Comparison of International, National and Farmers' Classification Systems, Applied to Soils of the Western Dagomba District (Northern Ghana)

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Abstract

Selected soils developed on the Voltaian Shale formation have been studied. Classification of a Vertic and a Lateritic soil is compared in four systems : 1) Soil Taxonomy (Soil Survey Staff 1996), 2) FAO-UNESCO (1990), 3) the Ghanaian soil classification system (Brammer 1962), and 4) the local Farmer's classification system (Mikkelsen 1994). The comparison deals with the quantity and quality of information provided by each classification name. The study reveals that the local Farmers' classification system provides a considerable amount of information. It appears to focus much attention upon the requirements for optimal crop production using existing cropping techniques. The latter is oriented to a sustainable form of agriculture that has little capacity for incorporation of new techniques such as the use of tractors, introduction of new crops,or intensive use of fertilisers. It is recommended in the future that soil surveys should make an effort to gather the information that the local population can provide and eventually include this information in the database. This procedure will provide a more holistic approach in future land use planning.

Keywords

Soil classification; farmers; sustainable land use; Northern Ghana;

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Attempts to improve the agricultural production of less developed countries, often neglect the knowledge of local farmers. Research projects, whether on national or a international scale, tend to use standard procedures and international guidelines, including soil classification, when the agricultural potential of an area has to be elaborated. A more holistic approach can be defined as the task of all people concerned with soils to direct their interests not just to the physical, chemical and biological aspects, but also to those environmental, economic, social, legal and technical aspects that affect soil use, (anonymous 1992).

In a soil survey, the soil map units are mostly defined according to a particular soil classification system. These taxonomies can range from international systems down to national, regional and local systems. Often international systems, constructed on a broad scientific basis, will meet less of the regional and local needs than a soil classification system constructed by the farmers themselves. Here we test the quantity and quality of information provided by two international, one national and one local system used by farmers in Ghana.

Geographical position

The study area, 9°37' N and 1°01' W, is situated in the Western Dagomba District, Northern Region, Ghana, near the village of Dalun (roughly 2000 inhabitants), (Figure 1). Eighteen soil profiles were dug and described during the summers of 1992 and 1993 (Figure 2).

The area has a gently rolling savannah landscape with an elevation ranging between 100-160 m above sea level. It is a part of the Guinea Savannah zone, with contrasting dry and rainy seasons. The rainy season, controlled by the Monsoon circulation regime, begins in April and increases in intensity towards a culmination in September. This rainy season ends abruptly in October, under the influence of the dry and hot Harmattan wind from the Sahara. The mean annual air temperature is 28° C.

The area is underlain by the Voltaian Formation, it is of upper Precambrian to Palaeozoic age, 225-1000 million years old (Hirst and Junner 1946). It is composed of a series of shale, slate and sandstone sediments from a shallow fresh water environment and it covers 40%

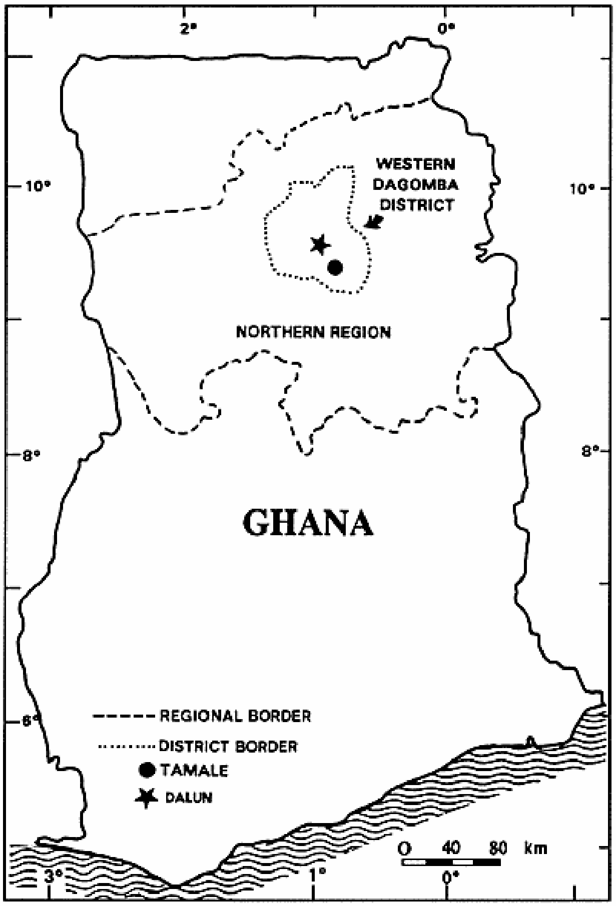

Figure 1: Simplified map of Ghana.

($103600\ km^2$) of Ghana's surface area (Kesse 1985).

The vegetation, characterised by tall grasses with scattered trees of 3-4 m in height, is strongly influenced by the agricultural use of the land, especially the annual burning.

Remnants exist of former surface soils which have largely been eroded, as evidenced by the presence of transported pisolitic iron and manganese nodules. This one major group of soils of the region, the lateritic soils, are formed directly on an abrupt unweathered substratum. Another major soil group includes the clayey soils. They have many characteristics in common with Vertisols such as intersecting slickensides and gilgai microrelief. They are formed by *in situ* weathering of the substratum. Transitions between the two soil types, the lateritic and the clayey soils along the soil catena, are relatively abrupt (Mikkelsen 1994).

Along the studied topotransect, lateritic soils are present on the ridge, on the mid slope and just before the river valley. On the ridge the hardpan is in places exposed due to erosion. Elsewhere the lateritic soils are commonly composed of 20-40 cm of loose lateritic gravel resting on top of laterite boulders or a hardpan.

The Vertic soils are developed in micro depressions situated on the higher slope and on the lower mid slope. The soils of the river valleys are developed in sand originating from colluvial sheet erosion. They show oxido-reduction features, and undergo the annual flooding of the valley bottom.

Materials and methods

The site and profile descriptions (18 in total) followed the FAO Guidelines for Soil Profile Description (1990) and the Handbook for Comprehensive and Adequate Field Soil Data Bases (Langohr 1993). Fine earth samples were analysed by the following methods (Soil Survey Staff 1972). Particle size distribution, by pipetting and sieving, after organic matter destruction by H_2O_2. pH : water/soil ratio 1:1. Organic carbon : acid dichromate digestion with

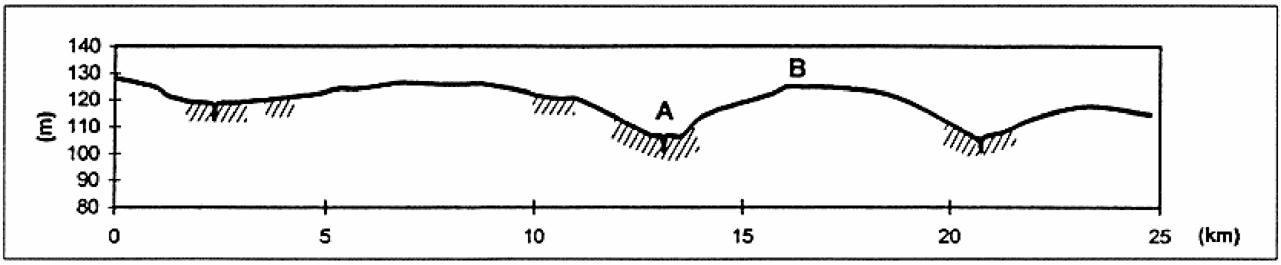

Figure 2: East-west oriented cross-section of the Dalun area. The slope between A (the tributary Bongtanga) and B (the village Dalun) has been studied for soilscape variability. Profile 1 and 2 are located at the mid and high part of the slope. Hatched areas are liable to flood. Vertical scale is in m.a.s.l.

Fe_2SO_4 titration. Total nitrogen : Kjeldahl digestion with ammonia distillation. CEC : NH_4OAc at pH 7.0 or 8.2 depending on the soil pH. Extractable basic cations : Na, Mg, Ca and K measured on the liquid of CEC extraction and determined by atomic absorption spectrophotometry. The same apparatus was used for the determination of sodium-dithionite citrate extractable Fe and Al.

A series of interviews were held with the purpose of evaluating the local Dalun farmers' knowledge of the soils in the area, and their agricultural potential. The chief of Dalun selected five farmers for interview according to their knowledge of the local soils. Later two other farmers were interviewed, to verify the information. The results of the interviews were discussed and further categorised in collaboration with local representatives from the Ghana Ministry of Agriculture. A classification system based on the collected information was elaborated. The international and national classification systems used are Soil Taxonomy (Soil Survey Staff 1996), FAO-UNESCO (1990) and the Ghanaian classification system (Brammer 1962).

Data

In order to compare the advantages and the disadvantages of the Farmers' soil classification versus the Ghanaian and the international soil taxonomies, two of the 18 soil profiles have been selected for a more detailed pedological study.

Profile 1 (P1) is a Pisolithic Laterite soil (Table 1) with a narrow transition zone to the substratum. The physical characteristics, such as the high content of gravel and laterite boulders, are the main limiting factors for agriculture. They result in a soil with a water deficit in the beginning and water logging at the end of the rainy season. The low content of fine earth means that the soil is also poor in plant nutrients, especially potassium (Table 2), which may easily be corrected by fertiliser application.

Table 1: Selected field data of profile 1 and 2.

Profile	*Horizon*			*Colour*	*Texture*	*Consistence*	*Roots*	*Cracks*	*Pressure faces*	*Slicken-sides*	*CaCO3*	*Other features*
	nr.	*symbol*	*depth*	*moist*							*nodules*	
1	H1	Ap	+5-16	7.5YR3/2	gr. sa. loam	very friable	common	-	-	-	-	ploughlayer
	H2	B1cs	16-48	7.5YR3/3	gr. sa. loam	loose	common	-	-	-	-	50-60% is cemented laterite boulders
	H3	B2cs	48-66	7.5YR4/4	gr. sa. loam	loose	very few	-	-	-	-	weak cementation of the nodules
	H4	B3gcs	66-87	7.5YR6/4	gr. loam	very friable	very few	-	-	-	-	sparse infilling of voids by clay
	H5	B4rcs	87-123		gr. clay	friable	very few	-	-	-	-	total infilling of voids by clay
	H8	C1x	123-?	2.5YR4/2			none	-	-	-	-	purple shales
2	H1	Ap	+21-11	10YR3/2	loam	SSP	frequent	no	none	none	very few	low aggregate stability; few charcoal
	H3	B1g	11-41	10YR4/2	clay loam	friable	common	yes	none	none	very few	much lower pearmeability
	H5	B3cs	41-80	10YR5/3	clay loam	firm	some	yes	many	many	few	intersecting slickensides
	H6	B4kcs	80-102	10YR5/3	clay	firm	some	yes	some	some	dominant	
	H7	B5w	102-124	10YR4/3	clay	very hard, firm	very few		few, dull	few	dominant	intersecting slickensides
	H8	B6gw	124-171	7.5YR4/2	gr. loam	very firm	none	yes	none	few	few	plenty hard shale frag.
	H13	C4x	187-232	5YR3.5/2			none	no	none	none	none	purple shales

Abbrivations : gr.: gravel; sa.: sandy; SSP: slightly sticky and plastic.

Profile 2 (P2) is an in situ weathered soil on a parent material nearly identical to that of P1. The texture is silty clay with a low organic matter content. Fertility is moderate with a deficiency of potassium (Table 2). The low content of organic matter seems related to the annual savannah burning; this produces ash that is easily removed from the surface by wind and rain.

Prevention against savannah burning, in combination with soil mulching, where organic material is mixed with the soil, is recommended to improve the fertility of these soils.

The Farmer's soil classification system

Essential information is collected on local soil names, grown food and cash crops, practices of fallow, fertilising, field preparation and harvest. The Farmer's soil classification system is based on these data. The information collected from the seven interviewed farmers shows a high degree of similarity. One particular soil (*Tanzei*) could, however, be described by only one of the farmers.

The system has two levels. On the first level, the soil types are divided into *Kukogu* (upland) and *Bani* (valley)

Table 2: Chemical and physical data of profile 1 and 2.

Profile	Horizon		Depth	Particle size (µm, %)#								Gravel (mm, %) $	
nr.	nr.	symbol	(cm)	< 2	2-20	20-50	50-100	100-250	250-500	500-1000	1000-2000	2-4	>4
1	H1	Ap	+5-16	10.4	10.8	12.5	8.7	10.9	2.7	6.4	37.6	33	18
	H2	B1cs	16-48	12.6	12.9	12.0	8.0	9.3	2.7	6.7	35.8	32	31
	H3	B2cs	48-66	17.0	20.7	16.2	7.3	5.2	2.2	5.8	25.6	27	56
	H4	B3gcs	66-87	16.8	20.8	20.0	11.7	6.4	1.1	2.5	20.7	47	20
	H5	B4rcs	87-123	70.0	3.4	5.7	1.3	0.9	0.9	1.7	16.1	46	28
	H8	C1x	123-?	48.7	48.6	1.8	0.5	0.3	0.1	0.1	0.0	1	2
2	H1	Ap	+21-11	14.0	18.5	25.3	23.3	16.1	1.2	0.5	1.1	2	tr
	H3	B1g	11-41	25.0	14.7	19.9	20.0	18.2	1.2	0.4	0.4	1	1
	H5	B3cs	41-80	46.6	16.6	11.8	9.9	11.2	1.4	0.9	1.6	6	2
	H6	B4kcs	80-102	48.1	18.8	10.3	8.8	8.2	1.4	1.1	3.4	7	8
	H7	B5w	102-124	48.2	24.2	16.9	4.9	3.9	0.5	0.3	1.1	3	tr
	H8	B6gw	124-171	49.1	35.4	12.7	2.0	0.6	0.1	tr	0.1	tr	0
	H13	C4x	187-232	41.1	49.4	8.8	0.5	0.2	tr	0.0	0.0	0	0

Profile	Horizon	Org.Carb.	Total N.	Exch. basic cations				CEC/ soil	CEC/ clay*	B.S.	pH H_2O	Dith. Citrate	
				Ca++	Mg++	K+	Na+					Fe_2O_3	MnO_2
nr.	nr.	(%)	(%)	cmol(+)/kg soil by NH_4OAc						(%)	(1:1)	(%) #	
1	H1	0.9	0.06	6.0	2.0	0.2	0.2	10.5	71	80	6.5	10.8	0.4
	H2	0.9	0.05	3.4	2.2	0.2	0.2	10.2	56	59	5.6	11.8	0.3
	H3										5.7	11.3	0.3
	H4			2.9	2.8	0.1	0.3	7.2	43	85	5.6	10.9	0.3
	H5		0.02	12.8	10.9	0.3	0.3	28.3	40	86	5.1	5.4	0.1
	H8			16.0	15.1	0.4	0.7	35.9	74	90	7.3	1.6	0.2
2	H1	0.5	0.03	9.0	3.7	0.3	0.3	14.9	94	89	6.1	1.1	0.0
	H3	0.5	0.02	10.6	5.5	0.6	0.4	16.0	57	107	5.8	1.1	0.0
	H5			17.3	9.0	0.8	0.5	27.0	58	102	7.2	1.8	0.1
	H6			16.1	8.8	0.5	0.3	26.9	56	96	7.8	1.6	0.1
	H7										7.7		
	H8			16.8	10.7	0.4	0.9	29.8	61	97	7.7	1.8	0.1
	H13			14.3	9.0	0.3	0.7	28.4	69	86	7.4	2.1	0.1

*: cmol(+)/kg clay #: % of fine earth fraction $: % of total soil weight

soils. They are subdivided into five and two subtypes respectively (Table 3). Probably there are more soil subtypes, but this study was dealing with land cropped by the farmers of Dalun. In other areas with different facies of the Voltaian shale formation, different soils are expected, with different combinations of crops grown and corresponding soil management.

Parameters of the system

The local soil classification has been developed by many generations of farmers using a system of shifting cultivation, the purpose of which is to maintain sustainable crop production. The knowledge and experience are past from father to son in order to guarantee the harvest, and with that the welfare of the family.

The natural vegetation is an important parameter as traditionally many plant species are used as indicators. Some plants provide information about mineral nutrient deficits, others indicate which crops are best adapted to the soil.

Unfortunately, the younger generation of farmers is less

Table 3: *Description of the types and subtypes of the Farmers' classification system.*

Type	*Subtype*	*Soil Quality*	*Geomorphology, hydrology, pedology*	*Crops*	*Soil Management*	*Special features*
Kukogu (upland)	Tansabli (black alluvial)	excellent	alluvial soil near the White Volta, with annual flooding;	all local crops, especially useful for maize;	crop early (May), due to flooding risk; crops have to rippen before the flooding begins; no fallow needed;	special sound and springy feeling when walking on the soil in the dry season;
	Bihisabli (black)	very good		yam (monocropped), cassava, sorghum, cotton, strong pepper, cowpea (pesticides), Bambara beens (local), okra; maize (+), groundnuts (+);	3 yr cropping, with fertilizer up to 5-6 yr; 3-4 yr fallow; ideal with two-year crop rotation : 1th yr, groundnuts and yam, 2nd yr, maize;	
	Bihizegu (brown)	moderate		Without fert. : groundnuts, late millet, tomatoes (+), strong pepper (+) okra (+). With fert.: maize, yam (-) crop quality lower than for the Bihisabli soil;	fallow and cropping periods as for the Bihisabli soil; fertilizer is recommended beside the fallow; good for vegetables;	
	Chicheli (sandy, gravely)	poor	mainly laterite gravel, laterite outcrop; drought at the beginning and water logging at the end of rainy season;	maize, groundnuts (-);	remove or crop between stones; farmers avoid cropping on this soil;	P1 is a Chicheli soil; vegetation: thorny-bushes and trees; strong termite activity.
	Trim (stony)	extremly poor	very stony some places complete sealing by a laterite hardpan	rough grazing;	no possibilities for cropping	none or very few plants and trees; vegetation killed in dry years;
	Tanzei (brown, salty)	extremly poor	salt concentration in the subsoil; subsoil is ash coloured, topsoil is brown;	cropping experiments gave extremely low harvest of very small yellow plants;	very shallow ploughing in order to prevent the saline subsoil to reach the surface;	salt probably of geological origin;
Bani (valley)	Bissavli (black)	very good;	dries out very slowly; water-logging early in the season	rice;	Cropping 5 to 10 yr; fallow: 2-3 years; rice planting in May to July depending on the variaty;	Bissavli occupies 15-20 % of the Bani soils
	Bapeilli (grayish)	good	high clay content, low infiltration rain; waterlogging after heavy but less than for the Bissavli soil	rice during wet years; maize, sorghum;	Maize or sorghum sowed May to June, 2-3 weeks later rice planting between the rows; cropping : 3 yr; fallow: 4-5 yr; often fert. is applied;	P2 is a Bapeilli soil

interested in the use of indicator plants; they simply use fertiliser in order to prevent nutrient deficiencies. Such a change in management makes the farmers more independent of these deficiencies but the sustainable system is lost. However, in the long term they disrupt the natural dynamics by using fertilisers and continuous cropping , so the environment may suffer serious damage, with strong soil erosion and loss of the fine earth and nutrients as a consequence. Before introducing new management methods, the side-effects need to be clarified, preferentially by experiments on the farmers' land.

The colour of the topsoil is also an important parameter in this classification system. The subsoil is largely ignored. It seems to be considered largely unimportant for agricultural production.

The Ghanaian soil classification system

The soil classification system used previously in Ghana was worked out by C.F. Charter for tropical soils (Brammer 1962). It was introduced in Ghana during the colonial period. Since the 1970's, Soil Taxonomy seems largely to have replaced the Ghanaian classification.

The Ghanaian system has four taxonomic levels. *Orders, suborders, great groups* and *series*. As there is a large number of divisions at the *great group* level, these are often grouped into *great group families*. The *series* are often placed into *series associations*. A more detailed description of this classification system is provided by Brammer (1962).

The factors of soil formation, i.e. climate, vegetation, relief, drainage, parent material and soil-age, are the diagnostic criteria for the *order* level. At *suborder* level, the differentiation for well drained soils is based on, whether excess precipitation reaches the groundwater table, and for imperfectly drained soils on the topographic position of the soil. At *great group* level soils within the same taxon have similar profile characteristics and similar environmental conditions. The differentiation is based on 1) the capability of the soil to release sufficient plant nutrients by weathering; or 2) on the quality of the ground water (acid, calcium or sodium-rich etc.). The *great group families* are split, if at all, according to the dominant type of vegetation (forest or savannah), as well as to the soil colour. The *series* are distinguished mainly on the nature of the soil parent material.

The diagnostic properties used at the two upper taxonomic levels concern rather general soil forming processes. More substantial soil data are needed from the *great group* and lower levels of classification.

The *series*, based on field descriptions, are most frequently referred to in the literature. They are named after the village where the series first was recorded (Stobbs 1960; Brammer 1962; Obeng 1970; Serno and Van De Weg 1985). The *series* similar to P1 and P2 are locally important, but do not cover extensive areas of the Voltaian Shale formation. On the experimental station surveyed by Stobbs (1960), 19 series were recognised over an area of 62 km^2. The series similar to P1 covered 1 %, the series similar to P2 covered 18 %. In the area of Dalun the extent of soils similar to P1 was much higher than the figures of Stobbs. A visual estimate indicated that 6-10 % of the soils were similar with P1 and around 8-12 % were similar to P2 in the area.

Soil series similar to P1

The soil series most similar to P1 (see Table 4) belong to

Table 4: *Important information deduced from the Ghanaian classification system for P1 (after Stobbs 1960; Brammer 1962).*

Level	*Classification*	*Important Information*
Order	Climatophytic	soil formation primarily determined by climate and vegetation
Suborder	Hygropeds	soil profile throughout leached
Great group	Savannah ochrosol	red and brown; friable; porous; loamy; gently undulating topography; on piedmont slopes soils are fine textured, on upland the soils contain a vesicular ironpan or abundant ironstone concretions at some depth; poorly nutrient status, nutrients concentrated in the topsoil organic matter, particular phosphorus and nitrogen deficit; subsoil with pH around 5.5.
Series	Ngane	very poor soil, only suitable for grazing; eroded remnant of an extensive peneplain drift; <30 cm silty loam with abundant iron nodules over 60-100 cm of massive vesicular ironpan.
	Jimbale	as the *Ngane* series, but the depth to the iron pan is 50 cm.

Table 5: Important information deduced from the Ghanaian classification system for P2 (after Stobbs 1960; Brammer 1962).

Level	Classification	Important Information
Order	Topohydric earths	soil formation primarily determined by relief and drainage
Suborder	Clinopeds	soils affected by water seepage from upslope and precipitating chemical substances
Great group	?	not defined in the system
Series	Kungawni	A grey clay developed in the weathering products from a rock pediment of shales and clay shales. Often the top-horizon has a markedly different texture as the material derives from upslope erosion. Presence of carbonate nodules is frequently noted. Bedrock within 75-120 cm in depth.
	Karaga	Lime rich clayey soil developed in colluvial material derived from the *Kungawni* soil. Lower part of the subsoil is developed in situ. Iron and manganese nodules tend to concentrate in same horizons as the calcite nodules. Depth to bedrock 180-200 cm.

the *Ngane-Jimbale* soil series association, which occurs on the nearly flat or very gently undulating peneplain remnants. It is characterised by the presence of a solid sheet of massive vesicular ironpan at a shallow depth, overlain by soil material composed of silty fine sand and containing abundant ironstone nodules. In the *Jimbale* series the ironpan is deeper than in the *Ngane* series.

In P1 the original thickness of the loose surface layer resting on the ironpan is difficult to estimate. Probably the present-day modern agricultural land use is responsible for the removal of shallow laterite boulders. Consequently it is difficult to allocate P1 in either one or other of these soil series.

Soil series close to P2

A semi-detailed soil survey of the Pong Tamale Veterinary Station was performed by Stobbs (1960), 25 km north of Dalun. Two *soil series* of this survey, the *Kungawani* and the *Karaga* series are similar to P2 and are summarised in Table 5.

The two *soil series* represent a transition zone in the catena, between soils with a net soil loss (erosion) and those with a net soil surplus (colluvial deposition). P2 is developed mainly in weathered substratum with the upper 50-60 cm receiving colluvium, and the profile therefore shows similarities with both soil *series*.

The International soil classification systems

In Soil Taxonomy P1 is classified as a *loamy skeletal, parasesquic, isohyperthermic Oxyaquic Ustropept,* with an ochric epipedon and a cambic B-horizon (Soil Survey Staff 1996) (Table 6).

In the FAO-UNESCO (1990) system the soil is an *Eutric Cambisol,-Petroferric Phase*, with the same diagnostic horizons as for Soil Taxonomy (Table 7). This soil has a cambic and not an oxic horizon because of the presence of considerable amounts of smectitic clay minerals (Mikkelsen 1994) which results in a high CEC per 100 g of clay. The soil has at present no more plinthite as the iron nodules are already indurated.

On the Danish agricultural experimental plot, where the profiles were dug, intensive use of fertiliser has raised the base saturation (BS) above 50% (Table 2). 8-10 years ago, before the Danish experiments began, the soils most probably had a BS below 50%. With BS below 50% the soil is an *Oxyaquic Dystropept* according to Soil Taxonomy, a taxon that better reflects the agricultural problems of the soil.

In the USDA Soil Taxonomy system, P2 is a *fine loamy, mixed, isohyperthermic Vertic Ustropept*, with an ochric epipedon and a cambic B-horizon (Soil Survey Staff 1996) (Table 6). According to FAO-UNESCO, (1990) it is *a Vertic Cambisol* with the same diagnostic horizons as for Soil Taxonomy (Table 7). The soil is not a Vertisol because of the 41 cm thick more coarse textured surface cover.

Discussion

The four soil classification systems are different in their construction and content. The Farmer's and the Ghanaian systems are largely descriptive. The Farmers' system concentrates on rather precise potentials for good crop yields

Table 6: Important information deduced from the Soil Taxonomy name of P1 and P2 (Soil Survey Staff 1996).

Level	Profile	Classification	Important Information
Order	P1, P2	Inseptisol	No other diagnostic horizons than an ochric epipedon, and a cambic horizon;
Sub-order	P1, P2	Tropept	Isomesic or warmer regime; no aquic regime; no plaggen epipedon;
Great Group	P1, P2	Ustropept	Ustic moisture regime; B.S > 50% between 25-100 cm; no sombric horizon;
Sub-group	P1	*Oxyaquic Ustropept*	Not vertic; no redox depletion but water saturated minimum 1 month/yr. within 100 cm;
	P2	*Vertic Ustropept*	Cracks as well as slickensides; no lithic contact within 50 cm;
Family	P1	loamy skeletal; para-sesquic; isohyperthermic	>35% rock fragments; mixed mineralogy; mean soil temp. >22°C; less than 5°C difference between mean winter and summer soil temp.;
	P2	fine loamy; mixed; isohyperthermic	> 15% of particles 0.1-75 mm in diameter; 18-35% clay; mixed mineralogy; soil temp. >22°C; less than 5°C difference between winter and summer soil temp.;

and relates this to mainly surface soil horizon characteristics, such as colour, texture and water infiltration capacity. The series of the Ghanaian system are largely based on soil parent material, texture and presence of particular features of pedogenetic origin such as secondary carbonate. The Ghanaian series concept is much broader than the diagnostic criteria for the soil series in the USDA Soil Taxonomy, and requires no chemical nor physical laboratory analyses. The international FAO and Soil Taxonomy systems are much more structured with taxon criteria based on measurable field and laboratory data. Those diagnostic criteria are based on concepts of soil genesis and of potential crop production. However, as they try to cover the soilscape at world-wide level, the diagnostic boundaries are largely arbitrary. It is evident that diagnostic criteria based on crop production potentials in the US are not necessarily valid for other ecological areas in the world.

At the first taxonomic level, the four systems start with different degrees of detail. The local Farmer's classification system, which demands a good insight in the environment, provides detailed information already at the first level. As it is restricted to one region of Ghana, a global setting of the climate and vegetation is felt unnecessary. The national system, a regional classification system, is specialised to serve classification of tropical soils. As a result P1 and P2 are already differentiated. The international systems dedicate first level to basic information about the degree of soil development, and relatively detailed information about the climate.

The Farmers' classification system

Advantages of the system:

- The system is based on a sustainable land use, with acceptable crop production without high inputs, such as irrigation, drainage systems, or chemical fertiliser applications;
- The system is based on the knowledge gained by several generations of farmers;
- Generations of farmers' experience automatically includes the range of management problems related to the climatic variability;
- The mixed cropping practise, which is not so easy to

Table 7: Important information included in the FAO/UNESCO (1990) Soil classification of P1 and P2.

Level	Profile	Classification	Important Information
Soil Groups	P1, P2	*Cambisol*	No other diagnostic horizons than an ochric or umbric A horizon and a cambic horizon;
Soil Units	P1	*Eutric (Petroferric phase)*	B.S. above 50%, lacking vertic, ferralic and gleyic properties; no permafrost; does not have a strong brown to red cambic B-horizon;
	P2	*Vertic*	Ochric A horizon, vertic properties, lacking gleyic properties, no permafrost;

handle, is a response to variations in precipitation which can differ more than 50% from one year to another;

- Low cost to obtain a fast overview. Interviewing the farmers on the types of soils, their fertility, and the related management type is possible at relatively low cost when comparing with the expenses for elaborating soil maps built on any of the other classifications;
- The system can be applied to the area underlain by the Voltaian Shale formation and settled by the Dagomba tribe. It is an area covering up to 20% of Ghana.

Disadvantages of the system:

- It is difficult to learn and apply for outsiders;
- It is an oral classification system, with no written records or guidelines, so cross checking is needed; there might also be minor differences in the definition over greater distances;
- It is adapted to the present day crops and is of little help for decisions related to introduction of new crops with other growth requirements.

Despite the disadvantages of the system, it certainly provides a first approximation of the agricultural potential of the soils. The potassium status on the exchange complex and the C/N ratio are the analytical data that could provide the most important supplementary information for estimating an optimal crop production.

Information about the subsoil is included indirectly in the system, but only when it has an important impact on the soil fertility. An example is the *Chicheli* subtype (P1), in which the surface layers are very similar to those of the *Bihizegu* subtype. However, because of the higher content of fine earth in the subsoil of the latter subtype, water drains more slowly at the beginning of the rainy season. For this reason the farmers crop the *Bihizegu* soils and leave the *Chicheli* for grazing.

A soil like the *Bapeilli* subtype (P2), which is waterlogged during the rainy season, is classified as a *Bani* (valley) soil, hence the soil is located on the gentle piedmont slope, more than one km upslope from the valley.

This is because water management problems have an important impact on the type of farming practise and crop types. The major part of the land of the Dalun village is actually covered by *Bani* soils, although most soils are in a *Kukogu* (upland) catena position.

The Farmers' classification system, a holistic approach

In recent years an attempt has been made to come to a more sustainable land-use through a more holistic approach of soil management. Indeed, earlier attempts have often faced failure. Muchena and Kioma (1995) highlight one of the reasons for failure in East Africa as being the lack of communication from soil scientists towards the land users. Unfortunately their recommendations for the future research concern only a better pedagogic one-way communication.

The information gathered from the Farmers' classification system therefore seems a better example of a step towards a more holistic view as it will permit a two-way communication with the land users. As Reate et. al. (1995, p 54) state in one of their conclusions, the true holistic person is the peasant, the miner, the woman carrying wood, or the child getting water.

The Ghanaian classification system

The Ghanaian classification system was constructed for tropical soils at a time where knowledge about them was sparse. The order and suborder levels are rather generally defined. From the great group level on, and on the following more detailed levels of classification, the information is sufficient for advice on land use management planning on a semi-local scale.

The system, despite the very detailed field descriptions of the soil series, lacks more specific information on soil fertility and recommended crops. However, information concerning soil fertility can be inferred from the system indirectly if one is familiar with soil profile descriptions. Unfortunately the data base seldom contains physical or chemical laboratory data.

Another difficulty is the numerous series definitions which are rather vague as the differentiating criteria largely depend on the decision of the individual surveyor rather than on pre-defined rules.

Summarising, the Ghanaian classification system can provide very detailed information on drainage conditions, vegetation, texture and some elements of the basic chemical status. The system is largely descriptive, and the usefulness largely depends on the experience of the surveyor.

The International classification systems

The FAO system requires a set of standard laboratory data for a proper classification. On the other hand the system is relatively easy to handle. It has two taxonomic levels and

is commonly used in reconnaissance and semi-detailed soil inventories. For more detailed surveys, the system must be further adapted.

Soil Taxonomy, with seven taxonomic levels, permits detailed soil maps (phases of soil series) to be made. Profiles P1 and P2 have been classified down to the family level. This fifth level already provides a large amount of important data for crop production. The seventh level in Soil Taxonomy, the phases, probably corresponds to the details provided by the Farmers' classification system. If, in the future, a survey is done on the basis of soils classified down to the series or phase level, the information gained from the Farmer's classification would be most useful.

Conclusions

The study shows that additional knowledge and information on crop production and soil management are available when farmers are consulted on their own soil classification rationale. This expertise is built up through several generations of traditional land use. Such knowledge is often largely ignored in modern national or regional soil management planning. This study shows that collecting the local farmers knowledge on soils and land use is one step closer towards a more holistic approach in land use planning.

Inclusion of such knowledge would not replace the international and national systems when classifying soils. Each classification system has its specific positive aspects and optimal results are reached when combining the information from two or more of the taxonomies. A good first-hand impression of the general soil fertility and management problems can be obtained through a preliminary soil survey in which the farmers are interviewed on the local soil types and their specific crop and management recommendations. In a second phase, and if needed, more structured classification systems, partly based on analytical data, can then be applied. Competent feedback concerning both types of systems would certainly be of great benefit for future studies on soil survey and land evaluation.

If a new classification system could be elaborated today in a country like Ghana, an optimal solution seems to be the adaptation of the FAO system. It is known world-wide, it is precise and relatively simple, but has only two well-defined levels. A third and possebly a fourth level could further be constructed on the basis of the FAO diagnostic horizons and properties. The one or two lower taxonomic levels should, however, be based on the farmers' experience. This research has shown that such information is most valuable and particularly well adapted to the concept of sustainable land use. It is very urgent to record this information before further modernisation of agriculture erases the knowledge. It will also create considerable risks of irreversible degradation of the soils in areas which for centuries have been under a traditional land use.

The Farmers' system is a result of the farmers direct needs for information on the crops to be grown with the best potential for success but without degradation of each of his parcels of land. The national classification system was constructed to give a precise view on the types of soils within the country, sufficiently detailed to plan the regional agricultural policy (what are the areas optimal for cassava, yam etc.). The international systems have been elaborated to provide a tool to compare results from one region of the world with another. Furthermore, they provide the soil scientists with a common language.

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