Report 2009/02b

IPCC default soil classes derived from the Harmonized World Soil Data Base

(Ver. 1.1)

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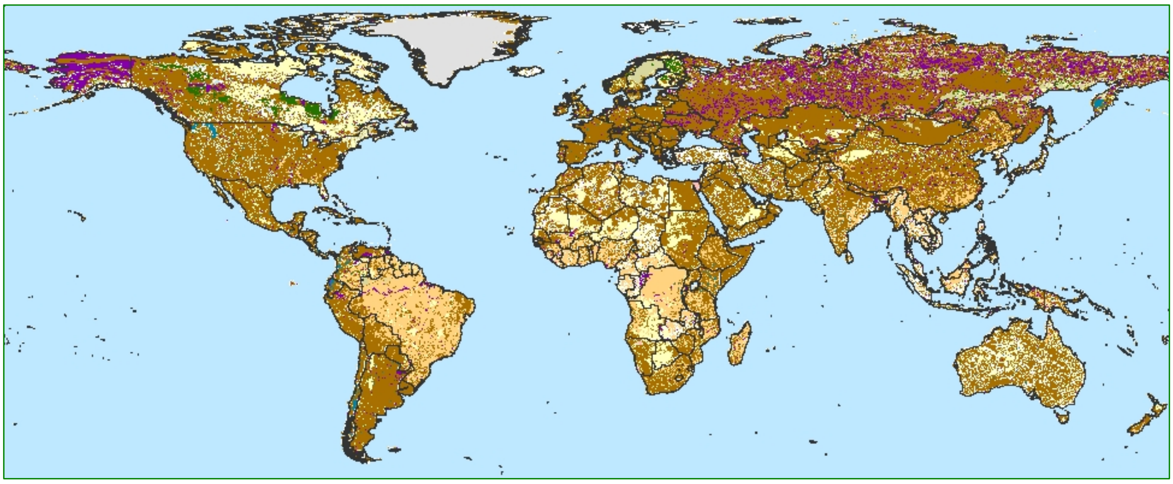
(November 2010)



ISRIC World Soil Information

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Context:
This study was made in the framework of the GEF co-funded Carbon Benefits Project: Measuring, Modelling and Monitoring. For details see the CBP Component A website.

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SUMMARY

This report describes the compilation of a global data set showing the spatial distribution of generalized soil classes as used for IPCC Tier-I level, national greenhouse gas inventory assessments. The database was derived from the Harmonized World Soil Data Base (HWSD, ver. 1.1) and a series of taxotransfer procedures to convert FAO soil classifications (1974, 1985, and 1990 Legend) to the seven default IPCC soil classes: high activity (HAC), low activity (LAC), Sandy (SAN), Spodic (POD), Volcanic (VOL), Wetland (WET), and Organic (ORG). The resulting GIS dataset may be used for assessments at national and broader scale (1:1-1:5 M), for regions that lack more detailed soil information. Inherent limitations of the database are discussed.

Keywords: IPCC soil classes, global dataset, soil carbon inventories

1 INTRODUCTION

The GEF co-funded Carbon Benefits Project (CBP), executed by the United Nations Environment Programme (UNEP-DEWA) and implemented by an international consortium, will provide scientifically rigorous and cost-effective tools to establish the carbon benefits of sustainable land management interventions in terms of protected or enhanced carbon stocks and reduced greenhouse-gas emissions. The CBP system will be applicable at various levels of scale, from the national level to the project-level. Upon its completion, it will be made available freely as a web-accessible system; for details see the CBP team A website[1].

Ultimately, the CBP-system will help project managers quantify carbon as a global environmental benefit in natural resource management projects and should enable developing countries to engage in the emerging carbon-offset markets with sustainable land management and land use activities. The system will be applicable across the full portfolio of land use projects implemented by the GEF and will thus provide a way to compare and document their performance in contributing to climate change mitigation.

Carbon inventory assessments involve estimation of stocks and net fluxes of carbon from different land use systems in a given area over a given period and under a given management system. Ultimately, the scale of a project will determine the methods and data to be used for the carbon inventory (Ravindranath and Ostwald 2008). Typically, default data sets for climate regions, land cover, and soil types will be used at national scale for data poor countries in combination with simple, empirical calculation approaches. More detailed data sets and dynamic modelling approaches will be required for inventories at sub-national up to project-level scale (IPCC 2006; Milne *et al.* 2007). This difference in methodological complexity has been expressed in terms of *tiers* in the approach of the International Panel on Global Change (IPCC 2006, 1996); a shift from lower tier (I) to a higher tier (III) is associated with an increased complexity in terms of data requirements (i.e. regional specificity of model parameters) and accuracy.

Stratification by broad climate regions, land use/cover, and soil types underlies Tier-I approaches at global and national scale (IPCC 2006). Conversely, countries and projects with detailed data on climatic conditions, soil types, and land use and management are encouraged to develop and use project specific data sets for applications at Tier-II and III level (IPCC 2006; Ravindranath and Ostwald 2008); such a capability will also be included in the new CBP system.

[1] http://carbonbenefitsproject-compa.colostate.edu/

With the release of the Harmonised World Soil Data Base (HWSD, see FAO/IIASA/ISRIC/ISSCAS/JRC 2009) it has become possible to compile a GIS data set showing the global distribution of default IPCC soil classes. This report describes how the database has been compiled and discusses the associated uncertainties.

2 DATA AND METHODS

2.1 Harmonized World Soil Database

The HWSD summarizes the latest regional soil information as compiled by the various partners — Food and Agriculture Organization of the United Nations (FAO), International Institute for Applied Systems Analysis (IIASA), ISRIC - World Soil Information, Institute of Soil Science - Chinese Academy of Sciences (ISSCAS), and the Joint Research Centre of the European Commission (JRC) — using the best (and sometimes only) available data.

The HWSD simplifies the global distribution of soils: it indicates the most common soil types in a region, but not exactly what the soil is at any one location within a given map unit. As such, it provides a synthesis of how soils relate to climate, vegetation and the geography of the continents. It can be used in conjunction with other broad-scale world maps that show, for example, major climate regions, vegetation zones, or the status of soil degradation.

Original data for HWSD (Fig. 1) were mapped at different scales: 1:5 million for the Soil Map of the World (DSWM, see FAO 1995), between 1:1 and 1:5 million for the various SOTER regional studies (e.g. FAO *et al.* 2007; FAO *et al.* 1998), 1:1 million for the European Soil Map (ESB 1999) and the Soil Map of China (Shi *et al.* 2004; Shi *et al.* 2005). As a result, the HWSD has a nominal scale of 1:1 million to 1:5 million depending on the area under consideration. At 1:5 million scale, for example, 1 cm on the map will correspond with 50 km in the field. Resolution at this scale is too coarse to reflect the full variety of soils, especially in countries with major differences in climate over short distances, major differences in altitude or parent materials (e.g. FAO 1993; Landon 1991). By its nature, the broad scale soil information shown on HWSD will not be appropriate for IPCC Tier-II and Tier-III level type assessments at sub-national or project-level scale. This need for different types of soil data for applications at various levels of detail has been discussed elsewhere (Landon 1991) and illustrated in the Australian Soil Resources Information System (http://www.asris.csiro.au/methods.html).

A raster size of 30 arc-seconds, corresponding with ~1x1 km at the equator, has been chosen for HWSD in the context of FAO/IIASA's Global Agro-Ecological Zones assessment (Fischer *et al.* 2008). This was done to ensure compatibility with important global inventories such as the slope and aspect database, based on 90 m resolution Shuttle Radar Topography Mission data (SRTM, see Farr *et al.* 2007), and Global Land Cover (GLC) data available at 30 arc seconds (Fritz *et al.* 2003). By implication, HWSD presents multiple grid cells with identical attributes occurring in individual soil mapping units as provided on the original vector maps at scale 1:1M to 1:5M.

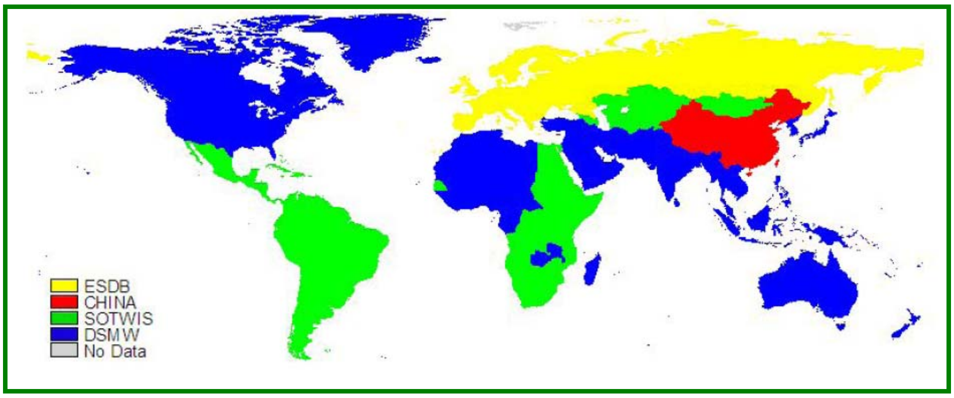

Fig. 1. Source material for the Harmonized World Soil Database
(ESDB: European Soil Database; China: Soil Map of China; SOTWIS: secondary databases derived from SOTER and WISE; DSMW: Digital Soil Map of the World) (Source: FAO/IIASA/ISRIC/ISSCAS/JRC 2009)

The reliability of the spatial and attribute information presented on the HWSD is variable: the parts of the database that still make use of the Soil Map of the World, such as North America, Australia, West Africa, and South Asia, are considered less reliable. Conversely, most of the areas covered by SOTER and WISE-derived databases are considered to have the highest reliability (Central and Southern Africa, Latin America and the Caribbean, Central and Eastern Europe). Further expansion and update of the HWSD is foreseen, notably with the soil resources databases held in the USA, Canada, Australia; for details see FAO/IIASA/ISRIC/ISSCAS/JRC (2009).

Figure 2 serves as an example of the level of detail shown on the HWSD; over 60 different soil units have been mapped for Africa (as complex map units). By comparison, the IPCC clustering scheme will generalize this information into seven broad classes.

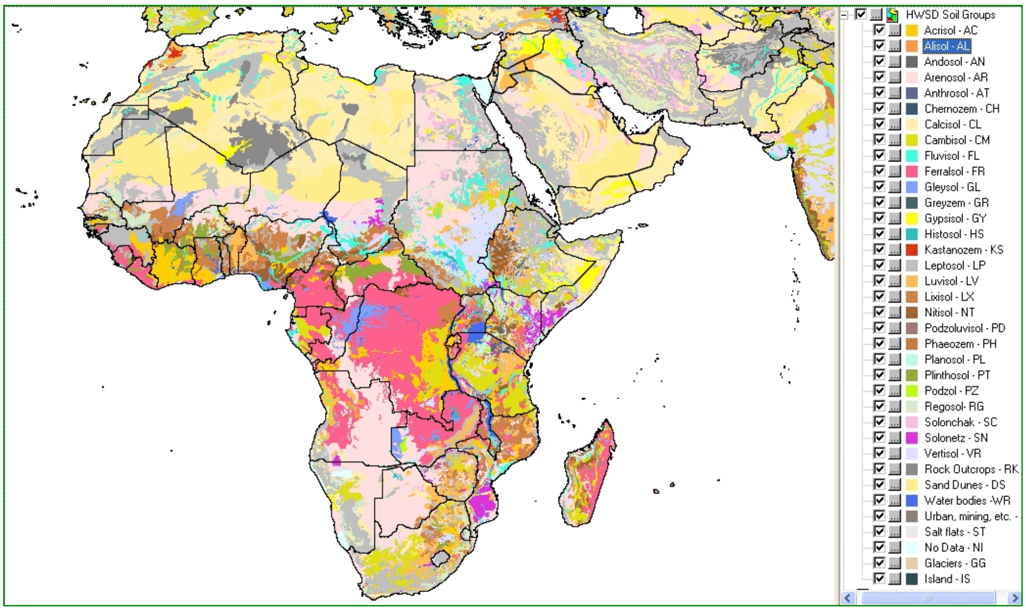

Fig. 2. Soil groups for Africa according to the Harmonised World Soil Database

2.2 IPCC procedure for grouping soils

For Tier-I type inventories, the IPCC has defined seven soil classes: high activity (HAC), low activity (LAC), sandy (SAN), spodic (POD), volcanic (VOL), wetland (WET), and organic (ORG). These classes are derived from soil classification, based on the World Reference Base for Soil Resources (WRB 2006) terminology, using a sequential approach based on necessarily coarse criteria (see IPCC 2006, p. 3.41). No attempt has been made here to refine the default IPCC scheme for clustering soils (Fig. 2) — specifying new criteria for clustering soil or climate types would require the derivation of new reference C stocks and stock change factors (IPCC 2006) which is beyond the scope of the CBP project.

First, WRB Histosols are allocated to the organic (ORG) class in the procedure. Next, six mineral soil classes are considered. The sandy class (SAN) keys out first. It has been defined in the IPCC Guidelines (2006) as ">70% sand and < 8% clay, irrespective of WRB classification (includes Arenosols)". Estimates for soil textural data, for 0-30 cm and 30-100 cm, for individual soil units were taken from HWSD. The SAN class will mainly include Arenosols, but also a number of coarse textured Podzols, Regosols and other soil units. Next, WRB Gleysols are allocated to the wetland class (WET). Thereafter, WRB Andosols key out to the volcanic (VOL) class. Subsequently, mineral soil units characterized by pronounced podzolisation, or Podzols in the WRB terminology, are allocated to the spodic (POD) class.

The remaining mineral soils are either allocated to the HAC or LAC class. In broad terms, the HAC class consists of slightly to moderately weathered soil types dominated by 2:1 clay type minerals. In the WRB terminology, the class includes Leptosols, Vertisols, Kastanozems, Chernozems, Phaeozems, Luvisols, Alisols, Albeluvisols, Solonetz, Calcisols, Gypsisols, Umbrisols, Cambisols, and Regosols; also Anthrosols and Solonchaks. Conversely, the LAC class is meant to represent highly weathered soil types dominated by 1:1 clay minerals and sesquioxides. In WRB, such soil units mainly correspond with Acrisols, Lixisols, Nitisols, Plinthosols, and Ferralsols that have a cation exchange capacity of less than 24 cmol kg^{-1} CEC_{clay}.

2.3 Taxotransfer rules

Map units on HWSD have been characterized according to three different soil classification schemes — the original Legend to the Soil Map of the World (FAO_1974, see FAO-Unesco 1974), an interim as version as used for the Soil Map of Europe (FAO_85, see ESB 1999), and the Revised Legend (FAO_90, see FAO 1988) — depending on the source of the original data (Figure 1).

The above FAO classifications, all predecessors to WRB, were transformed to IPCC default soil classes using simple taxotransfer rules (see Appendix 1 to 3). For some HWSD map units more than one classification is given, for example FAO_74 and FAO_90. In such instances, the most recent, and hence detailed, version was used for the conversion.

In some instances, the transformation had to be based on rather arbitrary rules (see also Bridges *et al.* 1998; FAO 1993) — this analysis should be seen as a first approximation. Acrisols in the FAO_74 Legend, for example, comprise Acrisols (LAC) and Alisols (HAC) units in the FAO_90 system. Ferric (Af) and plinthic (Ap) FAO_74 units, by definition have CEC_{clay} < 24 cmol kg^{-1} and thus were assigned to LAC. Conversely, a number of Acrisols (FAO_74) in the south-eastern USA and along the northwest coast of the USA are known to be dominated by Alisols (AL; FAO_90 system), which by definition are HAC soils (FAO 1993); these mainly correspond with Ag, Ao, and Ah units in the old FAO_74 system. The corresponding units have been identified using the querying facilities incorporated in the HWSD viewer, and assigned to HAC soils (see footnote 3, Appendix 1).

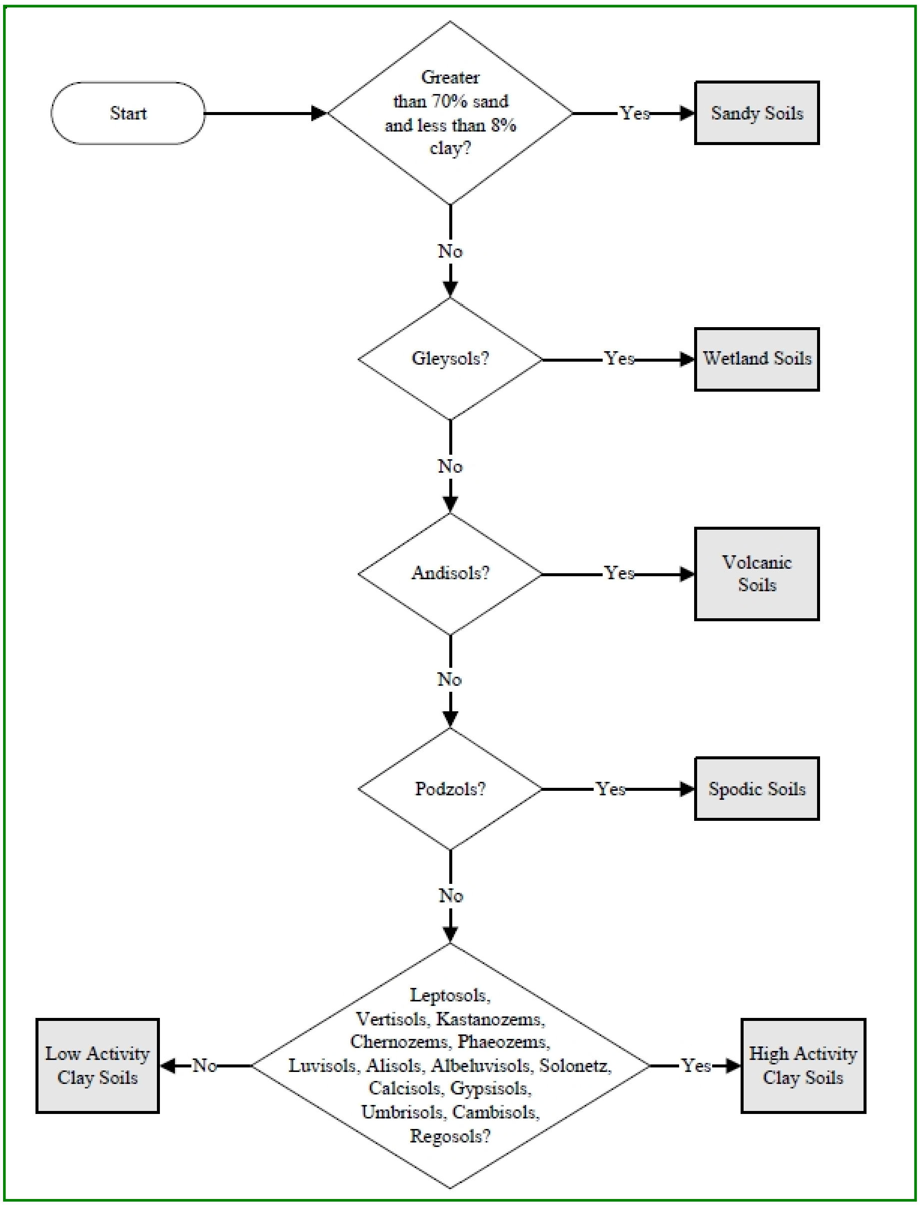

Fig. 3. IPCC Tier-I level scheme for grouping mineral soil types based on the WRB soil classification system (Source: IPCC 2006)

Ferric and plinthic members of Luvisols (FAO_74 and FAO_85) correspond with Lixisols (FAO_90 and WRB) and they were assigned to the LAC class and the remaining soil units to the HAC class.

Cambisols were considered to belong to the HAC class unless they have ferralic properties (Bf in FAO_74 and FAO_85).

Miscellaneous units defined as "Sand/dunes" (DS) were allocated to the SAN class. Areas mapped as Salt Flats (ST), Rock Outcrops (RK), Water Bodies (WR) or Land Ice (GG) were preserved as such. Alternatively, areas mapped as Urban (UR), Human-disturbed (HD), Fish Pond (FP) or Island (IS) were allocated to the No Data (ND) class.

3 RESULTS

3.1 Tabular data

Computerized procedures were written for the conversion; results are presented in an MSAccess® table (Table 1) that has been linked to the HWSD GIS-raster set using ArcGis9.3.1®. The data set is provided in compressed format (~93 Mb; decompressed ~ 4.1 Gb).

HWSD map unit 27127, based on soil information derived from SOTWIS for Tanzania (TZ), may be used as an example here (Table 2). It is comprised of five different soil units classified according to the FAO_90 Legend. The main soil unit (SEQ= 1), which accounts for 40% (SHARE) of the map unit is classified as GLd, a Dystric Gleysol. According to Appendix 3, this soil unit has been assigned to the WET class in the IPCC system.

Table 1. Structure of output file *CBP_IPCCsolclas*

CBP_IPCCsolclas : Table

Field Name	Data Type	Description
MU_GLOBAL	Number	Map unit ID on HWSD v1.1 (see: http://www.iiasa.ac.at/Research/LUC/luc07/External-World-soil-database/HTML/)
MU_SOURCE1	Text	Mapping Unit Code (in Source Database)
D_Coverage	Text	Source of data (see report)
SEQ1_IPCCsoilclass	Text	IPCC soil class for main (SEQ=1) soil unit in map unit
SEQ1_PERC	Number	Share (% of whole map unit)
DOM_IPCCsoilclass	Text	Dominant IPCC soil class in map unit (based on analysis of all component soil units, i.e. from SEQ=1 up to SEQ=10)
DOM_SHARE	Number	Share (% of whole map unit) for above
DOM_Number	Number	Number of FAO soil units in map unit allocated to DOM_IPCCsoilclass
HAC	Number	Share of High Activity Clay Soils (% of whole map unit)
LAC	Number	As above, for Low Activity Clay Soils
SAN	Number	As above, for Sandy Soils
POD	Number	As above, for Podzolic (Spodic) Soils
VOL	Number	As above, for Volcanic Soils
WET	Number	As above, for Wetland Soils
ORG	Number	As above, for Organic Soils
WR	Number	As above, for Water Bodies
GG	Number	As above, for Land Ice
RK	Number	As above, for Rock Outrcops
ST	Number	As abover, for SALT Flats
ND	Number	As abover, for No Data
NumComp	Number	Total number of soil units in map unit
TotalShare	Number	Total area represented (control field, should always be 100%)

Table 2. Example of output for map unit TZ114

Query_TZ144 : Select Query

MU_GLOBAL	MU_SOURCE1	Expr1002	SHARE	SU_SYM90	IPCC_Soil_final
27127	TZ114	1	40	GLd	WET
27127	TZ114	2	20	FLe	HAC
27127	TZ114	3	15	FLe	HAC
27127	TZ114	4	10	CMv	HAC
27127	TZ114	5	15	HSf	ORG

Record: 1 of 5

Alternatively (Table 3), if the whole map unit composition (i.e., SEQ=1 to 10) is considered rather than the main (SEQ=1) soil unit only, the dominant IPCC soil class is HAC (45% share); it is comprised of three different FAO soil units (SEQ=2, 3 and 4). The remainder of map unit TZ114 consists of the WET (40%) and ORG (15) class.

Table 3. Aggregated IPCC soil classes for different map units

CBP_IPCCsolclas : Table

MU_GLOBAL	MU_SOUF	D_Coverag	SEQ1_IPC	SEQ1_PER	DOM_IPC(	DOM_SHARI	DOM_Numb	HAC	LAC	SAN	POD	VOL	WET	ORG
27123	TZ110	SOTWIS	HAC	30	LAC	70	4	30	70	0	0	0	0	0
27124	TZ111	SOTWIS	LAC	25	LAC	65	3	35	65	0	0	0	0	0
27125	TZ112	SOTWIS	LAC	35	LAC	85	4	0	85	0	0	0	0	15
27126	TZ113	SOTWIS	LAC	25	LAC	70	4	0	70	0	0	0	15	15
27127	TZ114	SOTWIS	WET	40	HAC	45	3	45	0	0	0	0	40	15
27128	TZ115	SOTWIS	ORG	55	ORG	55	1	15	0	0	0	0	30	55
27129	TZ116	SOTWIS	HAC	55	HAC	100	3	100	0	0	0	0	0	0
27130	TZ117	SOTWIS	HAC	50	HAC	100	3	100	0	0	0	0	0	0
27131	TZ118	SOTWIS	VOL	45	HAC	55	3	55	0	0	0	45	0	0
27132	TZ119	SOTWIS	HAC	70	HAC	100	3	100	0	0	0	0	0	0

Record: 16 of 170 (Filtered)

3.2 GIS layers

Results presented in table *CBP_IPCCsolclas* can be linked to the spatial units of HWSD by joining the map unit code (*MU_GLOBAL*) with the *VALUE* field in the raster data set. The IPCC soil class for the *so-called* main FAO soil unit (SEQ=1) in a given mapping unit is shown in Figure 4, for Africa as an example. For comparison, Figure 5 shows the distribution when the spatially most extensive or dominant IPCC soil class is considered instead. In some instances, for example when a map unit consists of say 50% HAC soils and 50% SAN soils, the allocation of a dominant soil class to a map unit will be arbitrary.

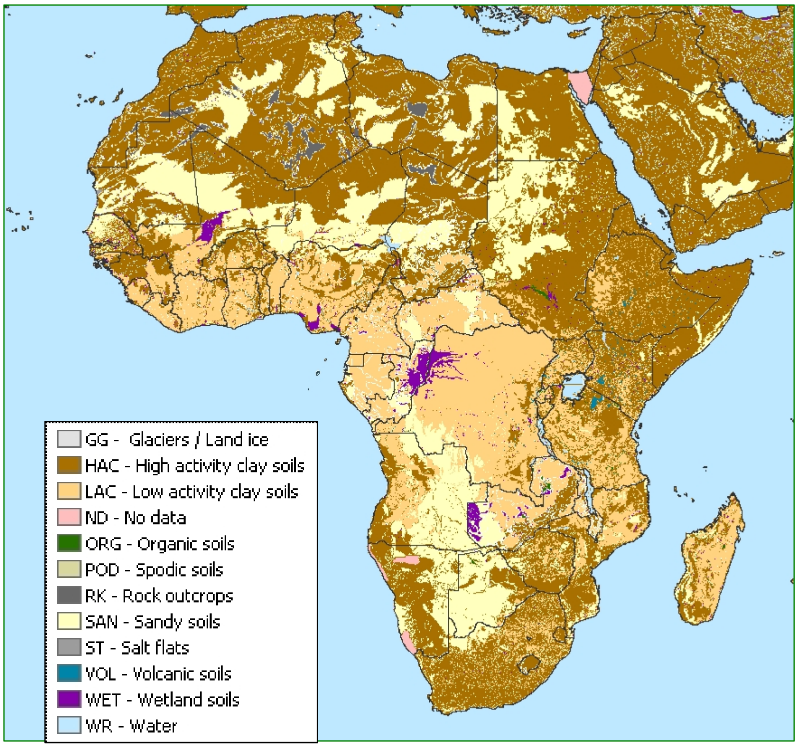

Fig. 4. Distribution of main IPCC soil classes for Africa (SEQ=1)

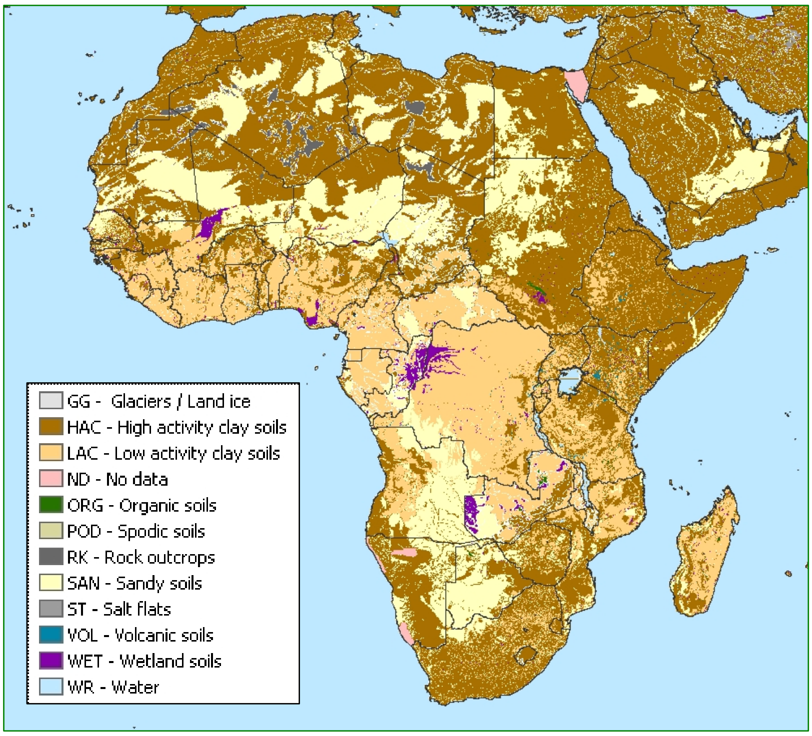

Fig. 5. Distribution of spatially dominant IPCC soil class for Africa

3.3 Uncertainties

In view of the above, the full map unit composition should be considered when making IPCC Tier I type inventory analyses rather than only the main (SEQ-1) soil class. Nonetheless, as discussed earlier, uncertainties associated with the scale of the source data and data clustering procedure will be large. For example, for Africa, HWSD considers over 20 different major soil groups (Figure 2) —representing over 60 different FAO soil units— while only seven IPCC classes can be mapped for the continent. Seen this generalization, the variation in reference soil carbon stocks will be large within each IPCC soil class, probably even larger than that reported for individual FAO soil units (Batjes 2002, 2006).

4. CONCLUSIONS

Spatial and attribute data of the HWSD were used to create a broad scale map showing main IPCC soil classes for the world. Inherently, this type of generalisation will involve a marked loss of detail.

The present database may be used for IPCC Tier-I level inventory assessments in data poor regions, at national scale (1:1 M to 1:5 M). Representative SOC stock values under natural vegetation for the various default IPCC climate zones and soil classes may be derived from IPCC (2006, p. 2.31), pending the availability of revised estimates for these combined climate/soil classes.

More precise greenhouse gas inventories at sub-national to project-level, based on methodologically more complex IPCC Tier II and III level approaches, will require more detailed information on land use and management, climate and soil conditions. Within the CBP project, such data sets will be compiled by the test case partners.

ACKNOWLEDGEMENTS

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APPENDICES

Appendix 1. Conversion of FAO_74 soil unit names to default IPCC soil classes

VALUE	SYMBOL[2]	IPCCsoilclass[3]
Acrisols[4]	A	LAC/HAC
Ferric Acrisols	Af	LAC
Gleyic Acrisols	Ag	LAC/HAC
Humic Acrisols	Ah	LAC/HAC
Orthic Acrisols	Ao	LAC/HAC
Plinthic Acrisols	Ap	LAC
Cambisols	B	HAC
Chromic Cambisols	Bc	HAC
Dystric Cambisols	Bd	HAC
Eutric Cambisols	Be	HAC
Ferralic Cambisols	Bf	LAC
Gleyic Cambisols	Bg	HAC
Humic Cambisols	Bh	HAC
Calcic Cambisols	Bk	HAC
Vertic Cambisols	Bv	HAC
Gelic Cambisols	Bx	HAC
Chernozems	C	HAC
Glossic Chernozems	Cg	HAC
Haplic Chernozems	Ch	HAC
Calcic Chernozems	Ck	HAC
Luvic Chernozems	Cl	HAC
Podzoluvisols	D	HAC
Dystric Podzoluvisol	Dd	HAC
Eutric Podzoluvisols	De	HAC
Gleyic Podzoluvisols	Dg	HAC
Dunes/Sand	DS	SAN
Rendzinas	E	HAC
Ferralsols	F	LAC
Acric Ferralsols	Fa	LAC
Humic Ferralsols	Fh	LAC

[2] FAO_74 soil unit code, see FAO-Unesco (1974)
[3] For mineral soils, see also Figure 2 concerning allocation to the SANDY class if sand% > 70 and clay% <8 irrespective of FAO/WRB soil unit (includes Arenosols).
[4] Some Acrisols in the FAO_74 system (i.e. Ao, Ah and Ag units) may correspond with Alisols (AL, HAC soils) and Acrisols (AC, LAC soils) in WRB and FAO_90. AC-FAO_74 units have been assigned to HAC soils when: (MU_GLOBAL >= 4580 And MU_GLOBAL <= 4680) AND (SU_SYM74 = "Ao" OR SU_SYM74="Ag" OR SU_SYM74= "Ah"), these units correspond with Alisols (AL) in the southeastern USA and on the northwest coast of the USA (see FAO 1993).

VALUE	SYMBOL[2]	IPCCsoilclass[3]
Orthic Ferralsols	Fo	LAC
Plinthic Ferralsols	Fp	LAC
Rhodic Ferralsols	Fr	LAC
Xanthic Ferralsols	Fx	LAC
Gleysols	G	WET
Calcaric Gleysols	Gc	WET
Dystric Gleysols	Gd	WET
Eutric Gleysols	Ge	WET
Glaciers	GG	GG
Humic Gleysols	Gh	WET
Mollic Gleysols	Gm	WET
Plinthic Gleysols	Gp	WET
Gelic Gleysols	Gx	WET
Phaeozems	H	HAC
Calcaric Phaeozems	Hc	HAC
Gleyic Phaeozems	Hg	HAC
Haplic Phaeozems	Hh	HAC
Luvic Phaeozems	Hl	HAC
Lithosols	I	HAC
Fluvisols	J	HAC
Calcaric Fluvisols	Jc	HAC
Dystric Fluvisols	Jd	HAC
Eutric Fluvisols	Je	HAC
Thionic Fluvisols	Jt	HAC
Kastanozems	K	HAC
Haplic Kastanozems	Kh	HAC
Calcic Kastanozems	Kk	HAC
Luvic Kastanozems	Kl	HAC
Luvisols	L	HAC
Albic Luvisols	La	HAC
Chromic Luvisols	Lc	HAC
Ferric Luvisols	Lf	LAC
Gleyic Luvisols	Lg	HAC
Calcic Luvisols	Lk	HAC
Orthic Luvisols	Lo	HAC
Plinthic Luvisols	Lp	LAC
Vertic Luvisols	Lv	HAC
Greyzems	M	HAC
Gleyic Greyzems	Mg	HAC
Orthic Greyzems	Mo	HAC
Nitosols	N	LAC
Dystric Nitosols	Nd	LAC
Eutric Nitosols	Ne	LAC
Humic Nitosols	Nh	LAC

VALUE	SYMBOL[2]	IPCCsoilclass[3]
No Information	NI	ND
Histosols	O	ORG
Dystric Histosols	Od	ORG
Eutric Histosols	Oe	ORG
Gelic Histosols	Ox	ORG
Podzols	P	POD
Ferric Podzols	Pf	POD
Gleyic Podzols	Pg	POD
Humic Podzols	Ph	POD
Leptic Podzols	Pl	POD
Orthic Podzols	Po	POD
Placic Podzols	Pp	POD
Arenosols	Q	SAN
Albic Arenosols	Qa	SAN
Cambic Arenosols	Qc	SAN
Ferralic Arenosols	Qf	SAN
Luvic Arenosols	Ql	SAN
Regosols	R	HAC
Calcaric Regosols	Rc	HAC
Dystric Regosols	Rd	HAC
Eutric Regosols	Re	HAC
Rock Outcrops	RK	RK
Gelic Regosols	Rx	HAC
Solonetz	S	HAC
Gleyic Solonetz	Sg	HAC
Mollic Solonetz	Sm	HAC
Orthic Solonetz	So	HAC
Salt flats	ST	ST
Andosols	T	VOL
Humic Andosols	Th	VOL
Mollic Andosols	Tm	VOL
Ochric Andosols	To	VOL
Vitric Andosols	Tv	VOL
Rankers	U	HAC
Vertisols	V	HAC
Chromic Vertisols	Vc	HAC
Pellic Vertisols	Vp	HAC
Planosols	W	HAC
Dystric Planosols	Wd	HAC
Eutric Planosols	We	HAC
Humic Planosols	Wh	HAC
Mollic Planosols	Wm	HAC
Water bodies	WR	WR
Sodic Planosols	Ws	HAC

VALUE	SYMBOL[2]	IPCCsoilclass[3]
Gelic Planosols	Wx	HAC
Xerosols	X	HAC
Haplic Xerosols	Xh	HAC
Calcic Xerosols	Xk	HAC
Luvic Xerosols	Xl	HAC
Gypsic Xerosols	Xy	HAC
Yermosols	Y	HAC
Haplic Yermosols	Yh	HAC
Calcic Yermosols	Yk	HAC
Luvic Yermosols	Yl	HAC
Takyric Yermosols	Yt	HAC
Gypsic Yermosols	Yy	HAC
Solonchaks	Z	HAC
Gleyic Solonchaks	Zg	HAC
Mollic Solonchaks	Zm	HAC
Orthic Solonchaks	Zo	HAC
Takyric Solonchaks	Zt	HAC

Appendix 2. Conversion of FAO_85 soil unit names to default IPCC soil classes

VALUE	SYMBOL[1]	VAL85_trim	IPCCsoilclass[2]
Acrisol[3]	A	A	LAC/HAC
Ferric Acrisol	Af	Af	LAC
Gleyic Acrisol	Ag	Ag	LAC/HAC
Humic Acrisol	Ah	Ah	LAC/HAC
Orthic Acrisol	Ao	Ao	LAC/HAC
Plinthic Acrisol	Ap	Ap	LAC
Cambisol	B	B	HAC
Calcaric Cambisol	Ba	Ba	HAC
Chromic Cambisol	Bc	Bc	HAC
Calcaro-chromic Cambisol	Bcc	Bc	HAC
Humo-chromic Cambisol	Bch	Bc	HAC
Calci-chromic Cambisol	Bck	Bc	HAC
Rhodo-chromic Cambisol	Bcr	Bc	HAC
Dystric Cambisols	Bd	Bd	HAC
Ando-dystric Cambisol	Bda	Bd	HAC
Gleyo-eutric Cambisol	Bdg	Bd	HAC
Spodo-dystric Cambisol	Bds	Bd	HAC
Eutric Cambisol	Be	Be	HAC
Ando-eutric Cambisol	Bea	Be	HAC
Calcaro-eutric Cambisol	Bec	Be	HAC
Fluvi-eutric Cambisol	Bef	Be	HAC
Gleyo-eutric Cambisol	Beg	Be	HAC
Verti-eutric Cambisol	Bev	Be	HAC
Ferralic Cambisol	Bf	Bf	LAC
Gleyic Cambisol	Bg	Bg	HAC
Calcaro-gleyic Cambisol	Bgc	Bg	HAC
Eutri-gleyic Cambisol	Bge	Bg	HAC
Stagno-gleyic Cambisol	Bgg	Bg	HAC
Spodo-gleyic Cambisol	Bgs	Bg	HAC
Verti-gleyic Cambisol	Bgv	Bg	HAC
Humic Cambisol	Bh	Bh	HAC
Calcic Cambisol	Bk	Bk	HAC
Fluvi-calcic Cambisol	Bkf	Bk	HAC
Humo-calcic Cambisol	Bkh	Bk	HAC
Calci-vertic Cambisol	Bkv	Bk	HAC
Mollic Cambisol	Bm	Bm	HAC
Vertic Cambisol	Bv	Bv	HAC

[1] FAO_85, soil unit codes for the European soil data base (ESB 1999)
[2] For mineral soils, see also Figure 2 concerning allocation to the SANDY class if sand% > 70 and clay% <8 irrespective of FAO/WRB soil unit (includes Arenosols).
[3] See footnote 3, App. 1, for the conversion to Acrisols resp. Alisols (FAO_90).

VALUE	SYMBOL[1]	VAL85_trim	IPCCsoilclass[2]
Calcaro-vertic Cambisol	Bvc	Bv	HAC
Calci-vertic Cambisol	Bvk	Bv	HAC
Gelic Cambisol	Bx	Bx	HAC
Chernozem	C	C	HAC
Stagno-gleyic Chernozem	Cgs	Cg	HAC
Haplic Chernozem	Ch	Ch	HAC
Verti-haplic Chernozem	Chv	Ch	HAC
Calcic Chernozem	Ck	Ck	HAC
Vermi-calcic Chernozem	Ckb	Ck	HAC
Calcaro-calcic Chernozem	Ckc	Ck	HAC
Vermi-calcaro-calcic Chernozem	Ckcb	Ck	HAC
Luvic Chernozem	Cl	Cl	HAC
Podzolluvisol	D	D	HAC
Dystric Podzoluvisol	Dd	Dd	HAC
Eutric Podzoluvisol	De	De	HAC
Gleyic Podzoluvisol	Dg	Dg	HAC
Dystri-gleyic Podzoluvisol	Dgd	Dg	HAC
Eutri-gleyic Podzoluvisol	Dge	Dg	HAC
Stagno-gleyic Podzoluvisol	Dgs	Dg	HAC
Rendzina	E	E	HAC
Cambic Rendzina	Ec	Ec	HAC
Histic Rendzina	Eh	Eh	HAC
Orthic Rendzina	Eo	Eo	HAC
Umbric Rendzina	Eu	Eu	HAC
Gleysol	G	G	WET
Calcaric Gleysol	Gc	Gc	WET
Fluvi-calcaric Gleysol	Gcf	Gc	WET
Stagno-calcaric Gleysol	Gcs	Gc	WET
Dystric Gleysol	Gd	Gd	WET
Stagno-dystric Gleysol	Gds	Gd	WET
Eutric Gleysol	Ge	Ge	WET
Fluvi-eutric Gleysol	Gef	Ge	WET
Humi-eutric Gleysol	Geh	Ge	WET
Stagno-eutric Gleysol	Ges	Ge	WET
Verti-eutric Gleysol	Gev	Ge	WET
Fluvic Gleysol	Gf	Gf	HAC
Molli-fluvic Gleysol	Gfm	Gf	HAC
Glaciers	GG	GG	GG
Humic Gleysol	Gh	Gh	WET
Fluvi-humic Gleysol	Ghf	Gh	WET
Histo-humic Gleysol	Ghh	Gh	WET
Histo-humo-calcaric Gleysol	Ghhc	Gh	WET
Thioni-humic Gleysol	Ght	Gh	WET
Histic Gleysol	Gi	Gi	WET

VALUE	SYMBOL[1]	VAL85_trim	IPCCsoilclass[2]
Humo-histic Gleysol	Gih	Gi	WET
Luvic Gleysol	Gl	Gl	WET
Stagno-luvic Gleysol	Gls	Gl	WET
Mollic Gleysols	Gm	Gm	WET
Calcaro-mollic Gleysol	Gmc	Gm	WET
Fluvi-mollic Gleysol	Gmf	Gm	WET
Stagno-mollic Gleysol	Gms	Gm	WET
Stagnic Gleysol	Gs	Gs	WET
Thionic Gleysols	Gtz	Gt	WET
Gelic Gleysol	Gx	Gx	WET
Phaeozem	H	H	HAC
Calcaric Phaeozem	Hc	Hc	HAC
Vermi-calcaric Phaeozem	Hcb	Hc	HAC
Fluvi-calcaric Phaeozem	Hcf	Hc	HAC
Gleyo-calcaric Phaeozem	Hcg	Hc	HAC
Alkalino-Calcaric Phaeozem	Hcn	Hc	HAC
Human disturbed soil	HD	ND	HD
Gleyic Phaeozems	Hg	Hg	HAC
Calcaro-gleyic Phaeozem	Hgc	Hg	HAC
Stagno-gleyic Phaeozem	Hgs	Hg	HAC
Verti-gleyic Phaeozem	Hgv	Hg	HAC
Haplic Phaeozem	Hh	Hh	HAC
Verti-haplic Phaeozem	Hhv	Hh	HAC
Luvic Phaeozems	Hl	Hl	HAC
Verti-luvic Phaeozem	Hlv	Hl	HAC
Haplic Phaeozem	Ho	Ho	HAC
Lithosol	I	I	HAC
Calcaric Lithosol	Ic	Ic	HAC
Humo-calcaric Lithosol	Ich	Ic	HAC
Dystric Lithosol	Id	Id	HAC
Eutric Lithosol	Ie	Ie	HAC
Fluvisol	J	J	HAC
Calcaric Fluvisol	Jc	Jc	HAC
Fluvi-calcaric Fluvisol	Jcf	Jc	HAC
Gleyo-calcaric Fluvisol	Jcg	Jc	HAC
Dystric Fluvisol	Jd	Jd	HAC
Gleyo-dystric Fluvisol	Jdg	Jd	HAC
Eutric Fluvisols	Je	Je	HAC
Fluvi-eutric Fluvisol	Jef	Je	HAC
Gleyo-eutric Fluvisol	Jeg	Je	HAC
Mollic Fluvisols	Jm	Jm	HAC
Gleyo-mollic Fluvisol	Jmg	Jm	HAC
Verti-mollic Fluvisol	Jmv	Jm	HAC
Thionic Fluvisol	Jt	Jt	HAC

VALUE	SYMBOL[1]	VAL85_trim	IPCCsoilclass[2]
Haplic Kastanozem	Kh	Kh	HAC
Calcic Kastanozem	Kk	Kk	HAC
Vermi-calcic Kastanozem	Kkb	Kk	HAC
Verti-calcic Kastanozem	Kkv	Kk	HAC
Luvic Kastanozems	Kl	Kl	HAC
Orthic Kastanozems	Ko	Ko	HAC
Luvisol	L	L	HAC
Albic Luvsol	La	La	HAC
Chromic Luvisol	Lc	Lc	HAC
Plano-chromic Luvisol	Lcp	Lc	HAC
Rhodo-chromic Luvisol	Lcr	Lc	HAC
Chromo-vertic Luvisol	Lcv	Lc	HAC
Dystric Luvisol	Ld	Ld	HAC
Gleyo-dystric Luvisol	Ldg	Ld	HAC
Ferric Luvisol	Lf	Lf	LAC
Gleyic Luvisol	Lg	Lg	HAC
Albo-gleyic Luvisol	Lga	Lg	HAC
Plano-gleyic Luvisol	Lgp	Lg	HAC
Stagno-gleyic Luvisol	Lgs	Lg	HAC
Humic Luvisol	Lh	Lh	HAC
Calcic Luvisol	Lk	Lk	HAC
Chromo-calcic Luvisol	Lkc	Lk	HAC
Rhodo-chromo-calcic Luvisol	Lkcr	Lk	HAC
Verti-calcic Luvisol	Lkv	Lk	HAC
Orthic Luvisol	Lo	Lo	HAC
Plano-orthic Luvisol	Lop	Lo	HAC
Plinthic Luvisol	Lp	Lp	LAC
Vertic Luvisols	Lv	Lv	HAC
Chromo-vertic Luvisol	Lvc	Lv	HAC
Calci-vertic Luvisol	Lvk	Lv	HAC
Marsh	MA	MA	WR
Orthic Greyzem	Mo	Mo	HAC
No Data	NI	NI	ND
not surveyed	NS	NS	ND
Histosol	O	O	ORG
Dystric Histosol	Od	Od	ORG
Placi-dystric Histosol	Odp	Od	ORG
Eutric Histosol	Oe	Oe	ORG
Gelic Histosol	Ox	Ox	ORG
Podzol	P	P	POD
Ferric Podzol	Pf	Pf	POD
Gleyic Podzol	Pg	Pg	POD
Histo-gleyic Podzol	Pgh	Pg	POD
Stagno-gleyic Podzol	Pgs	Pg	POD

VALUE	SYMBOL[1]	VAL85_trim	IPCCsoilclass[2]
Humic Podzol	Ph	Ph	POD
Ferro-humic Podzol	Phf	Ph	POD
Leptic Podzol	Pl	Pl	POD
Humo-leptic Podzol	Plh	Pl	POD
Orthic Podzols	Po	Po	POD
Ferro-orthic Podzol	Pof	Po	POD
Humo-orthic Podzol	Poh	Po	POD
Placic Podzol	Pp	Pp	POD
Plaggensol	PS	PS	HAC
Arenosol	Q	Q	SAN
Albic Arenosol	Qa	Qa	SAN
Cambic Arenosol	Qc	Qc	SAN
Calcaro-cambicx Arenosol	Qcc	Qc	SAN
Dystri-cambic Arenosol	Qcd	Qc	SAN
Gleyo-cambic Arenosol	Qcg	Qc	SAN
Spodo-cambic Arenosol	Qcs	Qc	SAN
Haplic Arenosol	Qh	Qh	SAN
Luvic Arenosols	Ql	Ql	SAN
Dystri-luvic Arenosol	Qld	Ql	SAN
Gleyo-luvic Arenosol	Qlg	Ql	SAN
Regosol	R	R	HAC
Calcaric Regosol	Rc	Rc	HAC
Dystric Regosol	Rd	Rd	HAC
Stagno-dystric Regosol	Rds	Rd	HAC
Eutric Regosol	Re	Re	HAC
Rock outcrops	RK	RK	RK
Gelic Regosol	Rx	Rx	HAC
Gleyic Solonetz	Sg	Sg	HAC
Mollic Solonetz	Sm	Sm	HAC
Orthic Solonetz	So	So	HAC
Fluvi-orthic Solonetz	Sof	So	HAC
Humic Andosol	Th	Th	VOL
Mollic Andosol	Tm	Tm	VOL
Haplic Andosol	To	To	VOL
Vitric Andosol	Tv	Tv	VOL
Ranker	U	U	HAC
Dystric Ranker	Ud	Ud	HAC
Calcaric Ranker	Uk	Uk	HAC
Urban, mining, etc.	UR	ND	UR
Vertisol	V	V	HAC
Chromic Vertisol	Vc	Vc	HAC
Calcaro-chromic Vertisol	Vcc	Vc	HAC
Gleyic Vertisol	Vg	Vg	HAC
Pellic Vertisol	Vp	Vp	HAC

VALUE	SYMBOL[1]	VAL85_trim	IPCCsoilclass[2]
Calcaro-pellic Vertisol	Vpc	Vp	HAC
Gleyo-pellic Vertisol	Vpg	Vp	HAC
Sodi-pellic Vertisol	Vpn	Vp	HAC
Planosol	W	W	HAC
Dystric Planosol	Wd	Wd	HAC
Verti-dystric Planosol	Wdv	Wd	HAC
Eutric Planosols	We	We	HAC
Verti-eutric Planosol	Wev	We	HAC
Humic Planosol	Wh	Wh	HAC
Mollic Planosol	Wm	Wm	HAC
Water bodies	WR	WR	WR
Solodic Planosol	Ws	Ws	HAC
Calcic Xerosol	Xk	Xk	HAC
Luvic Xerosol	Xl	Xl	HAC
Gypsic Xerosol	Xy	Xy	HAC
Solonchak	Z	Z	HAC
Gleyic Solonchak	Zg	Zg	HAC
Fluvi-gleyic Slonchak	Zgf	Zg	HAC
Orthic Solonchak	Zo	Zo	HAC
Thionic Solonchak	Zt	Zt	HAC

Appendix 3. Conversion of FAO_90 soil unit names to default IPCC soil classes

VALUE	SYMBOL[1]	IPCCsoilclass[2]
ACRISOLS	AC	LAC
Ferric Acrisols	Acf	LAC
Gleyic Acrisols	Acg	LAC
Haplic Acrisols	ACh	LAC
Plinthic Acrisols	ACp	LAC
Humic Acrisols	ACu	LAC
ALISOLS	AL	HAC
Ferric Alisols	ALf	HAC
Gleyic Alisols	ALg	HAC
Haplic Alisols	ALh	HAC
Stagnic Alisols	ALj	HAC
Plinthic Alisols	ALp	HAC
Humic Alisols	ALu	HAC
ANDOSOLS	AN	VOL
Gleyic Andosols	ANg	VOL
Haplic Andosols	ANh	VOL
Gelic Andosols	ANi	VOL
Mollic Andosols	ANm	VOL
Umbric Andosols	ANu	VOL
Vitric Andosols	ANz	VOL
ARENOSOLS	AR	SAN
Albic Arenosols	ARa	SAN
Cambic Arenosols	ARb	SAN
Calcaric Arenosols	ARc	SAN
Gleyic Arenosols	ARg	SAN
Haplic Arenosols	ARh	SAN
Luvic Arenosols	ARl	SAN
Ferralic Arenosols	ARo	SAN
ANTHROSOLS	AT	HAC
Aric Anthrosols	ATa	HAC
Cumulic Anthrosols	ATc	HAC
Fimic Anthrosols	ATf	HAC
Urbic Anthrosols	ATu	HAC
CHERNOZEMS	CH	HAC
Gleyic Chernozems	CHg	HAC
Haplic Chernozems	CHh	HAC
Calcic Chernozems	CHk	HAC
Luvic Chernozems	CHl	HAC

[1] FAO_90 soil unit code, Revised Legend (FAO 1988).
[2] For mineral soils, see also Figure 2 concerning the allocation to the SANDY class if sand% > 70 and clay% <8 irrespective of FAO/WRB soil unit (includes Arenosols).

VALUE	SYMBOL[1]	IPCCsoilclass[2]
Glossic Chernozems	CHw	HAC
CALCISOLS	CL	HAC
Haplic Calcisols	CLh	HAC
Luvic Calcisols	CLl	HAC
Petric Calcisols	CLp	HAC
CAMBISOLS	CM	HAC
Calcaric Cambisols	CMc	HAC
Dystric Cambisols	CMd	HAC
Eutric Cambisols	CMe	HAC
Gleyic Cambisols	CMg	HAC
Gelic Cambisols	CMi	HAC
Ferralic Cambisols	CMo	LAC
Humic Cambisols	CMu	HAC
Vertic Cambisols	CMv	HAC
Chromic Cambisols	CMx	HAC
Dunes & shift.sands	DS	SAN
FLUVISOLS	FL	HAC
Calcaric Fluvisols	FLc	HAC
Dystric Fluvisols	FLd	HAC
Eutric Fluvisols	FLe	HAC
Mollic Fluvisols	FLm	HAC
Salic Fluviosls	FLs	HAC
Thionic Fluvisols	FLt	HAC
Umbric Fluvisols	FLu	HAC
Fishpond	FP	WR
FERRALSOLS	FR	LAC
Geric Ferralsols	FRg	LAC
Haplic Ferralsols	FRh	LAC
Plinthic Ferralsols	FRp	LAC
Rhodic Ferralsols	FRr	LAC
Humic Ferralsols	FRu	LAC
Xanthic Ferralsols	FRx	LAC
Glaciers	GG	GG
GLEYSOLS	GL	WET
Andic Gleysols	GLa	WET
Dystric Gleysols	GLd	WET
Eutric Gleysols	GLe	WET
Gelic Gleysols	GLi	WET
Calcic Gleysols	GLk	WET
Mollic Gleysols	GLm	WET
Thionic Gleysols	GLt	WET
Umbric Gleysols	GLu	WET
GREYZEMS	GR	HAC
Gleyic Greyzems	GRg	HAC

VALUE	SYMBOL[1]	IPCCsoilclass[2]
Haplic Greyzems	GRh	HAC
GYPSISOLS	GY	HAC
Haplic Gypsisols	GYh	HAC
Calcic Gypsisols	GYk	HAC
Luvic Gypsisols	GYl	HAC
Petric Gypsisols	GYp	HAC
Humanly disturbed	HD	ND
HISTOSOLS	HS	ORG
Fibric Histosols	HSf	ORG
Gelic Histosols	HSi	ORG
Folic Histosols	HSl	ORG
Terric Histosols	HSs	ORG
Thionic Histosols	HSt	ORG
Island	IS	ND
KASTANOZEMS	KS	HAC
Haplic Kastanozems	KSh	HAC
Calcic Kastanozems	KSk	HAC
Luvic Kastanozems	KSl	HAC
Gypsic Kastanozems	KSy	HAC
LEPTOSOLS	LP	HAC
Dystric Leptosols	LPd	HAC
Eutric Leptosols	LPe	HAC
Gelic Leptosols	LPi	HAC
Rendzic Leptosols	LPk	HAC
Mollic Leptosols	LPm	HAC
Lithic Leptosols	LPq	HAC
Umbric Leptosols	LPu	HAC
LUVISOLS	LV	HAC
Albic Luvsiols	LVa	HAC
Ferric Luvisols	LVf	HAC
Gleyic Luvisols	LVg	HAC
Haplic Luvisols	LVh	HAC
Stagnic Luvisols	LVj	HAC
Calcic Luvisols	LVk	HAC
Vertic Luvisols	LVv	HAC
Chromic Luvisols	LVx	HAC
LIXISOLS	LX	LAC
Albic Lixisols	LXa	LAC
Ferric Lixisols	LXf	LAC
Gleyic Lixisols	LXg	LAC
Haplic Lixisols	LXh	LAC
Stagnic Lixisols	LXj	LAC
Plinthic Lixisols	LXp	LAC
Marsh	MA	WR

VALUE	SYMBOL[1]	IPCCsoilclass[2]
No Data	ND	ND
No Information	NI	ND
NITISOLS	NT	LAC
Haplic Nitisols	NTh	LAC
Rhodic Nitisols	NTr	LAC
Humic Nitisols	NTu	LAC
PODZOLUVISOLS	PD	HAC
Dystric Podzoluvisols	PDd	HAC
Eutric Podzoluvisols	PDe	HAC
Gleyic Podzoluvisols	PDg	HAC
Gelic Podzoluvisols	PDi	HAC
Stagnic Podzoluvisols	PDj	HAC
PHAEOZEMS	PH	HAC
Calcaric Phaeozems	PHc	HAC
Gleyic Phaeozems	PHg	HAC
Haplic Phaeozems	PHh	HAC
Stagnic Phaeozems	PHj	HAC
Luvic Phaeozems	PHl	HAC
PLANOSOLS	PL	HAC
Dystric Planosols	PLd	HAC
Eutric Planosols	PLe	HAC
Gelic Planosols	PLi	HAC
Mollic Planosols	PLm	HAC
Umbric Planosols	PLu	HAC
PLINTHOSOLS	PT	LAC
Albic Plinthosols	PTa	LAC
Dystric Plinthosols	PTd	LAC
Eutric Plinthosols	PTe	LAC
Humic Plinthosols	PTu	LAC
PODZOLS	PZ	POD
Cambic Podzols	PZb	POD
Carbic Podzols	PZc	POD
Ferric Podzols	PZf	POD
Gleyic Podzols	PZg	POD
Haplic Podzols	PZh	POD
Gelic Podzols	PZi	POD
REGOSOLS	RG	HAC
Calcaric Regosols	RGc	HAC
Dystric Regosols	RGd	HAC
Eutric Regosols	RGe	HAC
Gelic Regosols	RGi	HAC
Umbric Regosols	RGu	HAC
Gypsic Regosols	RGy	HAC
Rock outcrops	RK	RK

VALUE	SYMBOL[1]	IPCCsoilclass[2]
SOLONCHAKS	SC	HAC
Gleyic Solonchaks	SCg	HAC
Haplic Solonchaks	SCh	HAC
Gelic Solonchaks	SCi	HAC
Calcic Solonchaks	SCk	HAC
Mollic Solonchaks	SCm	HAC
Sodic Solonchaks	SCn	HAC
Gypsic Solonchaks	SCy	HAC
SOLONETZ	SN	HAC
Gleyic Solonetz	SNg	HAC
Haplic Solonetz	SNh	HAC
Stagnic Solonetz	SNj	HAC
Calcic Solonetz	SNk	HAC
Mollic Solonetz	SNm	HAC
Gypsic Solonetz	SNy	HAC
Salt flats	ST	ST
Urban, mining, etc.	UR	ND
VERTISOLS	VR	HAC
Dystric Vertisols	VRd	HAC
Eutric Vertisols	VRe	HAC
Calcic Vertisols	VRk	HAC
Gypsic Vertisols	VRy	HAC
Water bodies	WR	WR
Inland water, salt	WRs	WR