate data, is stored.

No further revisions of the Manual are planned until more experience has been gained in the application of the methodology according to the current guidelines. Nevertheless, all comments are welcome, and should be sent to the Manager of the SOTER project[1] or to the Chief, Soil Resources, Management and Conservation Service, FAO.

Original editors: Vincent van Engelen and Wen Ting-tiang

[1] c/o Director, International Soil Reference and Information Centre, P.O.Box 353, 6700 AJ Wageningen, The Netherlands.

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Acknowledgements

The SOTER project, an initiative of the ISSS, was very effectively supported by Working Group DM of the ISSS under chairmanship of M.F. Baumgardner. The project has benefited enormously from the experience of a wide range of soil and other natural resource scientists from all over the world. Our special thanks go to the following persons who were very active in the compilation of the manual:

D.R. Coote
J.H.M. Pulles
J. Shields

Participation of the following persons in the various workshops and pilot area studies is also highly appreciated:

C. Alvarez, D. Arnold, A. Ayoub, N.H. Batjes, M.F. Baumgardner, P. Brabant, R. Brinkman, P.A. Burrough, T. Calhoun, A. Califra, C. Clerici, T.T. Cochrane, R.M. Di Giacomo, E. Di Landro, P.J. Fasolo, N. Fernandez, I.P. Garbouchev, R. Godagnone, M. Ilaiwi, E. Klamt, J. Lamp, K.B. MacDonald, J.H. Molfino, F.N. Muchena, F. Nachtergaele, L.R. Oldeman, J. Olmos, W.L. Peters, C. Petraglia, R. Pötter, M.F. Purnell, W. Reybold, J.C. Salazar, C. Scoppa, J.L. Seghal, D. Sims, W.G. Sombroek, R.F. van de Weg, G. Varallyay, D. Yost, J.A. Zinck.

PART I

SOILS AND TERRAIN

Chapter 1

General introduction

AIM

The aim of the SOTER project is to utilize current and emerging information technology to establish a World Soils and Terrain Database, containing digitized map units and their attribute data (ISSS, 1986b). The main function of this database is to provide the necessary data for improved mapping and monitoring of changes of world soil and terrain resources.

It is composed of sets of files for use in a Relational DataBase Management System (RDBMS) and Geographic Information System (GIS). It is capable of delivering accurate, useful and timely information to a wide range of scientists, planners, decision-makers and policy-makers.

CENTRAL DATABASE

In the initial phases of the SOTER project no concrete plans have been formulated for the physical establishment of a centralized database. Rather, a separate database will be set up for each area for which a land resource inventory is being undertaken according to the SOTER methodology. The common approach does, however, guarantee the possibility of merging the individual databases into a global database if and when this becomes feasible. Through its basic activities SOTER also intends to contribute to the establishment of national and regional soil and terrain databases, founded upon the same commonly acceptable principles and procedures, so as to further facilitate the exchange of land resource information and ultimate incorporation into a global database.

CHARACTERISTICS

The database has the following characteristics:

- it is structured to provide a comprehensive framework for the storage and retrieval of uniform soil and terrain data that can be used for a wide range of applications at different scales;
- it will contain sufficient data to allow information extraction at a resolution of 1:1 million, both in the form of maps and tables;

- it will be compatible with global databases of other environmental resources;
- it will be amenable to periodic updating and purging of obsolete and/or irrelevant data; and
- be accessible to a broad array of international, regional and national environmental specialists through the provision of standardized resource maps, interpretative maps and tabular information essential for the development, management and conservation of environmental resources.

PROCEDURES

The database is supported by a Procedures Manual which translates SOTER's overall objectives into a workable set of arrangements for the selection, standardization, coding and storing of soil and terrain data.

SOTER requires soils from all corners of the world to be characterized under a single set of rules. As the FAO-Unesco (1974-1981) Soil Map of the World was designed for this purpose, SOTER has adopted the recently Revised Legend (FAO, 1990b) as the main tool for differentiating and characterizing its soil components. As there is no universally accepted system for world-wide classification of terrain, SOTER has designed its own system, presented in chapter 6 of this Manual, which is partly based on earlier FAO work.

The input of soil and terrain data into the SOTER database is contingent upon the availability of sufficiently detailed information. Although some additional information gathering may be required when preparing existing data for acceptance by the database, the SOTER approach is not intended to replace traditional soil surveys. Hence this manual cannot be used as guidelines for soil survey procedures or any other methodology for the collection of field data. Nor does it present a methodology for the interpretation of remotely sensed data. Several handbooks on these techniques are available and details of land resource survey methodology are contained within them.

Chapter 2

Mapping approach and database construction

Within the context of the general objectives of SOTER, as defined in chapter 1, the following subjects will be treated in more detail:

- the procedure for delineating areas with a homogeneous set of soil and terrain characteristics;
- the construction of an attribute database related to the mapping units and based on well-defined differentiating criteria;
- the development of a methodology that should be transferable to and usable by developing countries for national database development at the same or at a larger scale (technology transfer).

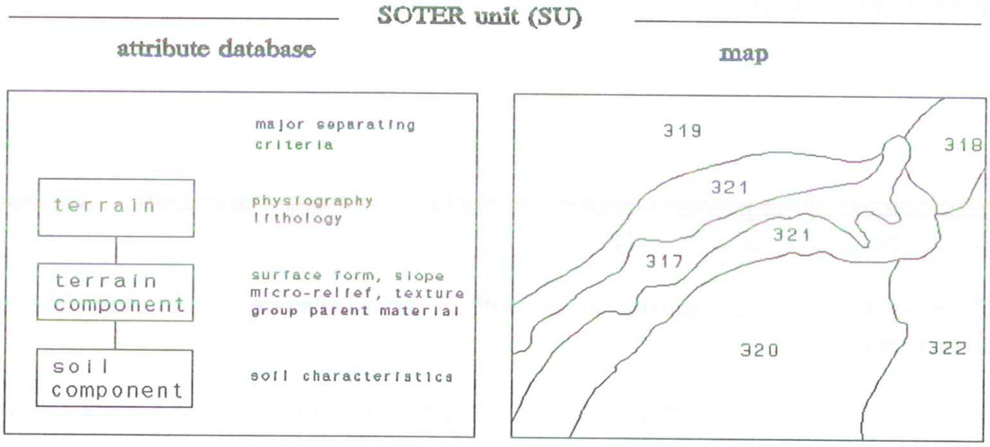
SOTER MAPPING APPROACH

The methodology of mapping of land characteristics outlined in this manual originated from the idea that land (in which terrain and soil occur) incorporates processes and systems of interrelationships between physical, biological and social phenomena evolving through time. This idea was developed initially in Russia and Germany (landscape science) and became gradually accepted throughout the world. A similar integrated concept of land was used in the land systems approach developed in Australia by Christian and Stewart (1953) and evolved further by Cochrane *et al.* (1981, 1985), McDonald *et al.* (1990) and Gunn *et al.* (1990). SOTER has continued this development by viewing land as being made up of natural entities consisting of combinations of terrain and soil individuals.

Underlying the SOTER methodology is the identification of areas of land with a distinctive, often repetitive, pattern of landform, lithology, surface form, slope, parent material, and soil. Tracts of land distinguished in this manner are named SOTER units. Each SOTER unit thus represents one unique combination of terrain and soil characteristics. Figure 1 shows the representation of a SOTER unit in the database and gives an example of a SOTER map, with polygons that have been mapped at various levels of differentiation.

The SOTER mapping approach in many respects resembles physiographic soil mapping. Its main difference lies in the stronger emphasis SOTER puts on the terrain-soil relationship as compared to what is commonly done in traditional soil mapping. This will be true particularly at smaller mapping scales. At the same time SOTER adheres to rigorous data

FIGURE 1
Relations between a SOTER Unit and their composing parts and major separating criteria



Example (see figure 1)

The map shown in figure 1 could have the following legend:

SOTER unit	*description*
317	one terrain type with one terrain component and one soil component
318	one terrain type consisting of an association of two terrain components each having a particular soil component
319	one terrain type, consisting of an association of two terrain components, the first having one soil component and the second having an association of two soil components
320	one terrain type, consisting of an association of three terrain components, the first having one soil component, the second having an association of three soil components and the third having one soil component
321	one terrain type with one terrain component having an association of two soil components (occurs as two polygons)
322	one terrain type, consisting of an association of two terrain components each with a soil component

entry formats necessary for the construction of an universal terrain and soil database. As a result of this approach the data accepted by the database will be standardized and will have the highest achievable degree of reliability.

The methodology presented in this manual has been developed for applications at a scale of 1:1 million and has been tested successfully in pilot areas in North and South America.

Nevertheless, the methodology also is intended for use at larger scales connected with the development of national soil and terrain databases. A first testing of such a detailed database was carried out in São Paulo State of Brazil at a scale of 1:100,000 (Oliviera and van den Berg, 1992). The SOTER methodology also lends itself well to the production of maps and associated tables at scales smaller than 1:1 million.

Attributes of terrain, soil and other units as used by SOTER are hierarchically structured to facilitate the use of the procedures at scales other than the reference scale of 1:1 million.

SOTER SOURCE MATERIAL

Basic data sources for the construction of SOTER units are topographic, geomorphological, geological and soil maps at a scale of 1:1 million or larger (mostly exploratory and reconnaissance maps). In principle all soil maps that are accompanied by sufficient analytical data for soil characterization according to the revised FAO-Unesco Soil Map of the World Legend (FAO, 1990b) can be used for mapping according to the SOTER approach. Seldom, however, will an existing map and accompanying report contain all the required soil and terrain data. Larger scale (semi-detailed and detailed) soil and terrain maps are only suitable if they cover sufficiently large areas. In practice such information will be mostly used to support source material at smaller scales.

As SOTER map sheets will cover large areas, often they will include more than one country, and correlation of soil and terrain units may be required. Where no maps of sufficient detail exist for a certain study area, or where there are gaps in the available data, it may still be possible to extract information from smaller scale maps (e.g. the FAO-Unesco Soil Map of the World at 1:5 million scale or similar national maps), provided that some additional fieldwork is carried out, where necessary in conjunction with the use of satellite imagery. Hence there will often be a need for additional field checks, sometimes supported by satellite imagery interpretation and extra analytical work to complement the existing soil and terrain information. This should be carried out, however, within the context of complementing, updating or correlating existing surveys. It must be stressed that SOTER specifically excludes the undertaking of new land resource surveys within its programme.

Where it is necessary to include an area in the SOTER database for which there is insufficient readily available information, then it is recommended that a survey be carried out according to national soil survey standards, while at the same time ensuring that all parameters required by the SOTER database but not already part of the data being collected. This will ease the subsequent conversion from the national data format into the SOTER data format.

SOTER uses the 1:1 million Operational Navigation Charts and its digital version, the Digital Chart of the World (DMA, 1992), for its base maps. Although it aims at eventual world-wide coverage, the SOTER approach does not envisage a systematic mapping programme, and hence does not prescribe a standard block size for incorporation in the database. Nevertheless, SOTER does recommend that at it its reference scale of 1:1 million a block should cover a substantial area (e.g. 100 000 km^2).

ASSOCIATED AND MISCELLANEOUS DATA

SOTER is a land resource database. For many of its applications SOTER data can only be used in conjunction with data on other land-related characteristics but SOTER does not aspire to be able to provide all these data. Nevertheless to obtain a broad characterization of tracts of land in terms of these complementary characteristics, the SOTER database does include files on climate, vegetation and land use. The former file is in the form of point data, that can be linked to SOTER units through GIS software. Vegetation and land use information is, on the other hand, provided at the level of SOTER units. However, it should be stressed that for specific applications, information on these characteristics should be obtained from specialized databases such as a climatic database. This also applies to natural resource data (e.g. groundwater hydrology) and socio-economic data (e.g. farming systems) which do not form part of the SOTER database.

Miscellaneous data refers to background information that is not directly associated with land resources. SOTER stores information on map source material, laboratory methods, and soil databases from which profile information has been extracted.

Chapter 3

SOTER differentiating criteria

The major differentiating criteria are applied in a step-by-step manner, each step leading to a closer identification of the land area under consideration. In this way a SOTER unit can be defined progressively into terrain, terrain component and soil component. Successively an area can thus be characterized by its terrain, its consisting terrain components and their soil components.

The level of disaggregation at each step in the analysis of the land depends on the level of detail or resolution required and the information available. The reference scale of SOTER being 1:1 million, this Manual provides the necessary detail to allow mapping at that scale.

TERRAIN

Physiography

Physiography is the first differentiating criterion to be used in the characterization of SOTER units. The term physiography is used in this context as the description of the landforms of the earth's surface. It can best be described as identifying and quantifying as far as possible the major landforms, based on the dominant gradient of their slopes and their relief intensity (see chapter 6). In combination with a hypsometric (absolute elevation above sea-level) grouping, and a factor characterizing the degree of dissection, a broad subdivision of an area can be made and delineated on the map (see Figure 2), referred to as first and second level major landform in Table 2 of chapter 6. In this way three major landforms can be distinguished in Figure 2.

Parent material

Areas corresponding to major or regional landforms can be subdivided according to lithology or parent material (see chapter 6). This will lead to a further definition of the physiographic units by the second differentiating criterion: lithology. The result is shown in Figure 3.

Terrain, in the SOTER context, is thus defined as a particular combination of landform and lithology which characterizes an area. It also possesses one or more typical combinations of surface form, mesorelief, parent material aspect and soil. These form the rationale for a further subdivision of the terrain into terrain components and soil components.

FIGURE 2
Terrain subdivided according to major landforms

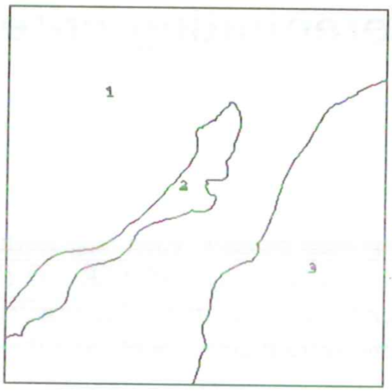


FIGURE 3
Terrain further subdivided according to lithology

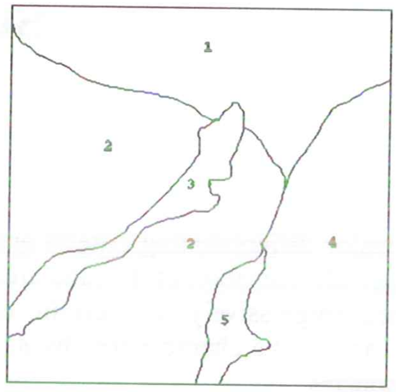


FIGURE 4
Terrain components differentiated according to surface forms

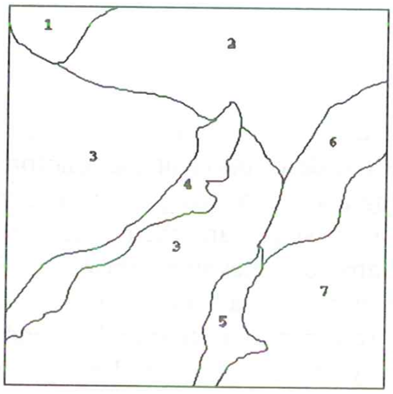
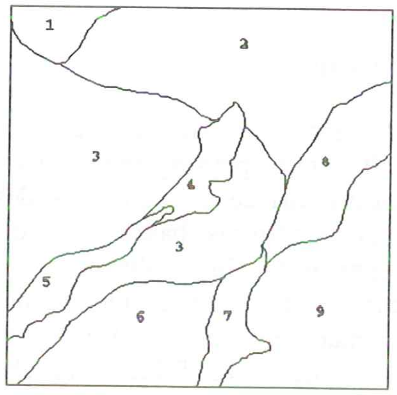


FIGURE 5
Terrain components differentiated according to slope gradients



There is no limit to the number of subdivisions that can be applied to the terrain (and terrain components). It is, however, expected that in most cases a maximum of 3 or 4 terrain components and 3 soil components will be sufficient to adequately describe the terrain.

TERRAIN COMPONENTS

Surface form, slope, etc.

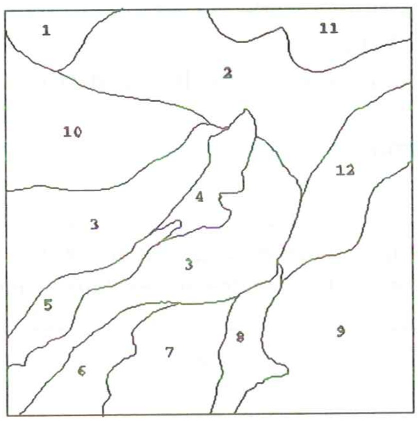
The second step in the subdivision is the identification of areas, within each terrain, with a particular (pattern of) surface form, slope, mesorelief and, in areas covered by unconsolidated material, texture of parent material. This will result in a further partitioning of the terrain into terrain components as is shown in Figures 4 and 5.

It should be noted that at this level of separation it is not always possible at a scale of 1:1 million to map terrain components individually, because of the complexity of their occurrence. In such cases the information related to non-mappable terrain components is stored in the attribute database only, and no entry is made into the geometric database.

SOIL COMPONENTS

The final step in the differentiation of the terrain is the identification of soil components within the terrain components. As with terrain components, soil components can be mappable or non-mappable at the considered scale. In the case of mappable soil components, each soil component represents a single soil within a SOTER unit (see Figure 6). However, at a scale of 1:1 million it often will be difficult to separate soils spatially, and a terrain component is likely to comprise a number of non-mappable soil components. In traditional soil mapping procedures such a cluster is known as a soil association or soil complex (two or more soils which, at the scale of mapping, cannot be separated). Non-mappable terrain components (of which there must be at least two in a SOTER unit) are by definition associated with non-mappable soil components. Nevertheless, in the attribute database each non-mappable terrain component can be linked to one or more specific (but non-mappable) soil components. Non-mappable soil components, as in the case of the non-mappable terrain components, do not figure in the geometric database.

FIGURE 6
SOTER units after differentiating soils



Differences in classification

As the SOTER soil components are characterized according to the FAO-Unesco Soil Map of the World Legend, so the criteria used for separating soil components within each terrain component are based on FAO diagnostic horizons and properties. At the SOTER reference scale of 1:1 million, soils must, in general, be characterized up to the 3rd (i.e. subunit) level following the guidelines provided for this in the annex to the Revised Legend (FAO, 1990b).

For soils classified according to Soil Taxonomy (Soil Survey Staff, 1975, 1990 and 1992), the FAO sub-unit level corresponds roughly to the subgroup level. As many of the diagnostic horizons and properties as used by Soil Taxonomy are similar to those employed by FAO, generally there will not be many problems at this level of classification in translating Soil Taxonomy units into FAO units. A major difference between the two systems is the use in Soil Taxonomy of soil temperature and soil moisture regimes, particularly at suborder level. Since these characteristics do not feature in the FAO classification, and SOTER being basically a land resource database, it tends to keep climatic data (including those related to soil climate) separated from land and soil data. A more drastic conversion will be required of Soil Taxonomy units which are defined in terms of soil temperature and soil moisture characteristics. Nevertheless, experience has shown that even in these cases conversion from Soil Taxonomy great groups to FAO sub-units usually will not necessitate major adjustments to the boundaries of soil mapping units.

Differences in use

In addition to diagnostic horizons and properties, soil components can also be separated according to other factors, closely linked to soils, that have a potentially restricting influence on land use or may affect land degradation. These criteria, several of which are listed by FAO as phases, can include both soil (sub-surface) and terrain (surface, e.g. micro-relief) factors.

Soil profiles

For every soil component at least one, but preferably more, fully described and analysed reference profiles should be available from existing soil information sources. Following judicious selection, one of these reference profiles will be designated as the representative profile for the soil component. The data from this representative profile must be entered into the SOTER database in accordance with the format as indicated in sections *Profile* and *Horizon data* in chapter 6 of this Manual. This format is largely based upon the FAO Guidelines for Soil Profile Description (FAO, 1990), which means that profiles described according to FAO or to the Soil Survey Manual (Soil Survey Staff, 1951), from which FAO has derived many of its criteria, can be entered with little or no reformatting being necessary. Compatibility between the FAO-ISRIC Soil Database (FAO, 1989) and the relevant parts of the SOTER database also will facilitate transfer of data already stored in databases set up according to FAO-ISRIC standards.

Horizons

It is recommended that for SOTER the number of horizons per profile is restricted to a maximum of five subjacent horizons, reaching a depth of at least 150 cm unless the soil is shallower. Except for general information on the profile, including landscape position and drainage, each horizon has to be fully characterized in the database by two sets of attributes based on chemical and physical properties. The first set consists of single value data that belong to the representative profile. The second set holds the maximum and minimum values of each numeric attribute, derived from all available reference profiles. In case there is only one reference profile for a soil component then it will obviously not be possible to complete these additional tables.

Optional and mandatory data

Both sets of horizon data consist of mandatory and optional data. Where mandatory data are missing, the SOTER database will accept expert estimates for such values. They will be flagged as such in the database. Optional data should only be entered where the information on them is reliable. For the representative profile these must be measured data.

As with terrain components, the percentage cover of the soil component within the terrain component is indicated. The relative position and relationship of soil components vis-à-vis each other within a terrain component is recorded in the database as well.

SOTER UNIT MAPPABILITY

SOTER units in the database and on the map

At the reference scale of 1:1 000 000 a SOTER unit is composed of an unique combination and pattern of terrain, terrain component and soil component. A SOTER unit is labelled by a SOTER unit identification code that allows retrieval from the database of all terrain, terrain component and soil component data, either in combination or separately. The inclusion of the three levels of differentiation in the attribute database does not imply that all components of a SOTER unit can be represented on a map, as the size of individual components, or the intricacy of their occurrence, may preclude cartographic presentation. The areas shown on a SOTER map can thus correspond to any of the three levels of differentiation of a SOTER unit: terrain, terrain components or soil components. The components not mapped are known to exist, and their attributes are included in the database, although their exact location and extent cannot be displayed on a 1:1 million map.

Differences

In an ideal situation, at least from the point of view of geo-referencing the data, a SOTER unit on the map would be similar to a soil component in the database, i.e. the soil component of the SOTER unit could be delineated on a map. However, at the SOTER reference scale of 1:1 million it is unlikely that many SOTER units can be distinguished on the map at soil component level. This would only be possible if the landscape is relatively homogeneous. A more common situation at this scale would be for a SOTER unit to consist of terrain with non-mappable terrain components linked to an assemblage of non-mappable soil components (a terrain component association) or, alternatively, a SOTER unit with mappable terrain components that contain several non-mappable soil components (a similar situation as with a soil association on a traditional soil map).

Thus, while in the attribute database a SOTER unit will hold information on all levels of differentiation, a SOTER map will display units whose content varies according to the mappability of the SOTER unit components. The disadvantage of not being able to accurately locate terrain components and/or soil components is therefore only relevant when data of complex terrains are being presented in map format. It does not affect the capability of the SOTER database to generate full tabular information on terrain, terrain component and soil component attributes while at the same indicating the spatial relationship between and within these levels of differentiation.

SOTER APPROACH AT OTHER SCALES

Smaller scales

The methodology presented in this manual has been developed for applications at a scale of 1:1 million, which is the smallest scale still suitable for land resource assessment and monitoring at national level. However, as potentially the most complete universal terrain and soil database, SOTER is also suited to provide the necessary information for the compilation of smaller scale continental and global land resource maps and associated data tables. The methodology was tested by FAO for the compilation of the physiographic base for a future update of the Soil Map of the World (Eschweiler, 1993; Wen, 1993).

Flexibility to cater for a wide range of scales is achieved through adopting a hierarchical structure for various major attributes, in particular those that are being used as differentiating criteria (landform, lithology, surface form, etc.). Examples of such hierarchies are given in this Manual for land use and vegetation (see chapter 7). Different levels of these hierarchies can be related to particular scales. A hierarchy for the soil component can be derived from the FAO-Unesco Soil Map of the World Legend, with the level of soil groupings being related to extremely small scale maps, as exemplified by the map of world soil resources at 1:25 million (FAO, 1993). Soil units (2nd level) can be used for 1:5 million world soil inventory maps, while the soil subunits are most suitable for 1:1 million mapping. The density per unit area of point observations will vary according to the scale employed, with larger scales requiring a more compact ground network of representative profiles, as soils are being characterized in more detail.

A simplification of the database can be applied at scales substantially smaller than the reference scale of 1:1 million, but only the most elementary soil physical and chemical data are relevant if the scale is smaller than 1:10 million. It is thus necessary to realize that the SOTER database discussed in this Manual is meant for a scale of 1:1 million only, and that expansion or contraction of the data set will be necessary when changing the resolution of the SOTER database.

Larger scales

As a systematic and highly organized way of mapping and recording terrain and soil data, the SOTER methodology can easily be extended to include reconnaissance level inventories, i.e. at a scale between 1:1 million and 1:100 000 (e.g. Oliveira and van den Berg, 1992).

Adjustments to the content of the attribute data set are necessary if SOTER maps at scales other than 1:1 million are being compiled. With an increase in resolution, the highest level constituents of a SOTER unit, i.e. the terrain, will gradually lose importance, and may disappear altogether at a scale of 1:100 000. This is because in absolute terms the area being mapped is becoming smaller, and terrain alone may not continue to offer sufficient differentiating power. Conversely, the lower part of the SOTER unit will gain in importance with more detailed mapping. At larger scales SOTER units will thus become delineations of soil entities, with the information on terrain becoming incorporated in the soil attributes. Hence scale increases require more detailed information on soils for most practical applications. Additional attributes which might be included could be soil micronutrient content, composition of organic fraction, detailed slope information, etc.

Chapter 4

SOTER database structure

In every discipline engaged in mapping of spatial phenomena, two types of data can be distinguished:

- geometric data, i.e. the location and extent of an object represented by a point, line or surface, and topology (shapes, neighbours and hierarchy of delineations),

- attribute data, i.e. characteristics of the object.

These two types of data are present in the SOTER database. Soils and terrain information consist of a geometric component, which indicates the location and topology of SOTER units, and of an attribute part that describes the non-spatial SOTER unit characteristics. The geometry is stored in that part of the database that is handled by Geographic Information System (GIS) software, while the attribute data are stored in a separate set of attribute files, manipulated by a Relational Database Management System (RDBMS). A unique label attached to both the geometric and attribute database connects these two types of information for each SOTER unit (see Figure 7, in which part of a map has been visualized in a block diagram).

The overall system (GIS plus RDBMS) stores and handles both the geometric and attribute database. This manual limits itself to the attribute part of the database only, in particular through elaborating on its structure and by providing the definitions of the attributes (chapter 6). A full database structure definition is given by Tempel (in prep.).

A relational database is one of the most effective and flexible tools for storing and managing non-spatial attributes in the SOTER database (Pulles, 1988). Under such a system the data is stored in tables, whose records are related to each other through the specific identification fields (primary keys), such as the SOTER unit identification code. These codes are essential as they form the links between the various subsections of the database, e.g. the terrain table, the terrain component and the soil component tables. Another characteristic of the relational database is that when two or more components are similar, their attribute data need only to be entered once. Figure 8 gives a schematic representation of the structure of the attribute database. The blocks represent tables in the SOTER database and the solid lines between the blocks indicate the links between the tables.

FIGURE 7
SOTER units, their terrain components (tc), attributes, and location

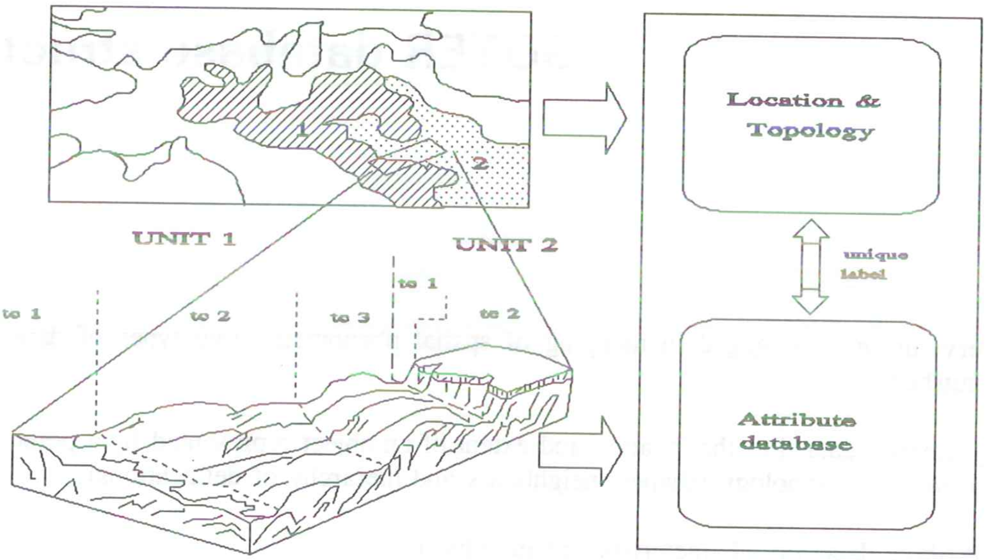
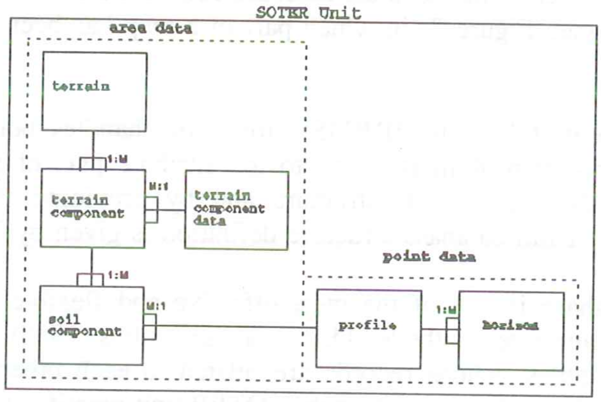


FIGURE 8
SOTER attribute database structure with area and point data (1:M = one to many, M:1 = many to one relations)



GEOMETRIC DATABASE

The geometric database contains information on the delineations of the SOTER unit. It also holds the base map data (cultural features such as roads and towns, the hydrological network and administrative boundaries). In order to enhance the usefulness of the database, it will be possible to include additional overlays for boundaries outside the SOTER unit mosaic.

Examples of such overlays could be socio-economic areas (population densities), hydrological units (watersheds) or other natural resource patterns (vegetation, agro-ecological zones).

ATTRIBUTE DATABASE

The attribute database consists of sets of files for use in a Relational DataBase Management System (RDBMS). The attributes of the terrain and terrain component are either directly available or can be derived from other parameters during the compilation of the database. Only for horizon data, two types of attributes can be distinguished, depending on their importance and availability: mandatory attributes and optional attributes

Many of the horizon parameters of the soil component consist of measured characteristics of which the availability varies considerably. However, there is a minimum set of soil attributes that are generally needed if any realistic interpretation of the soil component of a SOTER unit is to be expected. Therefore their presence is considered mandatory. Other soil horizon attributes are of lesser importance and there presence in the database is considered optional. Whether a horizon attribute is mandatory or optional is indicated in the chapter describing the attributes. It is imperative that, in order to preserve the integrity of the SOTER database, a complete list of mandatory attributes is entered for each soil component. Optional attributes are accepted by the database as and when available.

Each of the attributes can be divided into descriptive (e.g. landform) and numerical (e.g. pH, slope gradient) data.

Under the SOTER system of labelling (see *SOTER unit codes* in chapter 5 for a detailed description of the labelling conventions) all SOTER units are given an unique identification code, consisting of 4 digits. In the terrain component and soil component tables this identification code is completed with subcodes for terrain component and soil component number.

Where identical terrain components and soil components occur in several SOTER units in different proportions, a separation between the tables holding the data on proportion/position of the terrain component and soil component (terrain component block and soil component block) and the tables holding the data of the terrain component and soil component (terrain component data block and profile and horizon blocks) is made (see Figure 8).

Thus, the terrain component information is split into two tables:

- the *terrain component table* which indicates the SOTER unit to which the terrain component belongs and the proportion that it occupies within that unit;

- the *terrain component data table* which holds all specific attribute data for the terrain component.

In the first table there is space for an entry for each individual terrain component within a SOTER unit, while in the second table only entries are made for data of these terrain components if they possess a not previously occurring set of attribute values.

TABLE 1
Non-spatial attributes of a SOTER unit

TERRAIN

1 SOTER unit_ID
2 year of data collection
3 map_ID
4 minimum elevation
5 maximum elevation
6 slope gradient
7 relief intensity
8 major landform
9 regional slope
10 hypsometry
11 dissection
12 general lithology
13 permanent water surface

TERRAIN COMPONENT

14 SOTER unit_ID
15 terrain component number
16 proportion of SOTER unit
17 terrain component data_ID

TERRAIN COMPONENT DATA

18 terrain component data_ID
19 dominant slope
20 length of slope
21 form of slope
22 local surface form
23 average height
24 coverage
25 surface lithology
26 texture group non-consolidated parent material
27 depth to bedrock
28 surface drainage
29 depth to groundwater
30 frequency of flooding
31 duration of flooding
32 start of flooding

SOIL COMPONENT

33 SOTER unit_ID
34 terrain component number
35 soil component number
36 proportion of SOTER unit
37 profile_ID
38 number of reference profiles
39 position in terrain component
40 surface rockiness
41 surface stoniness
42 types of erosion/deposition
43 area affected
44 degree of erosion
45 sensitivity to capping
46 rootable depth
47 relation with other soil components

PROFILE

48 profile_ID
49 profile database_ID
50 latitude
51 longitude
52 elevation
53 sampling date
54 lab_ID
55 drainage
56 infiltration rate
57 surface organic matter
58 classification FAO
59 classification version
60 national classification
61 Soil Taxonomy
62 phase

HORIZON (* = mandatory)

63 profile_ID*
64 horizon number*
65 diagnostic horizon*
66 diagnostic property*
67 horizon designation
68 lower depth*
69 distinctness of transition
70 moist colour*
71 dry colour
72 grade of structure
73 size of structure elements
74 type of structure*
75 abundance of coarse fragments*
76 size of coarse fragments
77 very coarse sand
78 coarse sand
79 medium sand
80 fine sand
81 very fine sand
82 total sand*
83 silt*
84 clay*
85 particle size class
86 bulk density*
87 moisture content at various tensions
88 hydraulic conductivity
89 infiltration rate
90 pH H_2O*
91 pH KCl
92 electrical conductivity
93 exchangeable Ca^{++}
94 exchangeable Mg^{++}
95 exchangeable Na^{+}
96 exchangeable K^{+}
97 exchangeable Al^{+++}
98 exchangeable acidity
99 CEC soil*
100 total carbonate equivalent
101 gypsum
102 total carbon*
103 total nitrogen
104 P_2O_5
105 phosphate retention
106 Fe dithionite
107 Al dithionite
108 Fe pyrophosphate
109 Al pyrophosphate
110 clay mineralogy

In the same way the soil component information is stored in three tables:

- the *soil component table* holds the proportion of each soil component within a SOTER unit/terrain component combination and its position within the terrain component;
- the *profile table* holds all attribute data for the soil profile as a whole;
- the *horizon table* holds the data for each individual soil horizon. To be able to give some degree of variability it consists of four sets of attribute values:

  a. single values taken from the representative profile, either (1) measured or (2) estimated
  b. maximum (measured) values taken from all available profiles within the soil component
  c. minimum (measured) values taken from all available profiles within the soil component

For the profile and horizon tables the same conditions for the terrain component data table are valid. Only soil profiles not previously described may be entered. For profile/ horizon data describing soils occuring in various soil components only one entry is necessary.

The horizon tables must contain all mandatory measured data: (a1) data set. In case data is not available for some of the quantifiable attributes, SOTER will allow expert estimates to be used for attributes of the representative profile: (a2) data set. Measured and estimated values of the representative profile will thus be stored separately.

To be able to indicate the variability within a soil component various statistical parameters can be determined. Data from the representative profile are considered as modal values. However, considering the small number of profiles generally available for the compilation of the soil component, it is not realistic to aim at standard deviations and means. Therefore only maximum and minimum values of the profiles of the same soil component give an indication of the range of variation that exist within the component. They will be stored respectively in the (b) and (c) data sets.

It is strongly recommended that in conjunction with the SOTER database a national soil profile database be established along the lines of the FAO-ISRIC Soil Database (FAO, 1989), in which, amongst others, all representative profiles would be accommodated.

All mandatory and optional attributes for the soil component, as well as all other non-spatial attributes of the SOTER units, are listed in Table 1. The listing for the soil component attributes is compatible, but contains some additional items, with the data set that is stored in the FAO-ISRIC Soil Database.

The database can be asked to calculate automatically a number of derived parameters from the values entered for the mandatory and optional attributes. These include, amongst others, CEC per 100 g clay, base saturation and textural class.

Chapter 5

Additional SOTER conventions

The various conventions described in this chapter form an addition to those characterized in chapter 2. They mainly concern rules governing the minimum size of a SOTER unit, both in absolute and relative terms, as well as criteria determining the selection of representative profiles, relations with associated databases, type of data and missing data.

SOTER database management procedures, such as date stamps and backup procedures, are not treated in this manual, but are to be described in a separate manual (Tempel, in prep.).

SOTER UNIT CODES

Each SOTER unit is assigned an identifying code that is unique for the database in question. Tentatively, the SOTER coding will consist of a simple numbering system. This code will normally range from 1 to 999, or 9999 for large maps. The terrain components within each terrain unit are given single digit extension numbers separated by a slash (/) and ranked according to the size of the component. A similar single digit extension number is used to code the soil components. This means that a maximum of 10 terrain components (first digit with values from 0-9) each with 10 soil components (second digit) can be stored in the database. The component extension numbers are separated from the SOTER unit code by a slash. The identification code of a soil component in the database thus can range from 1/11 to 9999/99. Numbering is not strictly sequential, as the total number of terrain components per terrain and soil components per terrain component is limited (see section *Number of soil and terrain components*), and identification codes like 1/17 (7 soil components within terrain component 1) or 25/53 (3 soil components in terrain component 5) are unlikely to occur.

When individual databases are merged into regional and global databases, then the SOTER identification codes can be preceded by the FAO/ESS code for the country. When databases of neighbouringing countries are entered into one database, then cross-boundary SOTER units will have different codes in each country. If a GIS is used the SOTER units of one country can automatically be given the code of their counterpart on the other side of the border (assuming that proper correlation has been carried out), otherwise this has to be done manually.

At national level this coding convention is only applicable to 1:1 million maps. For larger scale maps and databases there is no need to follow a unified system.

MINIMUM SIZE OF THE SOTER UNIT

As a general rule of thumb the minimum size of a single SOTER unit is 0.25 cm^2 on the map which, at a scale of 1:1 million, equals 25 km^2 in the field. This is the smallest area that can still be cartographically represented. Mostly such tiny units will correspond to narrow elongated features (floodplains, ridges, valleys) or strongly contrasting terrain and soil features. In general, SOTER units will be much larger.

If there are gradual changes in landscape features, new SOTER units can be delineated when any one terrain component or soil component of a unit changes in area by more than 50%.

NUMBER OF SOIL AND TERRAIN COMPONENTS

Within a SOTER unit terrain components and soil components can occupy any percentage of the terrain and terrain component respectively, provided the total area of each component is not less than what is indicated in the previous section. In theory this would allow for an unlimited number of terrain components within each SOTER unit, or soil components within each terrain component. In practice this is unlikely to occur, as many terrain components and soil components cover sizeable areas. SOTER recommends that a minimum area of 15% of the SOTER unit is taken into account when defining terrain and soil components, unless the SOTER unit in question is very large, or it involves strongly contrasting terrain or soil components, when the percentage coverage can be less.

Most commonly it is expected that a SOTER unit would be subdivided into up to 3 or 4 terrain components, each with not more than 3 soil components, resulting in a maximum of 12 subdivisions. Obviously, the proportional areal sum of soil components within each terrain component, and terrain components within each SOTER unit, will always be 100%.

It is advisable that map compilers exercise restraint in subdividing terrain into terrain and soil components. Only those criteria that can be considered important for analyzing a landscape in subsequent interpretations should be selected. Significant changes in attributes such as parent material, surface form and slope gradient, which at the same time should cover substantial areas, qualify as criteria for defining new SOTER units. Terrain components should be split into soil components only if there are clear changes in diagnostic criteria which will reflect in land use or land degradation aspects. Minor changes in any of these criteria should be considered as part of the natural variability that at a scale of 1:1 million can be expected to occur within each SOTER unit. Discretion in defining terrain and soil components is absolutely necessary in order not to generate an excessive number of components and so lengthening the time required for coding, entering and processing of data.

REPRESENTATIVE SOIL PROFILES

The representative profile used to typify a specific soil component is chosen from amongst a number of reference profiles with similar characteristics. Where possible SOTER will rely on a selection of reference profiles made by the original surveyors. It is envisaged that all reference profiles taken into consideration be stored in a national soil profile database, preferably based on the FAO-ISRIC Soil Database format. The SOTER database includes a key to national databases.

The SOTER database also includes a code that shows how many reference profiles were considered for the selection of the representative profile, and were used to determine the maximum and minimum values of attributes as well.

UPDATING PROCEDURES

SOTER units and their attributes are unique in both space and time, and although soil and in particular terrain characteristics are thought to have a high degree of temporal stability, it might become necessary to update certain attributes from time to time. At present, there is no procedure for updates of the geographic data, such as the boundaries of the SOTER units. However, replacing (parts of) map sheets by more recent maps will involve changes in attribute data as well, for which the guidelines below can be used.

Updating the attribute database could become necessary because of *missing data*, *incorrect data* or *obsolete data* in the database. If there are some data gaps, the voids can be filled when additional data becomes available. Incorrect data, which include data that is being replaced by (a set of) more reliable data (e.g. a representative profile is being substituted by another, more representative profile) can be replaced by new data, although a note has to be made of this in the database. In contrast, obsolete data is not simply replaced by more up-to-date information. Instead, old data is downloaded into a special database containing obsolete data, after which the latest data is entered into the regular database. In this way the database with obsolete data can be used for the monitoring of changes over time. When certain parameters are measured at regular intervals, then periodic updating will become necessary.

The SOTER unit Identification code does indicate to which level of differentiation the SOTER unit can be mapped. The database is capable of generating a number of relational data that are pertinent to each SOTER unit, and between the SOTER units (e.g. percentage of each soil component within terrain component or SOTER unit, total area of all terrain components with identical terrain component data code, etc.).

Chapter 6

Attribute coding

Note that the numbers preceding the attributes in Table 1 are identical to the numbers of the attributes in this chapter, written in the left margin. They also figure on the SOTER data entry forms (see Annex 5 for a proforma).

The SOTER unit identification code, referring to the map unit, is completed in the database by two additional digits, separated from the SOTER unit code by a slash. The first digit represents the terrain component number. The second digit constitutes the soil component number. Eventually, the SOTER unit identification code will be the unique identifier for SOTER units on a worldwide scale (see also *SOTER unit codes* in chapter 5).

However, for compilers of SOTER data on a national or regional scale it is sufficient to attach locally unique identification codes to each SOTER unit, taking into account the coding conventions explained in the section *SOTER unit codes*. These identification codes will be converted into globally unique identifiers before entry into a continental or worldwide SOTER database.

Class limits as used in this manual are defined as follows. The upper class limit is included in the next class. For example, slope class 2-5% (item 9) includes all slopes from 2.0 to 4.9%. Hence, a slope of 5% would fall in slope class 5-8%.

TERRAIN

1 *SOTER unit_ID*

The SOTER unit_ID is the identification code of a SOTER unit on the map and in the database. It links the mapped area to the attributes in the database and in particular, it identifies which terrain belongs to a SOTER unit. SOTER units which have identical attributes carry the same SOTER unit_ID. In other words the SOTER unit_ID is similar to a code for a mapping unit on a conventional soil map.

For each SOTER map, a unique code (up to 4 digits) is assigned to every SOTER unit that has been distinguished. On most SOTER maps 2 or 3 digits will suffice.

2 *year of data collection*

The year in which the original terrain data were collected will serve as the time stamp for each SOTER unit. Where the SOTER unit has been composed on the basis of several

TABLE 2
Hierarchy of major landforms

1st level	2nd level	gradient (%)	relief intensity
L level land	**LP** plain	<8	<100m/km
	LL plateau	<8	<100m/km
	LD depression	<8	<100m/km
	LF low-gradient footslope	<8	<100m/km
	LV valley floor	<8	<100m/km
S sloping land	**SM** medium-gradient mountain	15-30	>600m/2km
	SH medium-gradient hill	8-30	>50m/slope unit
	SE medium-gradient escarpment zone	15-30	<600m/2km
	SR ridges	8-30	>50m/slope unit
	SU mountainous highland	8-30	>600m/2km
	SP dissected plain	8-30	<50m/slope unit
T steep land	**TM** high-gradient mountain	>30	>600m/2km
	TH high-gradient hill	>30	<600m/2km
	TE high-gradient escarpment zone	>30	>600m/2km
	TV high gradient valleys	>30	var.
C land with composite landforms	**CV** valley	>8	var.
	CL narrow plateau	>8	var.
	CD major depression	>8	var.

Notes: var. = variable.

sources of information, it is advisable to use the major source for dating it. In this manner a link between the SOTER unit and the major source of information, which should be listed under map_ID, can easily be made. The year of compiling the data according to the SOTER procedures is thus not recorded, unless the compilation itself has resulted in some major reinterpretation based on additional sources of information, like fresh satellite imagery. In general the year of compilation can be deducted from the year in which the data was entered into the database, as both years are likely to be the same or very close to each other. It is assumed that the year in which the terrain date were collected also applies to the terrain component data, and no separate date entry is required for this.

3 *map_ID*

The source map identification code from which the data were derived for the compilation of the SOTER units. There is room for 12 characters.

4 *minimum elevation*

Absolute minimum elevation of the SOTER unit, in metres above sea level. Both the minimum and maximum elevation can be read from a contoured topographic map.

5 *maximum elevation*

Absolute maximum elevation of the SOTER unit, in metres above sea level.

6 *slope gradient*

The dominant slope angle, expressed as a percentage, prevailing in the terrain.

7 *relief intensity*

The relief intensity is the median difference between the highest and lowest point within the terrain per specified distance. This specified distance can be variable, but is expressed in m/km in the database.

8 *major landform*

Landforms are 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. The relief intensity is normally given in m/km, but for distinction between hills and mountains it is practical to use two kilometre intervals (see Table 2).

At the highest level of landform separation, suitable for scales equal to or smaller than 1:10 million, four groups are being distinguished (adapted from Remmelzwaal, 1991). They can be subdivided when the position of the landform vis-a-vis the surrounding land is taken into consideration.

Where not clear from the gradient or relief intensity, the distinction between the various second level landforms follows from the description in Annex 1.

REGIONAL LANDFORMS

Major landforms can be further characterized according to three criteria. These are:

1. regional slope
2. hypsometry
3. dissection

The differentiating power of these criteria is highest with respect to level lands, although they can be used for sloping lands with a relief intensity of less than 600 m/2 km as well. For steep lands with a high relief intensity they have little utility, with the exception of the hypsometric level.

9 *regional slope*

A refining of slope classes compared to those used for major landforms is possible. The dominant slopes can be broken down into the following classes:

a) Simple landforms

W	0-2 %	flat, wet*
F	0-2 %	flat
G	2-5 %	gently undulating
U	5-8 %	undulating
R	8-15 %	rolling
S	15-30 %	moderately steep
T	30-60 %	steep
V	≥ 60 %	very steep

* wet is defined as < 90% permanent water surface > 50% (see also item 12)

b) Complex landforms**

CU	Cuestashaped
DO	Dome-shaped
RI	Ridged
TE	Terraced
IN	Inselberg covered (occupying at least 1% of level land)
DU	Dune-shaped
IM	With intermontane plains (occupying at least 15%)
WE	With wetlands (occupying at least 15%)
KA	Strong karst

** in the case of complex landforms, the protruding landform should be at least 25 m high (if not it is to be considered mesorelief) except for terraced land, where the main terraces should have elevation differences of at least 10 m.

These subdivisions are mainly applicable to level landforms, and to some extent to sloping landforms. They are not to be used for steep lands, except in the case of mountains with intermontane plains, but may be used for lands with complex landforms, where the subdivision can be related to the constituent landform with the lesser slope.

10 *hypsometry*

The hypsometric level is, for level and slightly sloping land (relief intensity of less than 50 m) an indication of the height above sea level of the local base level. For lands with a relief intensity of more than 50 m the hypsometric is used to indicate the height above the local base (i.e. local relief).

a) Level lands and sloping lands (relief intensity < 50 m/slope unit)

1	< 300 m	very low level (plain etc.)
2	300-600 m	low level
3	600-1500 m	medium level
4	1500-3000 m	high level
5	≥ 3000 m	very high level

b) Sloping lands (relief intensity > 50 m/slope unit)

6	< 200 m	low (hills etc.)
7	200-400 m	medium
8	≥ 400 m	high

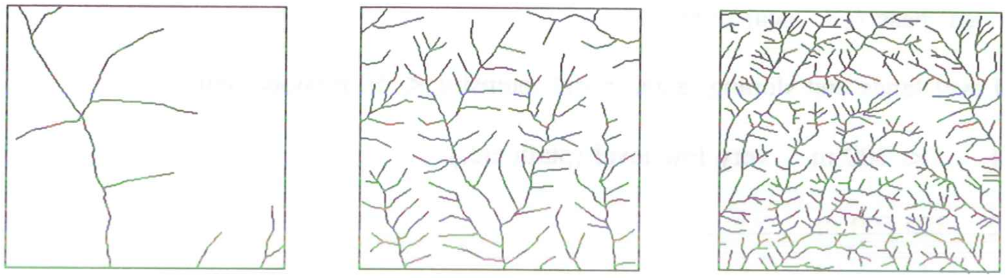
c) Steep and sloping lands (relief intensity > 600 m/2 km)

9	600-1500 m	low (mountains etc.)
10	1500-3000 m	medium
11	3000-5000 m	high
12	≥ 5000 m	very high

11 *dissection*

The degree of dissection is difficult to quantify in a practical manner. Factors like coverage, slope and depth of dissected features all contribute to the intensity of landscape dissection. SOTER uses the drainage density as a qualitative measure of the degree of dissection. The higher the drainage density, the more dissected a tract of land is, and in general also the steeper the slopes of the dissected parts will be. The depth of dissection can be assumed to increase with an increased density of the drainage network and steeper landscape slopes. Conversely, a high drainage density on very flat land (dominant slopes

FIGURE 9
Examples of degrees of dissection as indicated by drainage density on 1:50 000 maps



a) low b) medium c) high

< 2%) is not necessarily related to the dissection of the terrain, but could be an indication of the wetness of the land.

The most accurate way to measure the drainage density (defined as the average length of drainage channels per unit area of land, expressed as km km^{-2}) is to actually measure the length of all well-defined, permanent and seasonal, streams and rivers within a representative block. This should be done on good quality 1:50 000 or larger maps. Techniques exist to speed up this measurement through intersection point counting (Verhasselt, 1961).

In practice the necessary material to carry out this measurement is often not available, and only quantitative estimates can be made. This should be done with aid of the most detailed material available (maps, aerial photos or satellite images). Only three classes are being distinguished:

1	< 10 km km^{-2}	slightly dissected
2	10-25 km km^{-2}	dissected
3	≥ 25 km km^{-2}	strongly dissected

Figure 9 provides an illustration, at a scale of 1:50 000, of two of these classes. The degree of dissection is not applicable to land with a relief intensity of more than 600 m.

12 *general lithology*

For each SOTER unit a generalized description of the consolidated or unconsolidated surficial material, underlying the larger part of the terrain, is given. Major differentiating criteria are petrology and mineralogical composition (Holmes, 1968, Strahler, 1969). At the 1:1 million scale the lithology should at least be specified down to group level. Codes are shown in Table 3.

TABLE 3
Hierarchy of lithology

Major class		Group		Type	
I	igneous rock	IA	acid igneous	IAI	granite
				IA2	grano-diorite
				IA3	quartz-doprite
				IA4	rhyolite
"		II	intermediate igneous	II1	andesite, trachyte, phonolite
				II2	diorite-syenite
"		IB	basic igneous	IB1	gabbro
				IB2	basalt
				IB3	dolerite
"		IU	ultrabasic igneous	IU1	peridotite
				IU2	pyroxenite
				IU3	ilmenite, magnetite, ironstone, serpentine
M	metamorphic rock	MA	acid metamorphic	MA1	quartzite
				MA2	gneiss, magmatite
"		MB	basic metamorphic	MB1	slate, phyllite (pelitic rocks)
				MB2	schist
				MB3	gneiss rich in ferro-magnesian minerals
				MB4	metamorphic limestone (marble)
S	sedimentary rock	SC	clastic sediments	SC1	conglomerate, breccia
				SC2	sandstone, greywacke, arkose
				SC3	siltstone, mudstone, claystone
				SC4	shale
'		SO	organic	SO1	limestone, other carbonate rocks
				SO2	marl and other mixtures
				SO3	coals, bitumen and related rocks
"		SE	evaporites	SE1	anhydrite, gypsum
				SE2	halite
U	unconsolidated	UF	fluvial		
		UL	lacustrine		
		UM	marine		
		UC	colluvial		
		UE	eolian		
		UG	glacial		
		UP	pyroclastic		
		UO	organic		

13 *permanent water surface*

Indicate the percentage of the SOTER unit that is largely (i.e. > 90%, thus excluding small islands etc.) and permanently (i.e. more than 10 month/year) covered by water. Bodies of water large enough to be delineated on the map are not considered part of a SOTER unit.

TERRAIN COMPONENT

This section includes attributes to identify any terrain component, its percentage within the SOTER unit (15-100%) and a link to the complete set of attribute data of a terrain component (section *Terrain component data*).

14 *SOTER unit_ID*

See SOTER unit_ID under paragraph 6.1 Terrain.

15 *terrain component number*

The sequence number of the terrain component in the terrain. The largest terrain component in the SOTER unit comes first, followed by the second in size, and so on. The combination SOTER unit_ID and terrain component number (e.g. 2034/1) gives the complete identification code for each terrain component within the database.

16 *proportion of SOTER unit*

The proportion that the terrain component occupies within the SOTER unit. As stated in the section *Number of soil and terrain components* in chapter 5, a terrain component normally covers not less than 15% of a terrain. The sum of all terrain components should be 100%.

Examples

SOTER unit_id = 2034,
terrain component number = 1
proportion within SU = 70%

SOTER unit_id = 2034
terrain component number = 2
proportion within SU = 30%

17 *terrain component data_ID*

If two (or more) terrain components are completely similar, then their data will only be entered once in the database. The data code has the format SOTER unit_ID/terrain

Examples

case A (two terrain components, both not yet described in the attribute database)

SOTER unit_ID = 2034,
terrain component number = 1
proportion within SU = 70%
terrain component data_ID = 2034/1

SOTER unit_ID = 2034
terrain component number = 2
proportion within SU = 30%
terrain component data_ID = 2034/2

case B (two terrain components, one already described (marked with *), one not yet)

SOTER unit_ID = 2035
terrain component number = 1
proportion within SU = 60%
terrain component data_ID = 2034/2*

SOTER unit_ID = 2035
terrain component number = 2
proportion within SU = 40%
terrain component data_ID = 2035/2

component number. When referring to an already described terrain component data_ID the first terrain component with a particular attribute content will also be used for subsequent identical terrain components. In case a terrain component has not been described before in the database, then its code will also be used as its data code (four plus one digits).

TERRAIN COMPONENT DATA

18 *terrain component data_ID*

See terrain component data_ID under section *Terrain*.

SLOPE CHARACTERISTICS

Items 19-21 characterize the slope of the terrain component.

19 *dominant slope*

Dominant slope gradient of the terrain component, %.

20 *length of slope (m)*

Estimated dominant length of slope, m.

21 *form of slope*

The form of the dominant slope (only entered if the dominant slope gradient > 2%)

U Uniform slope.

C Concave, lower slope with decreasing gradient downslope.

V Convex, upper slope with decreasing gradient upslope.

I Irregular slope.

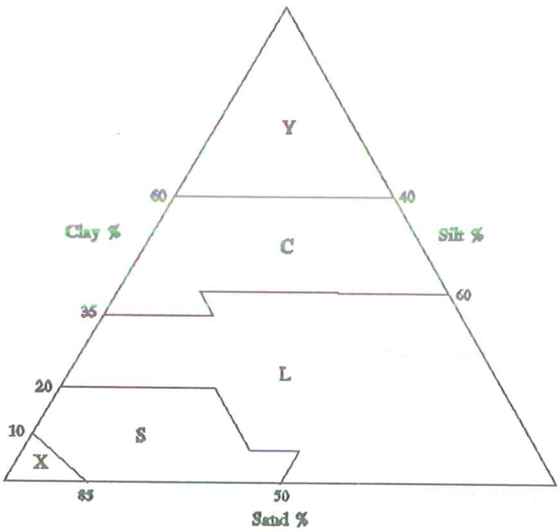
MESO-RELIEF

Items 22-24 characterize the meso-relief or local surface forms.

22 *local surface form*

A number of characteristic meso-relief or local surface forms can be recognized at the 1:1 million scale (Day, 1983; FAO, 1977; Soil Survey Staff, 1951), in addition to the slope form as listed below (this list is not exhaustive).

FIGURE 10
Texture groups of parent material



Y very clayey	more than 60% clay
C clayey	sandy clay, silty clay and clay texture classes
L loamy	loam, sandy clay loam, clay loam, silt, silt loam and silty clay loam texture classes
S sandy	loamy sand and sandy loam texture classes
X extremely sandy	sand texture classes

H hummocky	very complex pattern of slopes extending from somewhat rounded depressions or kettleholes of various sizes to irregular conical knolls or knobs. There is a general lack of concordance between knolls or depressions. Slopes ranges are large and vary generally between 4 % and 70 %.
M mounded	coverage (at least 5 %) by isolated mounds more than 2.5 m high.
K towered	coverage (at least 5 %) by isolated steep sided karst towers more than 2.5 m high.
R ridged	coverage (at least 5 %) by parallel, sub-parallel or intersecting usually sharpcrested ridges (elongated narrow elevations) more than 2.5 m high.
T terraced	level areas (less than 2 % slope) bounded on one side by a steep slope more than 2.5 m high with another flat surface above it.
G gullied	coverage (at least 5 %) by steep-sided gullies more than 2.5 m deep.
S strongly dissected	areas with a drainage density of more than 25 km km^{-2}, the depth dissected of the drainage lines being at least 2.5 m.

D dissected — areas with a drainage density of more than 10 km km^{-2}, the depth of the drainage lines being at least 2.5 m.

L slightly dissected — areas with a drainage density of less than 10 km km^{-2}, the depth of the dissected drainage lines being at least 2.5 m.

23 *average height*

The average height of the meso-relief (or depth where applicable) in metres, depth being indicated by a minus sign.

24 *coverage*

The estimated percentage coverage of the meso-relief elements within the terrain component

25 *lithology surficial material*

Description of the consolidated or unconsolidated surficial materials which underlie most of the terrain component. These include the types of rockmass from which parent material is derived, and other unconsolidated mineral or organic deposits. The same list of parent materials is used as was given for the terrain unit lithology (see Table 3). If the type level of parent material, already indicated at terrain level, does not vary, then no further entry has to be made here.

26 *texture of non-consolidated parent material*

The texture group of particles <2 mm of the non-consolidated parent material, or the parent material at 2 m if the soil is deeply developed, is given. Figure 10 shows the different groups in a texture triangle.

27 *depth to bedrock*

The average depth to consolidated bedrock in metres. For depths more than 10 m the depth can be given to the nearest 5 metres.

28 *surface drainage*

Surface drainage of the terrain component (after Cochrane *et al.*, 1985).

E extremely slow — water ponds at the surface, and large parts of the terrain are waterlogged for continuous periods of more than 30 days

S slow — water drains slowly, but most of the terrain does not remain waterlogged for more than 30 days continuously

W well — water drains well but not excessively, nowhere does the terrain remain waterlogged for a continuous period of more than 48 hours

R rapid	excess water drains rapidly, even during periods of prolonged rainfall
V very rapid	excess water drains very rapidly, the terrain does not support growth of short rooted plants even if there is sufficient rainfall

29 *depth of groundwater*

The depth in metres of the mean ground water level over a number of years as experienced in the terrain component.

FLOODING

Flooding is characterized by items 30-32:

30 *frequency*

Frequency of the natural flooding of the terrain component in classes after FAO (1990a).

N none

D daily

W weekly

M monthly

A annually

B biennially

F once every 2-5 years

T once every 5-10 years

R rare (less than once in every 10 years)

U unknown

31 *duration*

Duration of the flooding of the terrain component in classes after FAO (1990a).

1 less than 1 day

2 1-15 days

3 15-30 days

4 30-90 days

5 90-180 days

6 180-360 days

7 continuously

32 *start*

Give the month (indicated by a figure) during which flooding of the terrain component normally starts. Three entries are possible.

SOIL COMPONENT

This section includes, besides the SOTER identification codes, all the attributes of the soil component (items 33 to 47). General attributes linked to the representative soil profile and horizon attributes are dealt with in the next sections, *Profile* and *Horizon data*.

33 *SOTER unit_ID*

See SOTER unit_ID under the section *Terrain*. The SOTER unit_ID given in the terrain chapter should also be used here.

34 *terrain component number*

See terrain component number under section *Terrain component*. The terrain component number given in the terrain component chapter should also be used here.

35 *soil component number*

The sequence number of the soil within the terrain component according to the ranking of the soil component within the terrain component (the largest soil component is given number 1, the second largest number 2, etc.). Soil components are the lowest level of differentiation of the SOTER units.

36 *proportion of SOTER unit*

The proportion that the soil component occupies within the SOTER unit. As stated in the section *Number of soil and terrain components*, chapter 5, a soil component normally occupies not less than 15% of the terrain. The sum of all soil components should be 100% for each SOTER unit.

37 *profile_ID*

Code for the representative profile. Any national code is permitted provided it is unique at a national level. An ISO country code (see Annex 4) should precede the national code. There is room for 12 characters.

38 *number of reference profiles*

The number of reference profiles that were considered for the selection of the representative profile is indicated. These profiles have also contributed to the determination of maximum and minimum values for a number of chemical and physical parameters of the soil.

39 *position in terrain component*

The relative position of the soil component within the terrain component is characterized by one of the following descriptions:

H high	interfluve, crest or higher part of the terrain component
M middle	upper and middle slope or any other medium position within the terrain component
L low	lower slope or lower part of the terrain component
D lowest	depression, valley bottom or any other lowest part of the terrain component
A all	all positions within the terrain component

40 *surface rockiness*

The percentage coverage of rock outcrops according to the following classes (FAO, 1990a):

N none	0 %
V very few	0- 2 %
F few	2- 5 %
C common	5-15 %
M many	15-40 %
A abundant	40-80 %
D dominant	≥ 80 %

41 *surface stoniness*

The percentage cover of coarse fragments (> 0.2 cm), completely or partly at the surface, is described according to the following classes (FAO, 1990a):

N none	0 %
V very few	0- 2 %
F few	2- 5 %
C common	5-15 %

M many 15-40 %

A abundant 40-80 %

D dominant ≥ 80 %

OBSERVABLE EROSION

Any visible signs of (accelerated) erosion are to be indicated according to type, area affected and degree. If more than two types of erosion are active at the same time, then only the dominant type is indicated (items 42-44).

42 *types of erosion/deposition*

Characterization of the erosion or deposition type according to FAO (1990a):

N no visible evidence of erosion

S sheet erosion

R rill erosion

G gully erosion

T tunnel erosion

P deposition by water

W water and wind erosion

L wind deposition

A wind erosion and deposition

D shifting sand

Z salt deposition

U type of erosion unknown

43 *area affected*

The area affected by the above mentioned erosion. Classes according to ISRIC-UNEP (1988).

1 0- 5 %

2 5-10 %

3 10-25 %

4 25-50 %

5 ≥ 50 %

44 *degree of erosion*

After FAO (1990a).

S	slight	Some evidence of loss of surface horizons. Original biofunctions largely intact.
M	moderate	Clear evidence of removal or coverage of surface horizons. Original biofunctions partly destroyed.
V	severe	Surface horizons completely removed (with subsurface horizons exposed) or covered up by sedimentation of material from upslope. Original biofunctions largely destroyed.
E	extreme	Substantial removal of deeper subsurface horizons (badlands). Complete destruction of original biofunctions.

45 *sensitivity to capping*

The degree in which the soil surface has a tendency to capping and sealing (FAO, 1990a):

N	none	no capping or sealing observed
W	weak	the soil surface has a slight sensitivity to capping. Soft or slightly hard crust less than 0.5 cm thick.
M	moderate	the soil has a moderate sensitivity to capping. Soft or slightly hard crust more than 0.5 cm thick, or hard crust less than 0.5 cm thick.
S	strong	the soil surface has a strong sensitivity to capping. Hard crust more than 0.5 cm thick.

46 *rootable depth*

Estimated depth in cm to which root growth is unrestricted by any physical or chemical impediment, such as an impenetrable or toxic layer. Strongly fractured rocks, such as shales, may be considered as rootable. Classes after FAO (1990a).

V	very shallow	< 30 cm
S	shallow	30-50 cm
M	moderately deep	50-100 cm
D	deep	100-150 cm
X	very deep	≥ 150 cm

47 *relation with other soil components*

A free-format space of 254 characters is available to indicate succinctly the relationship between this soil component and adjoining soil components. Up to 254 characters are permitted.

For example: "Soil component A has formed in colluviated material derived from soil component B".

PROFILE

48 *profile_ID*

Same as profile_ID in the section *Soil component*.

49 *profile database_ID*

The identification code for the owner, institute or organization that holds (part of) the national soil profile database. The code consists of an ISO code for the country (see Annex 4) and a sequence number (see also the section *Soil profile database* in chapter 8).

LOCATION OF THE REPRESENTATIVE PROFILE

The latitude and longitude, as accurate as possible, and expressed in decimal degrees. A profile of which the approximate location (i.e. accurate to the nearest full minute) is not known cannot be accepted in the SOTER database.

50 *latitude*

The latitude is stored in decimal degrees north. Latitudes in the southern hemisphere are negative.

51 *longitude*

The longitude is stored in decimal degrees east. Longitudes in the western hemisphere are negative.

52 *elevation*

The elevation of the representative profile in metres above sea level, and at least indicated to the nearest 50 m contour (if this is not possible, no entry should be made).

53 *sampling date*

The date at which the profile was described and sampled. In case these two activities were carried out on different dates, the date of sampling should be taken. The format is MM/YYYY.

54 *lab_ID*

The ISRIC ID code for the soil laboratory that analyzed the samples: ISO country code followed by a sequence number.

55 *drainage*

The present drainage of the soil component is described according to one of the classes mentioned below (after FAO, 1990a).

E	excessively drained	Water is removed from the soil very rapidly.
S	somewhat excessively drained	Water is removed from the soil rapidly.
W	well drained	Water is removed from the soil readily but not rapidly.
M	moderately well drained	Water is removed from the soil somewhat slowly during some periods of the year. The soils are wet for short periods within rooting depth.
I	imperfectly drained	Water is removed slowly so that the soils are wet at shallow depth for a considerable period.
P	poorly drained	Water is removed so slowly that the soils are commonly wet for considerable periods. The soils commonly have a shallow water table.
V	very poorly drained	Water is removed so slowly that the soils are wet at shallow depth for long periods. The soils have a very shallow water table.

56 *infiltration rate*

The basic infiltration rate, in cm/h, is indicated according to the following 7 categories (BAI, 1991).

V	very slow	< 0.1 cm/h
S	slow	0.1-0.5 cm/h
D	moderately slow	0.5-2.0 cm/h
M	moderate	2.0-6.0 cm/h
R	rapid	6.0-12.5 cm/h
Y	very rapid	12.5-25.0 cm/h
E	extremely rapid	≥ 25 cm/h

57 *surface organic matter*

Any litter or other organic matter on the surface will be described according to thickness (in cm) and degree of decomposition (Soil Survey Staff, 1975):

F	fibric	weakly decomposed organic soil material (fibre content >2/3 of volume)
H	hemic	degree of decomposition intermediate between fibric and sapric (fibre content between 1/6 and 2/3 of volume)
S	sapric	highly decomposed organic soil material (fibre content <1/6 of volume)

58 *classification*

Characterization of profile according to the revised FAO-Unesco Soil Map of the World Legend (FAO, 1990b). The codes as given in this publication will be entered (see also FAO, 1989). Where possible the characterization should be up to subunit level.

59 *classification version*

The year of publication of the version of the FAO Legend used for the characterization.

60 *national classification*

The original national classification of the representative profile if different from item 58. Up to 12 characters are permitted.

61 *Soil Taxonomy*

Only the Soil Taxonomy classification (for codes see FAO, 1989) for representative profiles as indicated in the national database or relevant report is given. No entry will be made for soil profiles that were not originally classified according to Soil Taxonomy.

62 *phase*

Any potentially limiting factor related to surface or subsurface features of the terrain, and not already specifically described in the soil profile, can be made a phase (see FAO, 1989). The coding for phases currently used by FAO is given in the FAO-ISRIC Soil Database (FAO, 1989). A note should be made on the code for new phases recognized.

HORIZON DATA

This section provides the attributes for the various horizons that have been distinguished in the representative soil profile. In general, no more than 5 horizons should be described. Mandatory attributes must always be completed. If these data are not available, expert estimates are required. Expert estimates are also permitted for optional attributes. Measured data are entered as an actual value for the representative profile, and as maximum and minimum values derived from all the reference profiles of the soil component. Mandatory attributes are marked both in Table 1 and in the text.

63 *profile_ID* (mandatory)

Same as profile_ID in sections *Soil component* and *Profile*.

64 *horizon number* (mandatory)

A consecutive number, starting with the surface horizon, is allocated to each horizon.

65 *diagnostic horizon* (mandatory)

Descriptions are taken from the Revised Legend of the FAO-Unesco Soil Map of the World (FAO, 1990b). For more precise definitions refer to this publication.

HI histic — An horizon which is more than 20 cm but less than 40 cm thick. It can be more than 40 cm but less than 60 cm thick if it consists of 75 percent or more, by volume, of sphagnum fibres or has a bulk density when moist of less than 0.1 kg dm^{-3}. A surface layer less than 25 cm thick qualifies as a histic horizon if, after having been mixed to a depth of 25 cm, it has 16% or more organic carbon and the mineral fraction contains more than 60% clay, or 8% or more organic carbon for intermediate contents of clay.

MO mollic — A horizon with the following properties for the upper 18 cm:

1) the soil structure is sufficiently strong that the horizon is not both massive and hard or very hard when dry. Very coarse prisms larger than 30 cm in diameter are included in the meaning of massive if there is no secondary structure within the prisms.
2) the chroma is less than 3.5 when moist, the value darker than 3.5 when moist and 5.5 when dry; the colour value is at least one unit darker than that of the C (both moist and dry). If a C horizon is not present, comparison should be made with the horizon immediately underlying the A horizon. If there is more than 40% finely divided lime, the limits of the colour value dry are waived; the colour value moist should then be 5 or less.
3) the base saturation (by NH_4OAc) is 50% or more
4) the organic carbon content is at least 0.6% throughout the thickness of mixed soil, as specified below. It is at least petrocalcic or a petrogypsic horizon or a petroferric phase.

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

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

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

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

NA natric — An argic horizon with

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

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

SP spodic

A spodic horizon meets one of the following requirements below a depth of 12.5 cm:

1) a subhorizon more than 2.5 cm thick that is continuously cemented by a combination of organic matter with iron and/or aluminium
2) a sandy or coarse-loamy texture with distinct dark pellets of coarse silt size or larger or with sand grains covered with cracked coatings which consist of organic matter and aluminium with or without iron.
3) one or more subhorizons in which a) if there is 0.1% or more extractable iron, the ratio of iron plus Al extractable by pyrophosphate at pH 10 to clay% is 0.2 or more, or if there is less than 0.1% extractable iron, the ratio of Al plus organic carbon to clay is 0.2 or more; and b) the sum of pyrophosphate-extractable Fe+Al is half or more of the sum of dithionite-citrate extractable Fe+Al; and c) the thickness is such that the index of accumulation of amorphous material in the subhorizons that meet the preceding requirements is 65 or more. This index is calculated by subtracting half the clay% from CEC at pH 8.2 mmol/kg clay and multiplying the remainder by the thickness of the subhorizon in cm. The results of all subhorizons are then added.

FA ferralic

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

CA calcic

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

PC petrocalcic

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

GY	gypsic	The gypsic horizon is enriched with secondary calcium sulphate ($CaSO_4$ $2H_2O$), is 10 cm or more thick, has at least 5% more gypsum than the underlying horizon, and the product of the thickness (cm) and the percent of gypsum is 150 or more.
PG	petrogypsic	A gypsic horizon that is so cemented with gypsum that dry fragments do not slake in water and roots cannot enter. The gypsum content usually exceeds 60%.
SU	sulphuric	The sulphuric horizon forms as a result of artificial drainage and oxidation of mineral or organic materials which are rich in sulphides. It is at least 15 cm thick and characterized by a pH(H_2O) less than 3.5 and generally has jarosite mottles with a hue of 2.5YR or more and a chroma of 6 or more.
AL	albic	Clay and free iron oxides have been removed, or the oxides have been segregated to the extent that the colour of the horizon is determined by the colour of the primary sand and silt particles rather than by coatings of these particles. An albic horizon has a colour value moist of 4 or more, or a value dry of 5 or more, or both. If the value dry is 7 or more, or the value moist is 6 or more, the chroma is 3 or less. If the value dry is 5 or 6, or the value moist 4 or 5, the chroma is closer to 2 than to 3. If the parent materials have a hue of 5YR or redder, a chroma moist of 3 is permitted in the albic horizon where the chroma is due to the colour of uncoated silt or sand grains.

66 *diagnostic property* (mandatory)

Diagnostic properties (FAO, 1990b).

TC	abrupt textural change	A clay increase between two layers, which takes place over a distance of less than 5 cm, where the lower layer shows a clay content of twice the clay content of the overlying layer if the latter has less than 20% clay, or an increase of 20% or more if the latter has 20% clay or more.
AD	andic properties	Soil materials which meet one or more of the following requirements: 1) acid oxalate extractable Al plus 1/2 acid oxalate extractable Fe is 2.0% or more in the fine earth fraction; bulk density of the fine earth fraction, measured in the field moist state, is 0.9 kg/dm^3 or less; phosphate retention is more than 85%. 2) more than 60% by volume of the whole soil is volcani-clastic material coarser than 2 mm; acid oxalate extractable Al plus 1/2 acid oxalate extractable Fe is 0.40% or more in the fine earth fraction. 3) the 0.02 to 2.0 mm fraction is at least 30% of the fine earth fraction and meets one of the following: a) if the fine earth fraction has acid oxalate extractable Al plus 1/2 acid oxalate extractable Fe of 0.40% or less, there is at least 30% volcanic glass in the 0.02

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

CO calcareous — Soil material which shows strong effervescence with 10% HCl or which contains more than 2% calcium carbonate equivalent.

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

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

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

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

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

GE geric properties — Soil materials which have either: 1) 1.5 cmol(+) kg^{-1} clay or less of exchangeable bases (Ca, Mg, K, Na) plus unbuffered 1M KCl exchangeable acidity; or 2) a delta pH (pH KCl minus pH H_2O) of +0.1 or more.

GL	gleyic and stagnic properties	Soil materials which are saturated with water at some period of the year, or throughout the year, in most years, and which show evidence of reduction processes or of reduction and segregation of iron.
GY	gypsiferous	Soil material which contains 5% or more gypsum.
IN	inter fingering	Penetrations of an albic horizon into an underlying argic or natric horizon along ped faces, primarily vertical faces. The penetrations are not wide enough to constitute tonguing, but form continuous skeletans (ped coatings of clean silt or sand, more than 1 mm thick on the vertical ped faces).
NI	nitic properties	Soil material that has 30% or more clay, has a moderately strong angular blocky structure which falls easily apart into flat edged ('polyhedric' or 'nutty') elements which show shiny ped faces that are either thin clay coatings or pressure faces. This soil structure is apparently associated with the presence of significant amounts of active iron oxides and is indicative of a high effective moisture storage and favourable phosphate sorption - desorption properties.
OR	organic soil materials	Organic soil materials are: 1) saturated with water for long periods or are artificially drained and, excluding live roots, a) have 18% or more organic carbon if the mineral fraction is 60% or more clay, b) have 12% or more organic carbon if the mineral fraction has no clay, or c) have a proportional content of organic carbon between 12 and 18% if the clay content of the mineral fraction is less than 60%; or 2) never saturated with water for more than a few days and have 20% or more organic carbon.
PE	permafrost	Permafrost is a layer in which the temperature is perennially at or below 0°C.
PL	plinthite	Plinthite is an iron-rich, humus-poor mixture of clay with quartz and other diluents. It commonly occurs as red mottles, usually in platy, polygonal or reticulate patterns, and changes irreversibly to a hardpan or to irregular aggregates on exposure to repeated wetting and drying. In a moist soil, plinthite is usually firm but it can be cut with a spade. When irreversibly hardened the material is no longer considered plinthite. Such hardened material is shown as a petroferric or a skeletic phase.
SA	salic properties	The electric conductivity of the saturation extract is more than 15 dS/m within 30 cm of the surface, or more than 4 dS/m within 30 cm of the surface if the pH(H_2O) exceeds 8.5.
SI	slicken-sides	Slickensides are polished and grooved surfaces that are produced by one mass sliding past another. Some of them occur at the base of a slip surface where a mass of soil moves downward on a relatively

		steep slope. Slickensides are very common in swelling clays in which there are marked seasonal changes in moisture content.
SM	smeary consistence	Thixotropic soil material; it changes under pressure or by rubbing from a plastic solid into a liquefied stage and back to the solid condition. In the liquefied stage the material skids or smears between the fingers (Andosols).
SO	sodic properties	The exchangeable sodium percentage is 15% or more, or exchangeable sodium plus magnesium is 50% or more.
SL	soft powdery lime	Translocated authigenic lime, soft enough to be cut readily with finger nail, precipitated in place from the soil solution rather than inherited from a soil parent material. It should be present in a significant accumulation (coatings on pores or structural faces).
HU	strongly humic	Soil material with an organic carbon content of more than 14 g/kg fine earth as a weighted average over a depth of 100 cm from the surface. This calculation assumes a bulk density of 1.5 kg/dm^3.
SU	sulphidic materials	Sulphidic materials are waterlogged mineral or organic soil materials containing 0.75% or more sulphur (dry weight), mostly in the form of sulphides, having less than three times as much calcium carbonate equivalent as sulphur, and having a pH above 3.5. Sulphidic materials accumulate in a soil that is permanently saturated and having a pH above 3.5, generally with brackish water. If the soil is drained the sulphides oxidize to form sulphuric acid. The pH, which is normally near neutrality before drainage, drops below 3.5. At this point these materials become a sulphuric horizon. Sulphidic material differs from the sulphuric horizon in its reduced condition, its pH and the absence of jarosite mottles with a hue of 2.5YR or more or a chroma of 6 or more.
TO	tonguing	An albic horizon penetrates an argic horizon along ped surfaces, if peds are present. Tongues must have greater depth than width, have horizontal dimensions of 5 mm or more in fine textured argic horizons (clay, silty clay and sandy clay), 10 mm or more in moderately fine textured argic horizons, and 15 mm or more in medium or coarser textured argic horizons (silt loams, loams and sandy loams), and must occupy more than 15% of the mas of the upper part of the argic horizon.
VE	vertic properties	In connection with clayey soils which at some period in most years show one or more of the following: cracks, slickensides, wedge-shaped or parallelepiped structural aggregates, that are not in a combination, or are not sufficiently expressed, for the soils to qualify as Vertisols.

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

67 *horizon designation*

Master horizon with subordinate characteristics according to the rules given below (for more details see FAO, 1990a).

Master horizons

H H horizon/layer. Layer dominated by organic material, formed from accumulations of (partially) undecomposed organic material at the soil surface, which may be underwater. All H horizons are saturated with water for prolonged periods, or were once saturated but are now artificially drained. An H horizon may be on top of mineral soils or at any depth beneath the surface if it is buried.

O O horizon/layer. Layer dominated by organic material, consisting of (partially) undecomposed litter, such as leaves, twigs, moss etc., which has accumulated on the surface. They may be on top of either mineral or organic soils. An O horizon is not saturated with water for prolonged periods. The mineral fraction of such material is only a small percentage of the volume of the material and generally is much less than half the weight. An O horizon may be at the surface of a mineral soil or at any depth beneath the surface if it is buried.

A A horizon. Mineral horizon which formed at the surface or below an O horizon, and in which all or much of the original rock structure has been obliterated. The A horizon is characterized by one or more of the following:

- an accumulation of humified organic matter intimately mixed with the mineral fractions and not displaying properties characteristic of an E horizon (see below);
- properties resulting from cultivation, pasturing, or similar kinds of disturbance; or
- a morphology which is different from the underlying B or C horizon, resulting from processes related to the surface (e.g. vertisols).

E E horizon. Mineral horizon, in which the main feature is a loss of silicate clay, iron, aluminium, or some combination of these, leaving a concentration of sand and silt particles, and in which all or much of the original rock structure has been obliterated.

An E horizon is most commonly differentiated from an underlying B horizon by colour of higher value or lower chroma, or both; by coarser texture; or by a combination of these. Although an E horizon is usually near the surface, below an O or A horizon, and above a B horizon, the symbol E may be used without regard to position in the profile for any horizon that meets the requirements, and that has resulted from soil genesis.

B B horizon. A B horizon has formed below an A, E, O or H horizon, and has as dominant feature the obliteration of all or much of the original rock structure, together with one or a combination of the following:
- illuvial concentration, alone or in combination, of silicate clay, iron, aluminium, humus, carbonates, gypsum or silica;
- evidence of removal of carbonates;
- residual concentration of sesquioxides;
- coating of sesquioxides that make the horizon conspicuously lower in value, higher in chroma, or redder in hue than overlying and underlying horizons without apparent illuviation of iron;
- alteration that forms silicate clay or liberates oxides or both and that forms a granular, blocky or prismatic structure if volume changes accompany the changes in moisture content, or
- brittleness.

Layers with gleying but no other pedogenetic change are not considered a B horizon.

C C horizon/layer. A horizon or layer, excluding hard bedrock, that is little affected by pedogenetic processes and lacks properties of H, O, A, E or B horizons. Most are mineral layers, but some siliceous or calcareous layers (e.g. shells, coral and diatomaceous earth) are included. Sediments, saprolite and unconsolidated bedrock and other geological materials that commonly slake within 24 hours are included as C layers. Some soils form in highly weathered material that is considered a C horizon if it does not meet the requirements of an A, E or B horizon.

R R layer. Hard rock underlying the soil. Air dry chunks of an R layer will not slake within 24 hours if placed into water.

Subordinate properties

Subordinate distinctions and features within master horizons are indicated with lower case letters used as suffixes. The following subordinate properties may be used (see FAO, 1990a for more details).

b buried genetic horizon

c concretions or nodules

f frozen soil

g strong gleying

h accumulation of organic matter

j	jarosite mottling
k	accumulation of carbonates
m	cementation or induration
n	accumulation of sodium
o	residual accumulation of sesquioxides
p	ploughing or other disturbance
q	accumulation of silica
r	strong reduction
s	illuvial accumulation of sesquioxides
t	accumulation of silicate clay
v	occurrence of plinthite
w	development of colour or structure
x	fragipan character
y	accumulation of gypsum
z	accumulation of salts more soluble than gypsum

68 *lower depth* (mandatory)

The average depth of the lower boundary in cm (the upper boundary in the case of an **O** horizon).

69 *distinctness of transition*

Abruptness of horizon boundary to underlying horizon (FAO, 1990a).

A	abrupt	0-2 cm
C	clear	2-5 cm
G	gradual	5-15 cm
D	diffuse	$\geq$ 15 cm

70 *moist colour* (mandatory)

The Munsell colours (moist soil) should be given. Only integer values and chromas are accepted.

71 *dry colour*

The Munsell colours (dry soil) should be given. Only integer values and chromas are accepted.

STRUCTURE

The grade, size and type of structure, defined according to FAO (1990a), are described in items 72-74.

72 *grade of structure*

N	structureless	no observable aggregation or no orderly arrangement of natural planes of weakness (massive or single grain)
W	weak	soil with poorly formed indistinct peds, that are barely observable in place even in dry soil, breaks up into very few intact peds, many broken peds and much apedal material
M	moderate	soil with well-formed distinct peds, durable and evident in disturbed soil which produces many entire peds, some broken peds and little apedal material
S	strong	soil with durable peds that are clearly evident in undisturbed (dry) soil, which breaks up mainly into entire peds

73 *size of structure elements*

TABLE 4
Size classes for structure elements of various types (mm) (Soil Survey Staff, 1951; FAO, 1990a)

Size classes	Ranges of size of structure elements (mm)				
	platy	prismatic/columnar	(sub)ang.blocky	granul.	crumb
V very fine	< 1	< 10	< 5	< 1	<1
F fine	1- 2	10 - 20	5 - 10	1- 2	1-2
M medium	2- 5	20 - 50	10 - 20	2- 5	2-5
C coarse	5-10	50 -100	20 - 50	5-10	
X very coarse	>10	> 100	> 50	> 10	

74 *type of structure* (mandatory)

P	platy	particles arranged around a generally horizontal plane
R	prismatic	prisms without rounded upper end
C	columnar	prisms with rounded caps
A	angular blocky	bounded by plains intersecting at largely sharp angles

S	subangular blocky	mixed rounded and plane faces with vertices mostly rounded
G	granular	spheroidical or polyhedral, relatively non-porous
B	crumb	spheroidical or polyhedral, porous
M	massive	no structure
N	single grain	no structure, individual grains
W	wedge shaped	structure in horizons with slickensides

COARSE FRAGMENTS

The presence of any rock or mineral fragments in the horizon is described in items 75 and 76.

75 *abundance* (mandatory)

Classes of volume % of rock or mineral fragments (> 2 mm) in soil matrix (FAO, 1990a).

N	none	0 %
V	very few	0-2 %
F	few	2-5 %
C	common	5-15 %
M	many	15-40 %
A	abundant	40-80 %
D	dominant	≥ 80 %

76 *size of coarse fragments*

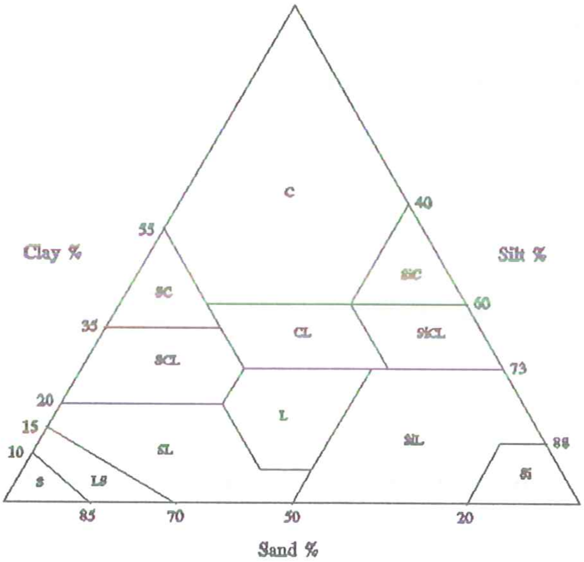
Size of dominant rock or mineral fragments in classes (FAO, 1990a).

V	very fine	< 2 mm
F	fine	2-6 mm
M	medium	6-20 mm
C	coarse	≥ 20 mm

77 *very coarse sand*

Weight % of particles 2.0-1.0 mm in fine earth fraction.

FIGURE 11
Texture classes of fine earth



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

78 *coarse sand*

Weight % of particles 1.0-0.5 mm in fine earth fraction.

79 *medium sand*

Weight % of particles 0.5-0.25 mm in fine earth fraction.

80 *fine sand*

Weight % of particles 0.25-0.10 mm in fine earth fraction.

81 *very fine sand*

Weight % of particles 0.10-0.05 mm in fine earth fraction.

82 *total sand* (mandatory)

Weight % of particles 2.0-0.05 mm in fine earth fraction. The total sand fraction, either as an absolute value, or as the sum of the sub-fractions.

83 *silt* (mandatory)

Weight % of particles 0.05-0.002 mm in fine earth fraction.

84 *clay* (mandatory)

Weight % of particles < 0.002 mm in fine earth fraction.

85 *particle size class*

The particle size class as derived, with the aid of Figure 11, from the particle size analysis results.

86 *bulk density* (mandatory)

The bulk density in kg dm^{-3}.

87 *moisture content at various tensions*

The database accepts the soil moisture content (%) at 5 different tensions, of which one should be the moisture content at field capacity (-33 KPa) and one the moisture content at wilting point (-1500 KPa).

For example:

KPa	-33	-98	-300	-510	-1500
soil moisture %	41	22	17	12	09

88 *hydraulic conductivity*

The saturated hydraulic conductivity in cm h^{-1}.

89 *infiltration rate*

The basic infiltration rate in cm h^{-1}.

90 *pH (H_2O)* (mandatory)

The pH is determined in the supernatant suspension of a 1:2.5 soil-water mixture (mandatory).

91 *pH (KCl)*

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

92 *electrical conductivity (EC_e)*

The electrical conductivity of saturation extract, dS/m, only mandatory if the soil contains salts.

93 *exchangeable Ca^{++}*

The exchangeable Ca in cmol(+) kg^{-1}.

94 *exchangeable Mg^{++}*

The exchangeable Mg in cmol(+) kg^{-1}.

95 *exchangeable Na^{+}*

The exchangeable Na in cmol(+) kg^{-1}.

96 *exchangeable K^{+}*

The exchangeable K in cmol(+) kg^{-1}.

97 *exchangeable Al^{+++}*

The exchangeable Al in cmol(+) kg^{-1}.

98 *exchangeable acidity*

The exchangeable acidity, as determined in 1N KCl, in cmol (+) kg^{-1}.

99 *CEC soil* (mandatory)

The cation exchange capacity of the soil at pH 7.0 in cmol(+) kg^{-1}.

100 *total carbonate equivalent*

The content of carbonates in g kg^{-1}.

101 *gypsum*

The gypsum content in g kg^{-1}.

102 *total carbon* (mandatory)

The content of total organic carbon in g kg^{-1}, a mandatory attribute for the topsoil (first 25 cm, or A horizon, whichever is deeper).

103 *total nitrogen*

The content of total N in g kg^{-1}.

104 *P_2O_5*

The P_2O_5 content in mg kg^{-1}.

105 *phosphate retention*

The phosphate retention in %.

106 *Fe, dithionite extractable*

The Fe fraction, in weight %, extractable in dithionite.

107 *Fe, pyrophosphate extractable*

The Fe fraction, in weight %, extractable in pyrophosphate at pH 10.

108 *Al, dithionite extractable*

The Al fraction, in weight %, extractable in dithionite.

109 *Al, pyrophosphate extractable*

The Al fraction, in weight %, extractable in pyrophosphate at pH 10.

110 *clay mineralogy*

The dominant type of mineral in the clay fraction.

AL	allophane
CH	chloritic
IL	illitic
IN	interstratified or mixed
KA	kaolinitic
MO	montmorillonitic
SE	sesquioxidic
VE	vermiculitic

PART II

LAND USE AND VEGETATION

Chapter 7

Land cover

In SOTER, land cover characteristics (vegetation and land use) are stored in two files that are separated from the soil and terrain properties. Attributes of land use and vegetation are displayed in Table 5. In contrast with the more stable attributes of the land which are covered in Part I of this manual, land cover is considered a more dynamic entity which can change quickly in time. Therefore there may be a frequent need for addition of more recent data. Moreover, third parties are working on global databases for land use (FAO) and for vegetation, or are planning to do so. At present, such databases are not available but the need exists for the subsequent incorporation of these data into SOTER.

TABLE 5
Attributes of land use and vegetation files

LAND USE	VEGETATION
1 SOTER unit_ID	1 SOTER unit_ID
2 date of observation	2 date of observation
3 land use	3 vegetation
4 proportion of SOTER unit	4 proportion of SOTER unit

For interpretative uses of the SOTER database there is a need for land cover data. A provisional system for such data is implemented for the SOTER database. In it, the land cover information is given at the level of the SOTER unit. By doing so, the effort of digitizing separate land cover boundaries is avoided and a simple link is possible between the soil and terrain data and the land cover.

LAND USE

The land use file contains only four attributes, of which the first two, viz. SOTER unit ID and date of observation, are the key attributes.

1 *SOTER unit_ID*

Identification code of a SOTER unit (see chapter 6 *Terrain*).

2 *date of observation*

Date of observation for the land use; stored in format MM/YYYY.

TABLE 6
Hierarchy of land use; land use orders, groups and systems

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

3 *land use*

Land use classes are defined in a hierarchical system (Remmelzwaal, 1990). At the highest level, classes are subdivided into subclasses and groupes on the basis of the type of land use, and the occurrence of input and/or output (animal products, crops). The codes for land use are given in Table 6 and full descriptions in Annex 2.

4 *proportion of SOTER unit*

Proportion that the land use occupies within the SOTER unit, in %.

VEGETATION

The vegetation file contains four attributes, of which the first two, viz. SOTER unit ID and date of observation, are the key attributes.

1 *SOTER unit_ID*

Identification code of a SOTER unit (see chapter 6 *Terrain*).

2 *date of observation*

Date of observation for the native vegetation; stored in format MM/YYYY.

3 *vegetation*

Generalized description of the physiognomy of the present native vegetation (Unesco, 1973). Table 7 gives the hierarchical classification of the vegetation to apply at the SOTER unit level. A full description of the classes is given in Annex 3. Vegetation should be specified at least on the formation subclass level.

4 *proportion of SOTER unit*

Proportion that the vegetation occupies within the SOTER unit, in %.

TABLE 7
Hierarchical vegetation classes

I	closed forest	IA	mainly evergreen forest	IA1	tropical ombrophilous forest
				IA2	tropical and subtropical evergreen seasonal forest
				IA3	tropical and subtropical semi-deciduous forest
				IA4	subtropical ombrophilous forest
				IA5	mangrove forest
				IA6	temperate and subpolar evergreen ombrophilous forest
				IA7	temperate evergreen seasonal broad-leaved forest
				IA8	winter-rain evergreen broad-leaved sclerophyllous forest
				IA9	tropical and subtropical evergreen needle-leaved forest
				IA10	temperate and subpolar evergreen needle-leaved forest

..		IB	mainly deciduous forest	IB1	tropical and subtropical drought-forest
				IB2	cold-deciduous forest with evergreen trees (or shrubs)
				IB3	cold-deciduous forest without evergreen trees
..		IC	extremely xeromorphic forest	IC1	sclerophyllous-dominated extremely xeromorphic forest
				IC2	thorn-forest
				IC3	mainly succulent forest
II	woodland	IIA	mainly evergreen woodland	IIA1	evergreen broad-leaved woodland
				IIA2	evergreen needle-leaved woodland
..		IIB	mainly deciduous woodland	IIB1	drought-deciduous woodland
				IIB2	cold-deciduous woodland with evergreen trees
				IIB3	cold-deciduous woodland without evergreen trees
..		IIC	extremely xeromorphic woodland		subdivisions as extremely xeromorphic forest (IC)
III	scrub	IIIA	mainly evergreen scrub	IIIA1	evergreen broad-leaved shrubland (or thicket)
				IIIA2	evergreen needle-leaved and microphyllous shrubland
..		IIIB	mainly deciduous scrub	IIIB1	drought-deciduous scrub with evergreen woody plants admixed
				IIIB2	drought-deciduous scrub without evergreen woody plants admixed
				IIIB3	cold-deciduous scrub
..		IIIC	extremely xeromorphic (subdesert) shrubland	IIIC1	mainly evergreen subdesert shrubland
				IIIC2	deciduous subdesert shrubland
IV	dwarf scrub and related communities	IVA	mainly evergreen dwarf-scrub	IVA1	evergreen dwarf-scrub thicket
				IVA2	evergreen dwarf shrubland
				IVA3	mixzed evergreen dwarf-shrubland and herbaceous formation

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8. Report of the Third Meeting of the Advisory Panel on the Soil Map of the World, Paris, 3 January 1964.**
9. Adequacy of Soil Studies in Paraguay, Bolivia and Peru, November-December 1963.**
10. Report on the Soils of Bolivia, January 1964.**
11. Report on the Soils of Paraguay, January 1964.**
12. Preliminary Definition, Legend and Correlation Table for the Soil Map of the World, Rome, August 1964.**
13. Report of the Fourth Meeting of the Advisory Panel on the Soil Map of the World, Rome, 16-21 May 1964.**
14. Report of the Meeting on the Classification and Correlation of Soils from Volcanic Ash, Tokyo, Japan, 11-27 June 1964.**
15. Report of the First Session of the Working Party on Soil Classification, Survey and Soil Resources of the European Commission on Agriculture, Florence, Italy, 1-3 October 1964.**
16. Detailed Legend for the Third Draft on the Soil Map of South America, June 1965.**
17. Report of the First Meeting on Soil Correlation for North America, Mexico, 1-8 February 1965.**
18. The Soil Resources of Latin America, October 1965.**
19. Report of the Third Correlation Seminar for Europe: Bulgaria, Greece, Romania, Turkey, Yugoslavia, 29 August-22 September 1965.**
20. Report of the Meeting of Rapporteurs, Soil Map of Europe (Scale 1:1 000 000) (Working Party on Soil Classification and Survey of the European Commission on Agriculture), Bonn, Federal Republic of Germany, 29 November-3 December 1965.**
21. Report of the Second Meeting on Soil Survey, Correlation and Interpretation for Latin America, Rio de Janeiro, Brazil, 13-16 July 1965.**
22. Report of the Soil Resources Expedition in Western and Central Brazil, 24 June-9 July 1965.**
23. Bibliography on Soils and Related Sciences for Latin America (1st edition), December 1965.**
24. Report on the Soils of Paraguay (2nd edition), August 1964.**
25. Report of the Soil Correlation Study Tour in Uruguay, Brazil and Argentina, June-August 1964.**
26. Report of the Meeting on Soil Correlation and Soil Resources Appraisal in India, New Delhi, India, 5-15 April 1965.**
27. Report of the Sixth Session of the Working Party on Soil Classification and Survey of the European Commission on Agriculture, Montpellier, France, 7-11 March 1967.**
28. Report of the Second Meeting on Soil Correlation for North America, Winnipeg-Vancouver, Canada, 25 July-5 August 1966.**
29. Report of the Fifth Meeting of the Advisory Panel on the Soil Map of the World, Moscow, USSR, 20-28 August 1966.**
30. Report of the Meeting of the Soil Correlation Committee for South America, Buenos Aires, Argentina, 12-19 December 1966.**
31. Trace Element Problems in Relation to Soil Units in Europe (Working Party on Soil Classification and Survey of the European Commission on Agriculture), Rome, 1967.**
32. Approaches to Soil Classification, 1968.**
33. Definitions of Soil Units for the Soil Map of the World, April 1968.**
34. Soil Map of South America 1:5 000 000, Draft Explanatory Text, November 1968.**
35. Report of a Soil Correlation Study Tour in Sweden and Poland, 27 September-14 October 1968.**
36. Meeting of Rapporteurs, Soil Map of Europe (Scale 1:1 000 000) (Working Party on Soil Classification and Survey of the European Commission on Agriculture), Poitiers, France 21-23 June 1967.**
37. Supplement to Definition of Soil Units for the Soil Map of the World, July 1969.**
38. Seventh Session of the Working Party on Soil Classification and Survey of the European Commission on Agriculture, Varna, Bulgaria, 11-13 September 1969.**
39. A Correlation Study of Red and Yellow Soils in Areas with a Mediterranean Climate.**
40. Report of the Regional Seminar of the Evaluation of Soil Resources in West Africa, Kumasi, Ghana, 14-19 December 1970.**
41. Soil Survey and Soil Fertility Research in Asia and the Far East, New Delhi, 15-20 February 1971.**
42. Report of the Eighth Session of the Working Party on Soil Classification and Survey of the European Commission on Agriculture, Helsinki, Finland, 5-7 July 1971.**

..		IVB	mainly deciduous dwarf-scrub	IVB1	facultatively drought-deciduous dwarf-thicket (or dwarf-shrubland)
				IVB2	obligatory, drought-deciduous dwarf-thicket (or dwarf-shrubland)
				IVB3	cold-deciduous dwarf-thicket (or dwarf-shrubland)
..		IVC	extremely xeromorphic dwarf-shrubland		subdivisions as extremely xeromorphic (subdesert) shrubland (IIIC)
..		IVD	tundra	IVD1	mainly bryophyte tundra
				IVD2	mainly lichen tundra
..		IVE	mossy bog formations with dwarf-shrub	IVE1	raised bog
				IVE2	non-raised bog
V	herbaceous vegetation	VA	tall graminoid vegetation	VA1	tall grassland with a tree synusia covering 10-40%
				VA2	tall grassland with a tree synusia <10%
				VA3	tall grassland with a synusia of shrubs
				VA4	tall grassland with a woody synusia
				VA5	tall grassland practically without woody synusia
..		VB	medium tall grassland	VB1	medium tall grassland with a tree synusia covering 10-40%
				VB2	medium tall grassland with a synusia <10%
				VB3	medium tall grassland with a synusia of shrubs
				VB4	medium tall grassland with an open synusia of tuft plants (usually palms)
				VB5	medium tall grassland practically without woody synusia
..		VC	short grassland	VC1	short grassland with a tree synusia covering 10-40%
				VC2	short grassland with a tree synusia <10%

			VC3	short grassland with a synusia of shrubs
			VC4	short grassland with an open synusia of tuft plants
			VC5	short grassland practically without woody synusia
			VC6	short to medium tall mesophytic grassland
			VC7	graminoid tundra
..	**VD**	forb vegetation	**VD1**	tall forb communities
			VD2	low forb communities
..	**VE**	hydromorphic fresh-water vegetation	**VE1**	rooted fresh-water communities
			VE2	free-floating fresh-water communities

PART III

MISCELLANEOUS FILES

Chapter 8

Reference files

Tables containing information on the source materials used for the compilation of the SOTER units, generally soil maps, the laboratories that analysed the soil samples, the laboratory methods and the organizations responsible for the national profile database are described in this chapter.

SOURCE MAP

In this file information on type of map, scale, location and date are stored. As the location in max and min X and Y-coordinates is recorded, the GIS can be used to overlay this information on the SOTER map. There exists a direct link (primary key 'map_ID') between the terrain table and the source map table. The attributes are shown in Table 8.

1 *map_ID*

The source map identification code from which the data were derived for the compilation of the SOTER units. See also map_ID in chapter 6, *Terrain*.

2 *map title*

The citation of the source map title. There is room for 40 characters.

3 *year*

The year of publication of the source map.

4 *scale*

The scale of the source map as a representative fraction.

5 *minimum latitude*

The minimum latitude (Y-coordinate) of the source map, in decimal degrees East. Latitude West is a negative figure.

TABLE 8
Attributes of related tables

SOURCE MAP	LABORATORY	PROFILE DATABASE
1 map_ID	1 lab_ID	1 soil profile database_ID
2 map title	2 laboratory name	2 name of institute
3 year		
4 scale	LABORATORY METHOD	
5 minimum latitude		
6 minimum longitude	3 lab_ID	
7 maximum latitude	4 date	
8 maximum longitude	5 attribute	
9 type of map	6 method of analysis_ID	
	ANALYTICAL METHOD	
	7 method of analysis_ID	
	8 description	

6 *minimum longitude*

The minimum longitude (X-coordinate) of the source map, in decimal degrees North. Longitude South gets a negative number.

7 *maximum latitude*

The maximum latitude (Y-coordinate) of the source map, in decimal degrees East.

8 *maximum longitude*

The maximum longitude (X-coordinate) of the source map, in decimal degrees North.

9 *type of source map*

The type of source map:

S pure soil map
M morpho-pedological map (soil-landscapes)
O other map

LABORATORY INFORMATION

For every analysis method that has been applied in a particular laboratory separate entries in these tables should be made.

Laboratory

1 *lab_ID*

Identification code for the laboratory that analysed the reference soil profile. A country code with a sequential number is given. See list of country codes in Annex 4.

2 *laboratory name*

Name of the laboratory, in full (up to 40 characters).

Laboratory method

3 *lab_ID*

Laboratory code (see attribute 1, lab_ID).

4 *date*

Date at which the laboratory introduced a method for a given attribute. Format is MM/YYYY.

5 *attribute*

Profile layer attribute that was analysed. The item code preceding the attribute in table 1 and in the margin is used.

6 *method of analysis_ID*

Identification code for the analysis method applied. This code consists of the attribute code (item 5) followed by a sequential number.

Analytical method

7 *method of analysis_ID*

Method code (see attribute 6).

8 *description*

A complete description of the analytical method used. There is room for 256 characters.

SOIL PROFILE DATABASE

Information on the (national) soil profile database that has been consulted for the selection of the SOTER profile data can be found as an additional file. A code for the country (from Annex 4) followed by a sequence number is given. Also the name of the organization can be indicated.

1 *profile database_ID*

The identification code for the owner, institute or organization that holds (part of) the national soil profile database. The code consists of a code for the country (see Annex 4) and a sequence number.

2 *name*

Name (in full) of the owner, institute or organization of the national soil profile database and address, up to 40 characters.

Chapter 9

Climate

Climatic data forms an inseparable part of the basic inventory of natural resources. Nevertheless, climate is treated separately from the SOTER database as the climate data are not directly linked to the SOTER units. Climate data are based on point observations only and the link with the soils and terrain information exists by means of the geographical location of these points. The SOTER climate files are intended for multiple applications of the soils and terrain database. Monthly data are considered sufficient for most of the (small scale) applications.

At the Workshop on Procedures Manual Revisions (ISRIC, 1990b), it was recommended that the attribute data for the climate database of SOTER should be derived, if possible, from existing computerized databases, e.g. WMO (CLICOM), FAO and CIAT. Data from these databases can be imported through an ASCII file interface. Care should be taken on the units of measure.

Data from point observations are extracted from meteorological data sets and consist of two major groupings: (i) climate station particulars, and (ii) monthly climate data.

The files shown in Table 9 are used to store the station particulars and the monthly climatic data as well as the data sources.

CLIMATE STATION

1 *climate station_ID*

The climate station_ID is given as a two-character ISO country code (according to Annex 4) followed by a four digit sequential number.

2 *climate station name*

The name of the climate station is given. Up to 40 characters are permitted.

3 *latitude*

The latitude is stored in decimal degrees north; latitudes in the southern hemisphere are negative.

TABLE 9
Attributes for climate station, climate data and source tables

CLIMATE STATION	CLIMATE DATA	DATA SOURCE
1 climate station_ID	6 climate station_ID	25 source_ID
2 climate station name	7 kind of data	26 source name
3 latitude	8 source_ID	
4 longitude	9 first year	
5 altitude	10 last year	
	11 years of record	
	12 jan	
	..	
	23 dec	
	24 annual	

4 *longitude*

The longitude is stored in decimal degrees east; longitudes in the western hemisphere are negative.

5 *altitude*

The altitude above or below (negative) sea level, m.

CLIMATE DATA

6 *climate station_ID*

Code for the climate station. See station code under Climate station.

7 *kind of data*

The various kinds of climatic data are treated in the next section.

8 *source_ID*

Identification code for the main source of the data for each separate kind of data. Codes are to be explained in the data source file (see section *Data sources*).

9 *first year*

The first year of the observation period.

10 *last year*

The last year of the observation period.

11 *years*

The number of years of record in the observation period.

12...23 *jan...dec*

The data values for each individual month. Average monthly value for the numbers of years recorded.

24 *annual*

The annual value (average or total).

VARIOUS CLIMATE CHARACTERISTICS

In this section various climate characteristics (attribute 8: 'kind of data') are arranged in several groups. The importance of the kind of data attribute is indicated by a letter (M = mandatory, D = desirable and O = optional). When a mandatory characteristic is missing, the station should not be included in the database.

Rainfall

Data on rainfall is recorded in mm. The amount of rainfall is a mandatory attribute; if it is missing, it is considered of no use to include the climate station in the database.

RAIN	M	precipitation total, mm
RDAY	D	number of rainy days; days with at least 1 mm of precipitation
RMAX	O	maximum 24-hour rainfall, mm
RR75	O	rainfall reliability; the amount of rainfall exceeded in 3 out of 4 years, mm

Temperature

Temperature is stored in degrees centigrade (°C). Both minimum and maximum temperatures are mandatory. The average temperature is optional because it can be derived from the minimum and maximum temperatures.

TEMP	O	mean temperature during 24-hour period
TMIN	M	minimum temperature during a 24 hour period
TMAX	M	maximum temperature during a 24 hour period

Radiation/sunshine

Either radiation or sunshine hours is mandatory; the other is then optional. Radiation data is preferred.

RADI	M/O	total radiation, $MJ.m^{-2}.day^{-1}$
SUNH	O/M	hours of bright sunshine per day
CLOU	O	degree of cloudiness, octas

TABLE 10
Example of various kinds of climatic data recorded for a climate station (Posedas, Argentina)

Stat.	SR	Data	F-yr	L-yr	Yrs	J	F	M	A	M	J	J	A	S	O	N	D	Ann.
AR21	06	rain	1901	1980	80	141	148	139	146	131	127	97	99	143	189	134	149	1643
AR21	07	rday	1951	1980	30	9.6	9.3	9.3	8.3	8.3	9.6	9.3	9.3	11.0	10.6	7.6	8.6	110.8
AR21	01	temp	1951	1980	30	26.2	25.8	24.3	20.7	18.1	16.5	15.6	17.3	18.8	20.9	23.3	25.7	21.1
AR21	01	Tmin	1951	1980	30	19.7	19.4	18.2	14.8	12.5	11.5	10.0	11.0	12.8	14.7	16.5	18.8	15.0
AR21	01	Tmax	1951	1980	30	32.7	32.2	30.4	26.6	23.6	21.5	21.2	23.6	24.8	27.1	30.1	32.6	27.2
AR21	01	vapp	1951	1980	30	24.2	24.5	32.0	19.3	17.5	15.9	14.2	14.7	16.5	18.5	19.7	21.8	19.2
AR21	01	wind	0.51	1980	30	1.5	1.7	1.5	1.5	1.7	1.7	2.0	2.0	2.0	2.0	1.7	1.7	1.8
AR21	01	PETP	0.51	1980	30	149	125	105	69	45	32	41	63	74	104	138	161	1109

Humidity

Either vapour pressure or relative humidity is mandatory. Vapour pressure is preferable to above relative humidity.

VAPP	M/O	vapour pressure, mbar
HUMI	O/M	average relative humidity during 24 hour period, %
HMIN	O	minimum relative humidity during 24 hour period, %
HMAX	O	maximum relative humidity during 24 hour period, %

Wind

Wind velocity in m/s.

WIND	D	mean wind velocity at 2 m during 24 hour period
WDAY	O	wind speed during day at 2 m during 24 hour period
WNIG	O	wind speed during night at 2 m during 24 hour period
WDIR	O	dominant wind direction at 2 m during 24 hour period

Risk or occurrence of adverse weather events

WRIS O risk or occurrence of adverse weather events like severe hailstorms, hurricanes and nightfrost. Indicated on a scale of 0 (never) to 1 (every year in the month under consideration). Intermediate values are used if the frequency is less than every year (for that month). For example: One occurrence every 5 years in the month of March = 0.2.

Evaporation

EPAN	O	class A pan evaporation, mm
ECOL	O	Colorado pan evaporation, mm
EPIC	O	evaporation, Piche, mm

Evapotranspiration

Because evapotranspiration is a calculated characteristic, it is optional.

PETP	O	Penman potential evapotranspiration, mm
PETH	O	Hargreaves potential evapotranspiration, mm
PETT	O	Thornthwaite potential evapotranspiration, mm

ADDITIONAL CONVENTIONS

Data can be given for different categories of climate characteristics:

For Penman calculations, mandatory data are minimum and maximum temperature, irradiation, vapour pressure or relative humidity, wind speed, monthly rainfall, and number of rainy days.

When data are missing, some parameters can be estimated from others:

- relative humidity and vapour pressure can be estimated from each other
- radiation, sunshine hours, and cloudiness degree
- minimum and maximum temperature determine average temperature.

DATA SOURCES

One related file to the climate database exists: data sources. It contains one key field namely the source_ID of the climate data file and one attribute: the full name of the source (published report, or name and address of the meteorological organisation holding the complete climate dataset).

25 *source_ID*

Identification code for the source of data (as item 8).

26 *source name*

The full name of the source from which the climatic data have been taken.

Annex 1

Hierarchy of landforms

The term landform as used in this manual, is land with a characteristic slope (see also Remmelzwaal, 1990). Landform separation (first and second level) is thus based on morphometric criteria, chief amongst which is the slope gradient. The relief intensity is the second most important criterion used to subdivide the landscape. Subdivisions of level lands also take into account the position of the landform vis-à-vis the surrounding land. Further separation of the landforms according to hypsometric criteria is different for each 1st level landform (see item 10). Exceptions to this are noted with the description of the 2nd level landforms. The classification as presented here has been tested for a 1:5 million physiographic inventory of South America and Africa (Eschweiler, 1993; Wen, 1993).

1ST LEVEL LANDFORMS

LEVEL LAND

Level lands are all lands with dominant slopes between 0 and 8% (0° and 4°40'). Moreover, the relief intensity is such that the difference between the highest and the lowest point within one slope unit is mostly less than 50 m.

SLOPING LAND

Sloping land embraces all landforms that have dominant slopes between 8% and 30%, combined with in most cases a relief intensity of more than 50 m per slope unit. In general, sloping land will be more heterogeneous with respect to its slope than level land.

STEEP LAND

Steep land is mainly confined to mountainous country, where average slopes are over 30% (the variability of slope gradients may be so much as to make it difficult to recognize a dominant slope) and the relief intensity is more than 600 m/2 km.

LANDS WITH COMPOSITE LANDFORMS

Two strongly contrasting landforms, themselves not separable at the scale of mapping, may be combined if they are part of an outstanding landform that as such can be delineated at the scale of mapping. Examples of such landforms associations are valleys, made up of side-slopes and a valley bottom, and narrow plateaux, where a level surface is surrounded by relative steeply sloping land. Not all possible combinations are given here and the user may define others if the need for them arises (e.g. deeply incised plateau, consisting of a plateau and high-gradient valleys).

2ND LEVEL LANDFORMS

L Level lands

Except for low-gradient footslopes, all types of level lands that can be distinguished meet the same criteria, although they differ in their relationship towards the surrounding land. As the upper slope limit for level land is a gradient of 8%, areas with a perceptible slope may still be considered level land.

LP Plains

Plains are all level lands that are not enclosed between higher lying lands, that do not protrude above the surrounding country, or that do not rise gently against land with a considerable steeper slope.

LL Plateaux

Plateaux are level lands that are, compared with the surrounding landscapes, situated at relatively elevated positions. Plateaux can be very extensive, but must always on at least one side be bounded by a slope or escarpment (8% ore more), connecting it with lower lying land. Many so-called plateaux are in fact elevated plains, and should be classified as such.

LD Depressions

A depression is an area of level land that is on all sides surrounded by higher lying level or sloping land. The area occupied by the band of sloping land that forms the transition from the higher ground to the floor of the depression is small compared to the area within the depression taken up by level land.

LF Low-gradient footslopes

Steadily rising level land, abutting strongly sloping or steep lands, are classified as low level footslopes. They merge into other types of level land, including low gradient footslopes that rise in an opposite direction. Pediments, (coalescing) alluvial fans and other similar landforms can all be considered low level footslopes. Footslopes with a higher gradient than 8% are accommodated under hills, as such slopes are usually incised to the extent that they take a hilly character.

LV Valley floors

Elongated strips of level land, on both sides flanked by areas with sloping or steep land, constitute valley floors. Valley floors normally taper off at one end, where they are embraced by steeper land on three sides. They may connect with other types of level land or sloping land at the other end. In mountainous areas valley floors can be surrounded on all sides by steep lands, and do not necessarily have to be elongated.

S Sloping land

Sloping land is land with a gradient of between 8 and 30%. In most cases the relief intensity of sloping land is more than 50 m per slope unit.

SM Medium-gradient mountains

Relatively gently sloping (15-30% gradient) mountains with a local relief intensity of more than 600 m. Many volcanoes will fall into this category, as do several foothill zones of major mountain systems.

SH Medium-gradient hills

All sloping land with an undulating relief (minimum relief intensity 50 m per slope unit), not elongated, or more than 600 m high, or incorporated in mountainous terrain, are considered hills. This group does not only include hilly landforms, but also accommodates other landforms such as medium-gradient footslopes, etc.

SE Medium-gradient escarpment zone

Relatively gently sloping (usually 15-30% gradient) zone that forms a transition between high and low lying country. The local relief intensity of this landform is normally less than 600 m/2 km.

SR Ridges

A ridge meets all the qualifications of medium-gradient hills, but has an elongated shape with a single crest, which may have a more or less constant elevation, or may contain a number of peaks. Relatively narrow plateaus are excluded from this landform group.

SU Mountainous highland

Land which, although forming part of a mountain range (slopes of more than 30% and relief intensities in excess of 600 m/2 km), constitute a restricted zone with less steep slopes and subdued relief. Mountainous highland always forms part of a mountain system, and is thus on at least at one side bounded by high-gradient mountains. Hypsometric subdivision of this category is according to the qualifiers for steep lands.

SP Dissected plains

Sloping land with a more or less constant crest level, and relief intensities of less than 50 m per slope unit.

T Steep land

All land with slopes in excess of 30% is considered steep land. The main landform in this category is mountainous land.

TM High-gradient mountains

All steep land with a relief intensity of more than 600 m/2 km, and surrounding one or more outstanding peaks.

TH High-gradient hills

Steep but low relief land (relief intensity of less than 600 m/2 km). Badlands would be a landform taken care of by this group, which is hypsometrically subdivided according to the qualifiers for sloping land.

TE High-gradient escarpment zone

Steep land that forms the transition between high and low lying country and lacks outstanding peaks. The relief intensity is normally more than 600 m/2 km.

TV High-gradient valleys

Very steep valleys, with normally very little valley floor. No height limit is given, as the lack of valley floor and the presence of steep slopes ensure that only deep valleys will cover sufficient area to produce mappable delineations, mostly incised elevated sedimentary plateaux.

C Lands with composite landforms

Landforms, containing both level and steep or sloping land, which cannot be separated at the scale of the mapping, are considered composite landforms. Composite landforms are using hypsometric qualifiers according to the characteristics of their level part.

CV Valleys

The valley, made up of sideslopes and a valley bottom, is taken as one landform.

CL Narrow plateaus

A narrow strip of level land surrounded on all sides by sloping or steep falling land form together a narrow plateau.

CD Major depressions

A large tract of level land, surrounded on all sides by high, rising sloping or steep land, is characterized as a major depression. Uvalas are typical for this group.

Annex 2

Hierarchy of land use

S **Settlement/industries**: Residential, industrial use.

- **SR** Residential use: Cities.
- **SI** Industrial use: Industries.
- **ST** Transport: Roads, railways etc.
- **SC** Recreation: In use for recreation.
- **SX** Excavations: Land used for excavations, quarries.

A **Agriculture**: Land used for cultivation of crops.

AA Annual field cropping: One or more crops harvested within one year. Land under temporary crops.

AA1 Shifting cultivation: Agricultural systems that involve an alternation between cropping for a few years on selected and cleared plots and a lengthy period when the soil is rested. The land is cultivated for less than 33% of the years.

AA2 Fallow system cultivation: Agricultural systems that involve an alternation of cropping periods and fallow periods. The land is cultivated between 33 and 67% of the growing seasons; bush or grass fallows are typical.

AA3 Ley system cultivation: Several years of arable cropping are followed by several years of grass and legumes utilized for livestock production.

AA4 Rainfed arable cultivation: Agricultural systems where the land is cultivated in more than 67% of the growing seasons.

AA5 Wet rice cultivation: Annual field cropping system for the production of wetland rice. Paddies with or without controlled water supply and drainage system. Plots are inundated during at least some part of the cropping period.

AA6 Irrigated cultivation: Annual field cropping system with an artificial supply of water, in addition to rain.

From Remmelzwaal, 1990

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

AP1 Non-irrigated cultivation
AP2 Irrigated cultivation

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

AT1 Non-irrigated tree crop cultivation
AT2 Irrigated tree crop cultivation
AT3 Non-irrigated shrub crop cultivation
AT4 Irrigated shrub crop cultivation

H **Animal husbandry**: Animal products.

HE Extensive grazing: Grazing on natural or semi-natural grassland or savanna vegetation.

HE1 Nomadism: Systems in which the animal owners do not have a permanent place of residence. No regular cultivation practices. People move with herds.

HE2 Semi-nomadism: Animal owners have a permanent place of residence where supplementary cultivation is practised. Herds are moved to distant grazing areas.

HE3 Ranching: Grazing within well defined boundaries, movements less distant and higher management level as compared to semi-nomadism.

HI Intensive grazing: Stationary animal husbandry. Grazing on permanent/semi-permanent improved grassland systems.

HI1 Animal production
HI2 Dairying

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

FN Exploitation of natural forest and woodland: Wood is extracted from natural forest and woodland for commercial purpose.

FN1 selective felling: Only selected species are removed from the natural vegetation.

FN2 clear felling: All natural vegetation is cleared after which the area is reforested. This land use system develops into a plantation forestry system.

FP Plantation forestry: Forested areas. Relatively high management level. Homogeneous tree stands.

M **Mixed farming**: Activities concerning cropping and forestry or animal husbandry are mixed.

MF Agro-forestry: Combination of agriculture and forestry (with reforestation).

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

E **Extraction/collecting**: Extraction of products from the environment.

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

EH Hunting and fishing: Extraction of animals or fish from ecosystem.

P **Nature protection**: No, or low intensity of use, but under management system; low level of interference with natural environment or ecosystem.

PN Nature and game preservation

PN1 Reserves
PN2 Parks
PN3 Wildlife management

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

PD1 Non-interference: All uses of the land are prohibited.

PD2 Interference: The land is managed. Works are implemented in order to stop degradation and limit the degradation risk.

U **Unused**: Not used and not managed.

Annex 3

Hierarchy of vegetation

I **Closed forest**: Formed by trees at least 5 m tall with their crowns interlocking.

IA Mainly evergreen forest: The canopy is never without green foliage. However, individual trees may shed their leaves for that period.

IA1 Tropical ombrophilous forest (tropical rain forest): Consisting mainly of broad-leaved evergreen trees, neither cold nor drought resistant. Truly evergreen, i.e. the forest canopy remains green all year though individual trees may be leafless for a few weeks.

IA2 Tropical and subtropical evergreen seasonal forest: Consisting mainly of broad-leaved evergreen trees. Foliage reduction during the dry season noticeable, often as partial shedding of leaves.

IA3 Tropical and subtropical semi-deciduous forest Most of the upper canopy trees deciduous or drought-resistant; many of the understorey trees and shrubs evergreen and more or less sclerophyllous[1].

IA4 Subtropical ombrophilous forest: Forest with a dry season and more pronounced temperature differences between summer and winter than tropical ombrophilous forest.

IA5 Mangrove forest: Composed almost entirely of evergreen sclerophyllous broad-leaved trees/shrubs with either stilt roots or pneumatophores.

IA6 Temperate and subpolar evergreen ombrophilous forest: Consisting mostly of truly evergreen hemi-sclerophyllous trees and shrubs. Rich in epiphytes and herbaceous ferns.

IA7 Temperate evergreen seasonal broad-leaved forest: Consisting mainly of hemi-sclerophyllous evergreen trees and shrubs, rich in herbaceous undergrowth.

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1 Sclerophyllous: thick, hard leaves

From Unesco, 1973

IA8 Winter-rain evergreen broad-leaved sclerophyllous forest (Mediterranean forest): Consisting mainly of sclerophyllous evergreen trees and shrubs, most of them showing rough bark. Herbaceous undergrowth almost lacking.

IA9 Tropical and subtropical evergreen needle-leaved forest: Consisting mainly of needle-leaved evergreen trees. Broad-leaved trees may be present.

IA10 Temperate and subpolar evergreen needle-leaved forest: Consisting mainly of needle-leaved or scale-leaved evergreen trees, but broad-leaved trees may be admixed.

IB **Mainly deciduous forest**: Majority of trees shed their foliage simultaneously in connection with the unfavourable season.

IB1 Tropical and subtropical drought-deciduous forest: Unfavourable season mainly characterized by drought, in most cases winter-drought. Foliage is shed regularly every year. Most trees with relatively thick, fissured bark.

IB2 Cold-deciduous forest with evergreen trees (or shrubs): Unfavourable season mainly characterized by winter frost. Deciduous broad-leaved trees dominant, but evergreen species present.

IB3 Cold-deciduous forest without evergreen trees: Deciduous trees absolutely dominant.

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

IC1 Sclerophyllous-dominated extremely xeromorphic forest: Predominance of sclerophyllous trees.

IC2 Thorn forest: Species with thorny appendices predominate.

IC3 Mainly succulent forest: Tree-formed and shrub-formed succulents

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

IIA Mainly evergreen woodland: The canopy is never without green foliage.

IIA1 Evergreen broad-leaved woodland: Mainly sclerophyllous trees and shrubs.

IIA2 Evergreen needle-leaved forest: Mainly needle-leaved or scale-leaved.

IIB Mainly deciduous woodland: Majority of trees shed their foliage simultaneously in connection with the unfavourable season.

IIB1 Drought deciduous woodland: Unfavourable season mainly characterized by winter-drought. Foliage is shed regularly every year. Most trees with relatively thick, fissured bark.

IIB2 Cold-deciduous woodland with evergreen trees: Unfavourable season mainly characterized by winter frost. Deciduous broad-leaved trees dominant, but evergreen species present.

IIB3 Cold-deciduous woodland without evergreen trees: Deciduous trees absolutely dominant.

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

IIC1 Sclerophyllous-dominated extremely xeromorphic woodland: Predominance of sclerophyllous trees.

IIC2 Thorn woodland: Species with thorny appendices predominate.

IIC3 Mainly succulent woodland: Tree-formed and shrub-formed succulents

III **Scrub** (shrubland or thicket): Mainly composed of woody plants 0.5 to 5 m tall. Subdivisions: Shrubland: most of the individual shrubs not touching each other; often grass undergrowth; Thicket: individual shrubs interlocked

IIIA Mainly evergreen scrub: The canopy is never without green foliage. However, individual shrubs may shed their leaves.

IIIA1 Evergreen broad-leaved shrubland (or thicket): Mainly sclerophyllous shrubs.

IIIA2 Evergreen needle-leaved and microphyllous shrubland (or thicket): Mainly needle-leaved or scale-leaved shrubs.

IIIB Mainly deciduous scrub: Majority of shrubs shed their foliage simultaneously in connection with the un-favourable season.

IIIB1 Drought-deciduous scrub with evergreen woody plants admixed
IIIB2 Drought-deciduous scrub without evergreen woody plants admixed
IIIB3 Cold-deciduous scrub

IIIC Extremely xeromorphic (subdesert) shrubland: Very open stands of shrubs with various xerophytic adaptations, such as extremely scleromorphic or strongly reduced leaves, green branches without leaves, or succulents stems, etc., some of them with thorns.

IIIC1 Mainly evergreen subdesert shrubland: In extremely dry years some leaves and shoot portions may be shed.

IIIC2 Deciduous subdesert shrubland: Mainly deciduous shrubs, often with a few evergreens

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

IVA Mainly evergreen dwarf-scrub: Most dwarf-scrubs evergreen.

IVA1 Evergreen dwarf-scrub thicket: Densely closed dwarf-scrub cover, dominating the landscape.

IVA2 Evergreen dwarf-shrubland: Open or more loose cover of dwarf-shrubs.

IVA3 Mixed evergreen dwarf-shrub and herbaceous formation.

IVB Mainly deciduous dwarf-scrub: Most dwarf-scrubs deciduous.

IVB1 Facultatively drought-deciduous dwarf-thicket (or dwarf-shrubland): Foliage is shed only in extreme years.

IVB2 Obligatory, drought-deciduous dwarf-thicket (or dwarf-shrubland): Densely closed dwarf-shrub stands which loose all or at least part of their leaves in the dry season.

IVB3 Cold-deciduous dwarf-thicket (or dwarf-shrubland): Densely closed dwarf-shrub stands which loose all or at least part of their leaves at the beginning of a cold season.

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

IVC1 Mainly evergreen subdesert dwarf-shrubland: In extremely dry years some leaves and shoot portions may be shed.

IVC2 Deciduous subdesert dwarf-shrubland: Mainly deciduous dwarf-shrubs, often with a few evergreens

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

IVD1 Mainly bryophyte tundra: Dominated by mats or small cushions of mosses (bryophytes).

IVD2 Mainly lichen tundra: Mats of lichen dominating.

IVE Mossy bog formations with dwarf-shrub: Oligotrophic peat accumulations formed by *Sphagnum* or other mosses.

IVE1 Raised bog: By growth of *Sphagnum* species raised above the general ground-water table.

IVE2 Non-raised bog: Not or not very markedly raised above the mineral-water table of the surrounding landscape.

V Herbaceous vegetation

VA Tall graminoid vegetation: Dominant graminoids over 2 m tall. Forb[1] coverage less than 50%.

VA1 Tall grassland with a tree synusia[2] covering 10-40%: More or less like a very open woodland.

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

VA3 Tall grassland with a synusia of shrubs

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

VA5 Tall grassland practically without woody synusia

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

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

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

VB3 Medium tall grassland with a synusia of shrubs

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

VB5 Medium tall grassland practically without woody synusia

VC Short grassland: The dominant graminoid growth forms are less than 50 cm tall. Forbs cover less than 50%.

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[1] Forb: non-graminoid/non-woody vegetation

[2] Synusia: layer

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

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

VC3 Short grassland with a synusia of shrubs

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

VC5 Short grassland practically without woody synusia

VC6 Short to medium tall mesophytic grassland

VC7 Graminoid tundra

VD Forb vegetation: Mainly forbs, graminoid cover less than 50%.

VD1 Tall forb communities: Dominant forb growth forms are more than 1 m tall.

VD2 Low forb communities: Dominant forb growth forms are less than 1 m tall.

VE Hydromorphic fresh-water vegetation

VE1 Rooted fresh-water communities

VE2 Free floating fresh-water communities

Annex 4

Country codes

FAO ESS CODE	STANDARD NAME (12)	ISO (3)	ISO (2)	UN CODE	UNDP (3)	ENGLISH NAME (24)
002	AFGHANISTAN	AFG	AF	004	AFG	AFGHANISTAN
003	ALBANIA	ALB	AL	008	ALB	ALBANIA
004	ALGERIA	DZA	DZ	012	ALG	ALGERIA
005	AMER SAMOA	ASM	AS	016	AMS	AMERICAN SAMOA
006	ANDORRA	AND	AD	020	AND	ANDORRA
007	ANGOLA	AGO	AO	024	ANG	ANGOLA
258	ANGUILLA	AIA	AI	660	ANL	ANGUILLA
030	ANTARCTICA	...	..	...	...	ANTARCTICA OTHERS
008	ANTIGUA BARB	ATG	AG	028	ANT	ANTIGUA AND BARBUDA
009	ARGENTINA	ARG	AR	032	ARG	ARGENTINA
001	ARMENIA	ARM	AM	051	...	ARMENIA
022	ARUBA	ABW	AW	533	ARU	ARUBA
010	AUSTRALIA	AUS	AU	036	AUL	AUSTRALIA
011	AUSTRIA	AUT	AT	040	AUS	AUSTRIA
052	AZERBAIJAN	AZE	AZ	031	...	AZERBAIJAN
012	BAHAMAS	BHS	BS	044	BHA	BAHAMAS
013	BAHRAIN	BHR	BH	048	BAH	BAHRAIN
016	BANGLADESH	BGD	BD	050	BGD	BANGLADESH
014	BARBADOS	BRB	BB	052	BAR	BARBADOS
057	BELARUS	BLR	BY	112	BYE	BELARUS
255	BELGIUM	BEL	BE	056	BEL	BELGIUM
023	BELIZE	BLZ	BZ	084	BZE	BELIZE
053	BENIN	BEN	BJ	204	BEN	BENIN
017	BERMUDA	BMU	BM	060	BER	BERMUDA
018	BHUTAN	BTN	BT	064	BHU	BHUTAN
019	BOLIVIA	BOL	BO	068	BOL	BOLIVIA
080	BOSNIA HERZG	BIH	BA	070	...	BOSNIA AND HERZEGOVINA
020	BOTSWANA	BWA	BW	072	BOT	BOTSWANA
021	BRAZIL	BRA	BR	076	BRA	BRAZIL
024	BR IND OC TR	IO	IO	086	...	BRITISH INDIAN OCEAN TER
239	BR VIRGIN IS	VGB	VG	092	BVI	BRITISH VIRGIN ISLANDS
026	BRUNEI DARSM	BRN	BN	096	BRU	BRUNEI DARUSSALAM
027	BULGARIA	BGR	BG	100	BUL	BULGARIA
233	BURKINA FASO	BFA	BF	854	BKF	BURKINA FASO
029	BURUNDI	BDI	BI	108	BDI	BURUNDI
115	CAMBODIA	KHM	KH	116	KAM	CAMBODIA
032	CAMEROON	CMR	CM	120	CMR	CAMEROON
033	CANADA	CAN	CA	124	CAN	CANADA
035	CAPE VERDE	CPV	CV	132	CVI	CAPE VERDE
036	CAYMAN IS	CYM	KY	136	CAY	CAYMAN ISLANDS
037	CENT AFR REP	CAF	CF	140	CAF	CENTRAL AFRICAN REPUBLIC

039	CHAD	TCD	TD	148	CHD	CHAD
040	CHILE	CHL	CL	152	CHI	CHILE
257	CHINA	...	..	...	...	CHINA
042	CHRISTMAS IS	CXR	CX	162	...	CHRISTMAS ISLAND (AUST.)
043	COCOS IS	CCK	CC	166	...	COCOS (KEELING) ISLANDS
044	COLOMBIA	COL	CO	170	COL	COLOMBIA
045	COMOROS	COM	KM	174	COI	COMOROS
046	CONGO	COG	CG	178	PRC	CONGO
047	COOK IS	COK	CK	184	CKI	COOK ISLANDS
048	COSTA RICA	CRI	CR	188	COS	COSTA RICA
107	COTE D'IVOIRE	CIV	CI	384	IVC	COTE D'IVOIRE
098	CROATIA	HRV	HR	191	...	CROATIA
049	CUBA	CUB	CU	192	CUB	CUBA
050	CYPRUS	CYP	CY	196	CYP	CYPRUS
167	CZECH REP	CZE	CZ	203	...	CZECH REPUBLIC
054	DENMARK	DNK	DK	208	DEN	DENMARK
072	DJIBOUTI	DJI	DJ	262	DJI	DJIBOUTI
055	DOMINICA	DMA	DM	212	DMI	DOMINICA
056	DOMINICAN RP	DOM	DO	214	DOM	DOMINICAN REPUBLIC
176	EAST TIMOR	TMP	TP	626	...	EAST TIMOR
058	ECUADOR	ECU	EC	218	...	ECUADOR
059	EGYPT	EGY	EG	818	EGY	EGYPT
060	EL SALVADOR	SLV	SV	222	ELS	EL SALVADOR
061	EQ GUINEA	GNQ	GQ	226	EQG	EQUATORIAL GUINEA
178	ERITREA	...	..	...	...	ERITREA
063	ESTONIA	EST	EE	233	...	ESTONIA
238	ETHIOPIA	ETH	ET	230	ETH	ETHIOPIA
064	FAEROE IS	FRO	FO	234	...	FAEROE ISLANDS
065	FALKLAND IS	FLK	FK	238	...	FALKLAND IS. (MALVINAS)
066	FIJI	FJI	FJ	242	FIJ	FIJI
067	FINLAND	FIN	FI	246	FIN	FINLAND
068	FRANCE	FRA	FR	250	FRA	FRANCE
069	FR GUIANA	GUF	GF	254	FGU	FRENCH GUIANA
070	FR POLYNESIA	PYF	PF	258	...	FRENCH POLYNESIA
071	FR SOUTH TR	...	..	...	FOS	FRENCH SOUTHERN TERR.
074	GABON	GAB	GA	266	GAB	GABON
075	GAMBIA	GMB	GM	270	GAM	GAMBIA
073	GEORGIA	GEO	GE	268	...	GEORGIA
079	GERMANY	DEU	DE	276	...	GERMANY
081	GHANA	GHA	GH	288	GHA	GHANA
082	GIBRALTAR	GIB	GI	292	...	GIBRALTAR
084	GREECE	GRC	GR	300	GRE	GREECE
085	GREENLAND	GRL	GL	304	...	GREENLAND
086	GRENADA	GRD	GD	308	GRN	GRENADA
087	GUADELOUPE	GLP	GP	312	GUD	GUADELOUPE
088	GUAM	GUM	GU	316	...	GUAM
089	GUATEMALA	GTM	GT	320	GUA	GUATEMALA
090	GUINEA	GIN	GN	324	GUI	GUINEA
175	GUINEABISSAU	GNB	GW	624	GBS	GUINEA-BISSAU
091	GUYANA	GUY	GY	328	GUY	GUYANA
093	HAITI	HTI	HT	332	HAI	HAITI
094	HOLY SEE	VAT	VA	336	HLS	HOLY SEE
095	HONDURAS	HND	HN	340	HON	HONDURAS
096	HONG KONG	HKG	HK	344	HOK	HONG KONG
097	HUNGARY	HUN	HU	348	HUN	HUNGARY
099	ICELAND	ISL	IS	352	ICE	ICELAND
100	INDIA	IND	IN	356	IND	INDIA
101	INDONESIA	IDN	ID	360	INS	INDONESIA
102	IRAN	IRN	IR	364	IRA	IRAN, ISLAMIC REP. OF

103	IRAQ	IRQ	IQ	368	IRQ	IRAQ
104	IRELAND	IRL	IE	372	IRE	IRELAND
105	ISRAEL	ISR	IL	376	ISR	ISRAEL
106	ITALY	ITA	IT	380	ITA	ITALY
109	JAMAICA	JAM	JM	388	JAM	JAMAICA
110	JAPAN	JPN	JP	392	JPN	JAPAN
111	JOHNSTON IS	JTN	JT	396	...	JOHNSTON ISLAND
112	JORDAN	JOR	JO	400	JOR	JORDAN
108	KAZAKHSTAN	KAZ	KZ	398	...	KAZAKHSTAN
114	KENYA	KEN	KE	404	KEN	KENYA
083	KIRIBATI	KIR	KI	296	KIR	KIRIBATI
116	KOREA D P RP	PRK	KP	408	DRK	KOREA, DEM. PEOPLE'S REP
117	KOREA REP	KOR	KR	410	ROK	KOREA, REPUBLIC OF
118	KUWAIT	KWT	KW	414	KUW	KUWAIT
113	KYRGYZSTAN	KGZ	KG	417	...	KYRGYZSTAN
120	LAOS	LAO	LA	418	LAO	LAOS
119	LATVIA	LVA	LV	428	...	LATVIA
121	LEBANON	LBN	LB	422	LEB	LEBANON
122	LESOTHO	LSO	LS	426	LES	LESOTHO
123	LIBERIA	LBR	LR	430	LIR	LIBERIA
124	LIBYA	LBY	LY	434	LIB	LIBYAN ARAB JAMAHIRIYA
125	LIECHTENSTEN	LIE	LI	438	LIE	LIECHTENSTEIN
126	LITHUANIA	LTU	LT	440	...	LITHUANIA
256	LUXEMBOURG	LUX	LU	442	LUX	LUXEMBOURG
128	MACAU	MAC	MO	446	...	MACAU
154	MACEDONIA	...	..	...	...	FORMER YUG REP MACEDONIA
129	MADAGASCAR	MDG	MG	450	MAG	MADAGASCAR
130	MALAWI	MWI	MW	454	MLW	MALAWI
131	MALAYSIA	MYS	MY	458	MAL	MALAYSIA
132	MALDIVES	MDV	MV	462	MDV	MALDIVES
133	MALI	MLI	ML	466	MLI	MALI
134	MALTA	MLT	MT	470	MAT	MALTA
127	MARSHALL IS	MHL	MH	584	...	MARSHALL ISLANDS
135	MARTINIQUE	MTQ	MQ	474	MAQ	MARTINIQUE
136	MAURITANIA	MRT	MR	478	MAU	MAURITANIA
137	MAURITIUS	MUS	MU	480	MAR	MAURITIUS
138	MEXICO	MEX	MX	484	MEX	MEXICO
145	MICRONESIA	FSM	FM	583	...	MICRONESIA,FED.STATES OF
139	MIDWAY IS	MID	MI	488	...	MIDWAY ISLANDS
146	MOLDOVA REP	MDA	MD	498	...	MOLDOVA, REP. OF
140	MONACO	MCO	MC	492	MNC	MONACO
141	MONGOLIA	MNG	MN	496	MON	MONGOLIA
142	MONTSERRAT	MSR	MS	500	MOT	MONTSERRAT
143	MOROCCO	MAR	MA	504	MOR	MOROCCO
144	MOZAMBIQUE	MOZ	MZ	508	MOZ	MOZAMBIQUE
028	MYANMAR	MMR	MM	104	MYA	MYANMAR
147	NAMIBIA	NAM	NA	516	NAM	NAMIBIA
148	NAURU	NRU	NR	520	NAU	NAURU
149	NEPAL	NPL	NP	524	NEP	NEPAL
150	NETHERLANDS	NLD	NL	528	NET	NETHERLANDS
151	NETH ANTILES	ANT	AN	530	NAN	NETHERLANDS ANTILLES
153	NEWCALEDONIA	NCL	NC	540	NCA	NEW CALEDONIA
156	NEW ZEALAND	NZL	NZ	554	NZE	NEW ZEALAND
157	NICARAGUA	NIC	NI	558	NIC	NICARAGUA
158	NIGER	NER	NE	562	NER	NIGER
159	NIGERIA	NGA	NG	566	NIR	NIGERIA
160	NIUE	NIU	NU	570	NIU	NIUE ISLAND
161	NORFOLK IS	NFK	NF	574	...	NORFOLK ISLAND
163	N MARIANA IS	MNP	MP	580	...	NORTHERN MARIANA IS.

162	NORWAY	NOR	NO	578	NOR	NORWAY
221	OMAN	OMN	OM	512	OMA	OMAN
165	PAKISTAN	PAK	PK	586	PAK	PAKISTAN
180	PALAU	PLW	PW	585	...	PALAU (PACIFIC ISLANDS)
166	PANAMA	PAN	PA	591	PAN	PANAMA
168	PAPUA N GUIN	PNG	PG	598	PNG	PAPUA NEW GUINEA
169	PARAGUAY	PRY	PY	600	PAR	PARAGUAY
170	PERU	PER	PE	604	PER	PERU
171	PHILIPPINES	PHL	PH	608	PHI	PHILIPPINES
172	PITCAIRN	PCN	PN	612	...	PITCAIRN
173	POLAND	POL	PL	616	POL	POLAND
174	PORTUGAL	PRT	PT	620	POR	PORTUGAL
177	PUERTO RICO	PRI	PR	630	PUE	PUERTO RICO
179	QATAR	QAT	QA	634	QAT	QATAR
182	REUNION	REU	RE	638	REU	REUNION
183	ROMANIA	ROM	RO	642	ROM	ROMANIA
185	RUSSIAN FED	RUS	RU	643	...	RUSSIAN FEDERATION
184	RWANDA	RWA	RW	646	RWA	RWANDA
187	ST HELENA	SHN	SH	654	STH	SAINT HELENA
188	ST KITTS NEV	KNA	KN	659	STK	SAINT KITTS AND NEVIS
189	ST LUCIA	LCA	LC	662	STL	SAINT LUCIA
190	ST PIER MQ	SPM	PM	666	...	SAINT PIERRE & MIQUELON
191	ST VINCENT G	VCT	VC	670	STV	SAINT VINCENT/GRENADINES
244	SAMOA	WSM	WS	882	SAM	SAMOA
192	SAN MARINO	SMR	SM	674	SNM	SAN MARINO
193	SAO TOME PRN	STP	ST	678	STP	SAO TOME AND PRINCIPE
194	SAUDI ARABIA	SAU	SA	682	SAU	SAUDI ARABIA
195	SENEGAL	SEN	SN	686	SEN	SENEGAL
196	SEYCHELLES	SYC	SC	690	SEY	SEYCHELLES
197	SIERRA LEONE	SLE	SL	694	SIL	SIERRA LEONE
200	SINGAPORE	SGP	SG	702	SIN	SINGAPORE
199	SLOVAKIA	SVK	SK	703	...	SLOVAKIA
198	SLOVENIA	SVN	SI	705	...	SLOVENIA
025	SOLOMON IS	SLB	SB	090	SOI	SOLOMON ISLANDS
201	SOMALIA	SOM	SO	706	SOM	SOMALIA
202	SOUTH AFRICA	ZAF	ZA	710	...	SOUTH AFRICA
203	SPAIN	ESP	ES	724	SPA	SPAIN
038	SRI LANKA	LKA	LK	144	SRL	SRI LANKA
206	SUDAN	SDN	SD	736	SUD	SUDAN
207	SURINAME	SUR	SR	740	SUR	SURINAME
260	SVALBARD IS	SJM	SJ	744	...	SVALBARD AND JAN MAYEN
209	SWAZILAND	SWZ	SZ	748	SWA	SWAZILAND
210	SWEDEN	SWE	SE	752	SWE	SWEDEN
211	SWITZERLAND	CHE	CH	756	SWI	SWITZERLAND
212	SYRIA	SYR	SY	760	SYR	SYRIAN ARAB REPUBLIC
208	TAJIKISTAN	TJK	TJ	762	...	TAJIKISTAN
215	TANZANIA	TZA	TZ	834	URT	TANZANIA, UNITED REP.
216	THAILAND	THA	TH	764	THA	THAILAND
217	TOGO	TGO	TG	768	TOG	TOGO
218	TOKELAU	TKL	TK	772	TOK	TOKELAU ISLANDS
219	TONGA	TON	TO	776	TON	TONGA
220	TRINIDAD TBG	TTO	TT	780	TRI	TRINIDAD AND TOBAGO
222	TUNISIA	TUN	TN	788	TUN	TUNISIA
223	TURKEY	TUR	TR	792	TUR	TURKEY
213	TURKMENISTAN	TKM	TM	795	...	TURKMENISTAN
224	TURKS CAICOS	TCA	TC	796	TCI	TURKS AND CAICOS ISLANDS
227	TUVALU	TUV	TV	798	TUV	TUVALU
226	UGANDA	UGA	UG	800	UGA	UGANDA
230	UKRAINE	UKR	UA	804	UKR	UKRAINE

225	UNTD ARAB EM	ARE	AE	784	UAE	UNITED ARAB EMIRATES
229	UK	GBR	GB	826	UK	UNITED KINGDOM
231	USA	USA	US	840	USA	UNITED STATES OF AMERICA
240	US VIRGIN IS	VIR	VI	850	UVI	US VIRGIN ISLANDS
234	URUGUAY	URY	UY	858	URU	URUGUAY
235	UZBEKISTAN	UZB	UZ	860	...	UZBEKISTAN
155	VANUATU	VUT	VU	548	VAN	VANUATU
236	VENEZUELA	VEN	VE	862	VEN	VENEZUELA
237	VIET NAM	VNM	VN	704	VIE	VIET NAM
242	WAKE IS	WAK	WK	872		WAKE ISLAND
243	WALLIS FUT I	WLF	WF	876	...	WALLIS AND FUTUNA IS.
205	WESTN SAHARA	ESH	EH	732	...	WESTERN SAHARA
249	YEMEN	YEM	YE	887	...	YEMEN
186	YUGOSLAVIA	YUG	YU	891	...	YUGOSLAVIA, FED. REP.
250	ZAIRE	ZAR	ZR	180	ZAI	ZAIRE
251	ZAMBIA	ZMB	ZM	894	ZAM	ZAMBIA
181	ZIMBABWE	ZWE	ZW	716	ZIM	ZIMBABWE

Use of the FAO/ESS numerical code is recommended rather than ISO 3-letter or 2-letter codes or UN number or UN 3-letter code, because these latter are less complete and the FAO/ESS number code is kept up-to-date, usually within one week of "real time changes". The present list has been updated to 19 November 1993. If new or additional numerical codes are needed (for example for a new country or area), or for any queries, please contact

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00100 Rome, Italy
Fax No: (6) 52253152 or 52255155

Please do not use the numerical codes 015, 031, 034, 041, 051, 062, 076, 077, 078, 092, 152, 164, 214, 228, 232, 245, 246, 247, 248, 252, 291, 292, 293, 294, 295, 296, 297. They are in use and reserved for other statistical purposes. The latest update added Eritrea and changed the FAO/ESS code to "new" Ethiopia. The ISO, UN and UNDP codes for Ethiopia still refer to "old" Ethiopia.

Annex 5

SOTER data entry forms

SOTER data entry

form 1

TERRAIN

1 SOTER unit_ID |_|_|_|_|

2 date of data collection |_|_|_|_|

3 map_ID |_|_|_|_|_|_|_|_|_|_|_|_|

4 minimum elevation |_|_|_|_|

5 maximum elevation |_|_|_|_|

6 slope gradient |_|_|

7 relief intensity |_|_|_|_|

8 major landform |_|_|

9 regional slope |_|_|

10 hypsometry |_|_|

11 dissection |_|

12 general lithology |_|_|_|

13 permanent water surface |_|_|

TERRAIN COMPONENT

14 SOTER unit_ID |_|_|_|_|

15 terrain component number |_| |_| |_| |_| |_|

16 proportion of SOTER unit |_|_|_| |_|_| |_|_| |_|_| |_|_|

17 terrain component data_ID |_|_|_|_|/|_| |_|_|_|_|/|_| |_|_|_|_|/|_| |_|_|_|_|/|_| |_|_|_|_|/|_|

TERRAIN COMPONENT DATA

18 terrain component data_ID

19 dominant slope

20 length of slope

21 form of slope

22 local surface form

23 average height

24 coverage

25 surface lithology

26 texture group non-consolidated parent material

27 depth to bedrock

28 surface drainage

29 depth to groundwater

30 frequency of flooding

31 duration of flooding

32 start of flooding

SOTER data entry

form 3

SOIL COMPONENT

33 SOTER unit_ID |_|_|_|_|

34 terrain component number |_|

35 soil component number |_|

36 proportion of SOTER unit |_|_|_|

37 profile_ID |_|_|_|_|_|_|_|_|_|_|_|_|

38 number of reference profiles |_|_|

39 position in terrain component |_|

40 surface rockiness |_|

41 surface stoniness |_|

42 types of erosion/deposition |_|

43 area affected |_|

44 degree of erosion |_|

45 sensitivity to capping |_|

46 rootable depth |_|

47 relation with other soil components

PROFILE

48 profile_ID |_|_|_|_|_|_|_|_|_|_|_|_|_|_|

49 profile database_ID |_|_|_|_|_|_|

50 latitude |_|I|_|_|_|·|_|_|

51 longitude |_|I|_|_|_|·|_|_|

52 elevation |_|_|_|_|_|

53 sampling date |_|_|/|_|_|

54 lab_ID |_|_|_|_|_|_|_|

55 drainage |_|

56 infiltration rate |_|

57 surface organic matter |_|

58 classification FAO |_|_|_|

59 classification version |_|_|_|_|_|

60 national classification |_|_|_|_|_|_|_|_|_|_|_|_|_|_|

61 Soil Taxonomy |_|_|_|_|_|_|_|_|_|_|_|_|_|_|

62 phase |_|_|

HORIZON representative profile (* = mandatory)

64 horizon number* |_| |_| |_| |_| |_|

65 diagnostic horizon* |_|_| |_|_| |_|_| |_|_| |_|_|

66 diagnostic property* |_|_| |_|_| |_|_| |_|_| |_|_|

67 horizon designation |_|_|_|_|_| |_|_|_|_|_| |_|_|_|_|_| |_|_|_|_|_| |_|_|_|_|_|

68 lower depth* |_|_|_| |_|_|_| |_|_|_| |_|_|_| |_|_|_|

69 distinctness transition |_| |_| |_| |_| |_|

70 moist colour* |_|_|_|_|_|_|_|_|_| |_|_|_|_|_|_|_|_|_| |_|_|_|_|_|_|_|_|_| |_|_|_|_|_|_|_|_|_| |_|_|_|_|_|_|_|_|_|

71 dry colour |_|_|_|_|_|_|_|_|_| |_|_|_|_|_|_|_|_|_| |_|_|_|_|_|_|_|_|_| |_|_|_|_|_|_|_|_|_| |_|_|_|_|_|_|_|_|_|

72 grade of structure |_| |_| |_| |_| |_|

73 size of structure elements |_| |_| |_| |_| |_|

74 type of structure* |_| |_| |_| |_| |_|

HORIZON representative profile (continued) (* = mandatory)

profile_ID |_|_|_|_|_|_|_|_|_|_|_|

<table>
<tr><td>horizon number*</td><td>|_|</td><td>|_|</td><td>|_|</td><td>|_|</td><td>|_|</td></tr>
<tr><td>75 abundance coarse fragments*</td><td>|_|</td><td>|_|</td><td>|_|</td><td>|_|</td><td>|_|</td></tr>
<tr><td>76 size of coarse fragments</td><td>|_|</td><td>|_|</td><td>|_|</td><td>|_|</td><td>|_|</td></tr>
<tr><td>77 very coarse sand</td><td>|_|_|_|</td><td>|_|_|_|</td><td>|_|_|_|</td><td>|_|_|_|</td><td>|_|_|_|</td></tr>
<tr><td>78 coarse sand</td><td>|_|_|_|</td><td>|_|_|_|</td><td>|_|_|_|</td><td>|_|_|_|</td><td>|_|_|_|</td></tr>
<tr><td>79 medium sand</td><td>|_|_|_|</td><td>|_|_|_|</td><td>|_|_|_|</td><td>|_|_|_|</td><td>|_|_|_|</td></tr>
<tr><td>80 fine sand</td><td>|_|_|_|</td><td>|_|_|_|</td><td>|_|_|_|</td><td>|_|_|_|</td><td>|_|_|_|</td></tr>
<tr><td>81 very fine sand</td><td>|_|_|_|</td><td>|_|_|_|</td><td>|_|_|_|</td><td>|_|_|_|</td><td>|_|_|_|</td></tr>
<tr><td>82 total sand*</td><td>|_|_|_|</td><td>|_|_|_|</td><td>|_|_|_|</td><td>|_|_|_|</td><td>|_|_|_|</td></tr>
<tr><td>83 silt*</td><td>|_|_|_|</td><td>|_|_|_|</td><td>|_|_|_|</td><td>|_|_|_|</td><td>|_|_|_|</td></tr>
<tr><td>84 clay*</td><td>|_|_|_|</td><td>|_|_|_|</td><td>|_|_|_|</td><td>|_|_|_|</td><td>|_|_|_|</td></tr>
<tr><td>85 particle size class</td><td>|_|_|_|_|</td><td>|_|_|_|_|</td><td>|_|_|_|_|</td><td>|_|_|_|_|</td><td>|_|_|_|_|</td></tr>
<tr><td>86 bulk density*</td><td>|_|_|.|_|_|</td><td>|_|_|.|_|_|</td><td>|_|_|.|_|_|</td><td>|_|_|.|_|_|</td><td>|_|_|.|_|_|</td></tr>
<tr><td>87 moisture content
at various tensions</td><td>-|_|_|3|3|/|_|_|
-|_|_|_|_|/|_|_|
-|_|_|_|_|/|_|_|
-|_|_|_|_|/|_|_|
-|1|5|0|0|/|_|_|</td><td>-|_|_|3|3|/|_|_|
-|_|_|_|_|/|_|_|
-|_|_|_|_|/|_|_|
-|_|_|_|_|/|_|_|
-|1|5|0|0|/|_|_|</td><td>-|_|_|3|3|/|_|_|
-|_|_|_|_|/|_|_|
-|_|_|_|_|/|_|_|
-|_|_|_|_|/|_|_|
-|1|5|0|0|/|_|_|</td><td>-|_|_|3|3|/|_|_|
-|_|_|_|_|/|_|_|
-|_|_|_|_|/|_|_|
-|_|_|_|_|/|_|_|
-|1|5|0|0|/|_|_|</td><td>-|_|_|3|3|/|_|_|
-|_|_|_|_|/|_|_|
-|_|_|_|_|/|_|_|
-|_|_|_|_|/|_|_|
-|1|5|0|0|/|_|_|</td></tr>
<tr><td>88 hydraulic conductivity</td><td>|_|_|_|.|_|</td><td>|_|_|_|.|_|</td><td>|_|_|_|.|_|</td><td>|_|_|_|.|_|</td><td>|_|_|_|.|_|</td></tr>
<tr><td>89 infiltration rate</td><td>|_|_|_|.|_|</td><td>|_|_|_|.|_|</td><td>|_|_|_|.|_|</td><td>|_|_|_|.|_|</td><td>|_|_|_|.|_|</td></tr>
<tr><td>90 pH H_2O*</td><td>|_|_|.|_|</td><td>|_|_|.|_|</td><td>|_|_|.|_|</td><td>|_|_|.|_|</td><td>|_|_|.|_|</td></tr>
<tr><td>91 pH KCl</td><td>|_|_|.|_|</td><td>|_|_|.|_|</td><td>|_|_|.|_|</td><td>|_|_|.|_|</td><td>|_|_|.|_|</td></tr>
</table>

Note: Estimated mandatory (numeric) attributes should be preceded by the character e.

HORIZON representative profile (continued) (* = mandatory) profile_ID □□□□□□□□□□□□□□

horizon number*	□	□	□	□	□
92 electrical conductivity	□□·□	□□·□	□□·□	□□·□	□□·□
93 exchangeable Ca^{++}	□□·□	□□·□	□□·□	□□·□	□□·□
94 exchangeable Mg^{++}	□□·□	□□·□	□□·□	□□·□	□□·□
95 exchangeable Na^{+}	□□·□	□□·□	□□·□	□□·□	□□·□
96 exchangeable K^{+}	□□·□	□□·□	□□·□	□□·□	□□·□
97 exchangeable Al^{+++}	□□·□	□□·□	□□·□	□□·□	□□·□
98 exchangeable acidity	□□·□	□□·□	□□·□	□□·□	□□·□
99 CEC soil*	□□□·□	□□□·□	□□□·□	□□□·□	□□□·□
100 total carbonate equivalent	□□·□	□□·□	□□·□	□□·□	□□·□
101 gypsum	□□·□	□□·□	□□·□	□□·□	□□·□
102 total carbon*	□□·□	□□·□	□□·□	□□·□	□□·□
103 total nitrogen	□□·□□	□□·□□	□□·□□	□□·□□	□□·□□
104 P_2O_5	□□□	□□□	□□□	□□□	□□□
105 phosphate retention	□□□	□□□	□□□	□□□	□□□
106 Fe dithionite	□□□	□□□	□□□	□□□	□□□
107 Al dithionite	□□□	□□□	□□□	□□□	□□□
108 Fe pyrophosphate	□□□	□□□	□□□	□□□	□□□
109 Al pyrophosphate	□□□	□□□	□□□	□□□	□□□
110 clay mineralogy	□□	□□	□□	□□	□□

Note: Estimated mandatory (numeric) attributes should be preceded by the character e.

SOTER data entry

form 7

HORIZON minimum values

profile_ID □□□□□□□□□□□□

64 horizon number	□	□	□	□	□
75 abundance coarse fragments	□	□	□	□	□
76 size of coarse fragments	□	□	□	□	□
77 very coarse sand	□□□	□□□	□□□	□□□	□□□
78 coarse sand	□□□	□□□	□□□	□□□	□□□
79 medium sand	□□□	□□□	□□□	□□□	□□□
80 fine sand	□□□	□□□	□□□	□□□	□□□
81 very fine sand	□□□	□□□	□□□	□□□	□□□
82 total sand	□□□	□□□	□□□	□□□	□□□
83 silt	□□□	□□□	□□□	□□□	□□□
84 clay	□□□	□□□	□□□	□□□	□□□
85 particle size class	□□□□	□□□□	□□□□	□□□□	□□□□
86 bulk density	□□.□□	□□.□□	□□.□□	□□.□□	□□.□□
87 moisture content at various tensions	-□□33/□□ -□□□□/□□ -□□□□/□□ -□□□□/□□ -1500/□□	-□□33/□□ -□□□□/□□ -□□□□/□□ -□□□□/□□ -1500/□□	-□□33/□□ -□□□□/□□ -□□□□/□□ -□□□□/□□ -1500/□□	-□□33/□□ -□□□□/□□ -□□□□/□□ -□□□□/□□ -1500/□□	-□□33/□□ -□□□□/□□ -□□□□/□□ -□□□□/□□ -1500/□□
88 hydraulic conductivity	□□□.□	□□□.□	□□□.□	□□□.□	□□□.□
89 infiltration rate	□□□.□	□□□.□	□□□.□	□□□.□	□□□.□
90 pH H_2O	□□.□	□□.□	□□.□	□□.□	□□.□
91 pH KCl	□□.□	□□.□	□□.□	□□.□	□□.□
92 electrical conductivity	□□.□	□□.□	□□.□	□□.□	□□.□

HORIZON minimum values (continued) profile_ID _ _ _ _ _ _ _ _ _ _ _ _

64 horizon number	_	_	_	_	_
93 exchangeable Ca^{++}	_ _ . _	_ _ . _	_ _ . _	_ _ . _	_ _ . _
94 exchangeable Mg^{++}	_ _ . _	_ _ . _	_ _ . _	_ _ . _	_ _ . _
95 exchangeable Na^{+}	_ _ . _	_ _ . _	_ _ . _	_ _ . _	_ _ . _
96 exchangeable K^{+}	_ _ . _	_ _ . _	_ _ . _	_ _ . _	_ _ . _
97 exchangeable Al^{+++}	_ _ . _	_ _ . _	_ _ . _	_ _ . _	_ _ . _
98 exchangeable acidity	_ _ . _	_ _ . _	_ _ . _	_ _ . _	_ _ . _
99 CEC soil*	_ _ _ . _	_ _ _ . _	_ _ _ . _	_ _ _ . _	_ _ _ . _
100 total carbonate equivalent	_ _ . _	_ _ . _	_ _ . _	_ _ . _	_ _ . _
101 gypsum	_ _ . _	_ _ . _	_ _ . _	_ _ . _	_ _ . _
102 total carbon*	_ _ . _	_ _ . _	_ _ . _	_ _ . _	_ _ . _
103 total nitrogen	_ _ . _ _	_ _ . _ _	_ _ . _ _	_ _ . _ _	_ _ . _ _
104 P_2O_5	_ _ _	_ _ _	_ _ _	_ _ _	_ _ _
105 phosphate retention	_ _ _	_ _ _	_ _ _	_ _ _	_ _ _
106 Fe dithionite	_ _ _	_ _ _	_ _ _	_ _ _	_ _ _
107 Al dithionite	_ _ _	_ _ _	_ _ _	_ _ _	_ _ _
108 Fe pyrophosphate	_ _ _	_ _ _	_ _ _	_ _ _	_ _ _
109 Al pyrophosphate	_ _ _	_ _ _	_ _ _	_ _ _	_ _ _

SOTER data entry

form 9

HORIZON maximum values

profile_ID |_|_|_|_|_|_|_|_|_|_|_|_|

64 horizon number	|_|	|_|	|_|	|_|	|_|
75 abundance coarse fragments	|_|	|_|	|_|	|_|	|_|
76 size of coarse fragments	|_|	|_|	|_|	|_|	|_|
77 very coarse sand	|_|_|_|	|_|_|_|	|_|_|_|	|_|_|_|	|_|_|_|
78 coarse sand	|_|_|_|	|_|_|_|	|_|_|_|	|_|_|_|	|_|_|_|
79 medium sand	|_|_|_|	|_|_|_|	|_|_|_|	|_|_|_|	|_|_|_|
80 fine sand	|_|_|_|	|_|_|_|	|_|_|_|	|_|_|_|	|_|_|_|
81 very fine sand	|_|_|_|	|_|_|_|	|_|_|_|	|_|_|_|	|_|_|_|
82 total sand	|_|_|_|	|_|_|_|	|_|_|_|	|_|_|_|	|_|_|_|
83 silt	|_|_|_|	|_|_|_|	|_|_|_|	|_|_|_|	|_|_|_|
84 clay	|_|_|_|	|_|_|_|	|_|_|_|	|_|_|_|	|_|_|_|
85 particle size class	|_|_|_|_|	|_|_|_|_|	|_|_|_|_|	|_|_|_|_|	|_|_|_|_|
86 bulk density	|_|_|·|_|_|	|_|_|·|_|_|	|_|_|·|_|_|	|_|_|·|_|_|	|_|_|·|_|_|
87 moisture content at various tensions	-|_|_|3|3|/|_|_| -|_|_|_|_|/|_|_| -|_|_|_|_|/|_|_| -|_|_|_|_|/|_|_| -|1|5|0|0|/|_|_|	-|_|_|3|3|/|_|_| -|_|_|_|_|/|_|_| -|_|_|_|_|/|_|_| -|_|_|_|_|/|_|_| -|1|5|0|0|/|_|_|	-|_|_|3|3|/|_|_| -|_|_|_|_|/|_|_| -|_|_|_|_|/|_|_| -|_|_|_|_|/|_|_| -|1|5|0|0|/|_|_|	-|_|_|3|3|/|_|_| -|_|_|_|_|/|_|_| -|_|_|_|_|/|_|_| -|_|_|_|_|/|_|_| -|1|5|0|0|/|_|_|	-|_|_|3|3|/|_|_| -|_|_|_|_|/|_|_| -|_|_|_|_|/|_|_| -|_|_|_|_|/|_|_| -|1|5|0|0|/|_|_|
88 hydraulic conductivity	|_|_|_|·|_|	|_|_|_|·|_|	|_|_|_|·|_|	|_|_|_|·|_|	|_|_|_|·|_|
89 infiltration rate	|_|_|_|·|_|	|_|_|_|·|_|	|_|_|_|·|_|	|_|_|_|·|_|	|_|_|_|·|_|
90 pH H_2O	|_|_|·|_|	|_|_|·|_|	|_|_|·|_|	|_|_|·|_|	|_|_|·|_|
91 pH KCl	|_|_|·|_|	|_|_|·|_|	|_|_|·|_|	|_|_|·|_|	|_|_|·|_|
92 electrical conductivity	|_|_|·|_|	|_|_|·|_|	|_|_|·|_|	|_|_|·|_|	|_|_|·|_|

HORIZON maximum values

profile_ID □□□□□□□□□□□□

horizon number	□	□	□	□	□
93 exchangeable Ca^{++}	□□.□	□□.□	□□.□	□□.□	□□.□
94 exchangeable Mg^{++}	□□.□	□□.□	□□.□	□□.□	□□.□
95 exchangeable Na^{+}	□□.□	□□.□	□□.□	□□.□	□□.□
96 exchangeable K^{+}	□□.□	□□.□	□□.□	□□.□	□□.□
97 exchangeable Al^{+++}	□□.□	□□.□	□□.□	□□.□	□□.□
98 exchangeable acidity	□□.□	□□.□	□□.□	□□.□	□□.□
99 CEC soil	□□□.□	□□□.□	□□□.□	□□□.□	□□□.□
100 total carbonate equivalent	□□.□	□□.□	□□.□	□□.□	□□.□
101 gypsum	□□.□	□□.□	□□.□	□□.□	□□.□
102 total carbon	□□.□	□□.□	□□.□	□□.□	□□.□
103 total nitrogen	□□.□□	□□.□□	□□.□□	□□.□□	□□.□□
104 P_2O_5	□□□	□□□	□□□	□□□	□□□
105 phosphate retention	□□□	□□□	□□□	□□□	□□□
106 Fe dithionite	□□□	□□□	□□□	□□□	□□□
107 Al dithionite	□□□	□□□	□□□	□□□	□□□
108 Fe pyrophosphate	□□□	□□□	□□□	□□□	□□□
109 Al pyrophosphate	□□□	□□□	□□□	□□□	□□□

SOTER data entry **form 11**

LAND USE		VEGETATION	
1 SOTER unit_ID	|_|_|_|_|	1 SOTER unit_iD	|_|_|_|_|
2 date of observation	|_|_|/|_|_|_|_|	2 date of observation	|_|_|/|_|_|_|_|
3 land use	|_|_|_|	3 vegetation	|_|_|_|_|_|
4 proportion of SOTER unit	|_|_|_|	4 proportion of SOTER unit	|_|_|_|

SOTER data entry

form 12

SOURCE MAP

1 map_ID	|_|_|_|_|_|_|_|_|_|_|_|_|
2 map title	
3 year	|_|_|_|_|
4 scale	1:|_|_|_|_|_|_|_|
5 minimum latitude	|_| |_|_|_|·|_|_|
6 minimum longitude	|_| |_|_|_|·|_|_|
7 maximum latitude	|_| |_|_|_|·|_|_|
8 maximum longitude	|_| |_|_|_|·|_|_|
9 type of map	|_|

SOTER data entry

form 13

LABORATORY

1 lab_ID |_|_|_|_|_|

2 laboratory name

LABORATORY METHODS

3 lab_ID |_|_|_|_|_|

4 date |_|_|/|_|_|_|_|

5 attribute |_|_|_|_|

6 method of analysis_ID |_|_|_|_|

ANALYLICAL METHOD

7 method of analysis_ID |_|_|_|_|

8 description

PROFILE DATABASE

1 soil profile database_ID |_|_|_|_|_|

2 name of institute

SOTER data entry — form 14

CLIMATE STATION

1 climate station_ID |_|_|_|_|_|_|

2 climate station name

3 latitude |_| |_|_|_|·|_|_|

4 longitude |_| |_|_|_|·|_|_|

5 altitude |_|_|_|_|

CLIMATE DATA

6 climate station_ID |_|_|_|_|_|

7 kind of data |_|_|_|_|

8 source_ID |_|_|_|_|_|_|

9 first year |_|_|_|_|

10 last year |_|_|_|_|

11 years |_|_|_|

12 January |_|_|_|_|_|·|_|_|

13 February |_|_|_|_|_|·|_|_|

14 March |_|_|_|_|_|·|_|_|

15 April |_|_|_|_|_|·|_|_|

16 May |_|_|_|_|_|·|_|_|

17 June |_|_|_|_|_|·|_|_|

18 July |_|_|_|_|_|·|_|_|

19 August |_|_|_|_|_|·|_|_|

20 September |_|_|_|_|_|·|_|_|

21 October |_|_|_|_|_|·|_|_|

22 November |_|_|_|_|_|·|_|_|

23 December |_|_|_|_|_|·|_|_|

24 annual |_|_|_|_|_|·|_|_|

DATA SOURCE

25 source_ID |_|_|_|_|_|_|

26 source name

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Glossary

attribute data	Non-graphic information on elements in a GIS. In this manual: associated with SOTER units.
database	A computerized recordkeeping system.
database structure	The way in which data are organized in a database.
backup	A copy of a file or of a whole disk in case the original is lost/ damaged.
DBMS	Database Management System; a system for management and manipulation a database.
geo-referenced data	Information that has a precise location (coordinates).
GIS	Geographic(al) Information System = a system of hardware, software and procedures designated to support the capture, management, manipulation, analysis, modelling and display of spatially referenced data.
input	The process of entering data.
mapping unit	A set of areas (polygons) on a map that represent a well-defined feature or set of features; mapping units are described by the map legend.
polygon	Delineated area on a map
primary key	Attribute or combination of attributes that uniquely identify a record in a table/file.
RDBMS	Relational Database Management System; a computerized recordkeeping system in which the data are structured in sets of records so that relationships between data can be used for the management and manipulation. The data files are perceived as tables.
SOTER unit	Special type of mapping unit; a set of areas (polygons) on a map that have a distinctive, often repetitive pattern of landform, surface form, parent material and soil.
topology	The way in which geographic elements are linked together (neighbouring elements, enclosed elements).

Related publications

ISSS. 1986. Project proposal "World Soils and Terrain Digital Database at a scale 1:1M (SOTER)". Ed. by M.F. Baumgardner. ISSS, Wageningen. 23 p.

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This publication describes the procedures for using the global and national soils and terrain digital databases (SOTER) to produce digitized map units and their attribute data. It explains how to delineate areas with a specific set of soil and terrain characteristics and how to construct an attribute database related to the mapping units. SOTER is a land resource database with specific information on landform, terrain and soil components that can be complemented by data on land-related characteristics such as land use, natural vegetation and climate. The main function of the SOTER approach is to store data at national and global scales in an easily accessible format for improved thematic mapping and monitoring of changes of soil and terrain resources useful to scientists, planners, decision-makers and policy-makers.

ISBN 92-5-103429-X ISSN 0532-0488

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M-51 T1149E/1/12.93/1500