Uganda Journal of Agricultural Sciences, 2004, 9,184 - 191
ISSN 1026-0919

Integrating indigenous and scientific knowledge on soils: recent experiences in Uganda and Tanzania and their relevance to participatory land use planning

***J. Gowing, R. Payton and M. Tenywa*[1]**

University of Newcastle upon Tyne, UK
[1]Makerere University, P.O. Box 7062, Kampala, Uganda

Abstract

The last decade has seen a reappraisal of the process of agricultural innovation and a convergence on participatory approaches to development planning and research. Recognising that practitioners face scarcity of information on how to operationalise the new paradigm, the project reported here aimed to develop a methodology for integrating scientific soil survey products with indigenous knowledge surveys. In principle, these methods offer complementary strengths. Scientific survey provides valuable insight into key soil properties and their spatial variability, but such mapping is generally not available at sufficiently detailed scale. On the other hand, indigenous knowledge is fine-tuned to locality and represents an assembly of accumulated local experience. Field research over 3 years on sites in Uganda and Tanzania aimed to test the hypothesis that indigenous knowledge and scientific soil assessment can both be represented within a common spatial frame and can therefore be usefully integrated. The research highlighted the importance of a systematic and iterative exploration of indigenous knowledge, which must extend beyond the level of rapid rural appraisal and include several different techniques of cross-validation of interpretations of indigenous soil classification systems. We conclude that there is much to be gained by combining elements of broad-scale scientific survey with a localised assessment of indigenous knowledge. The remaining challenge is to develop best practice guidelines that will allow agricultural researchers and planners to understand and use local knowledge combined with scientific understanding of soil and land resources.

Keywords: Ethnopedology, indigenous knowledge, land use, participatory approach, soil survey

Introduction

Uganda's soils were once considered to be among the most fertile in the tropics, but now we see reports that food insecurity is attributable to the interrelated problems of land degradation and declining agricultural productivity (Pender et al, 2004). This can be explained by increasing population pressure leading to increased demand on arable and grazing lands. Intensified production, cultivation of marginal land, drainage of swamps and clearance of forests may all contribute to land degradation. Land use planning is the process by which the potential impact of these changes is properly considered and informed decisions are taken on how best to utilise land resources for sustainable development. Recognising the recent paradigm shift in favour of participatory approaches to development planning, Zake (1999) called for greater involvement of all stakeholders in land improvement programmes. Hence we are dealing with participatory land use planning – an approach that is consistent with decentralised decision making.

Understanding the soil resource is central to sound land management, but availability of and access to soils knowledge is a problem. National, regional and global efforts have produced vast amounts of soils data which is captured on maps. Development of a standardised scientific method of soil survey has resulted in generalised classification systems, which aim to facilitate communication and transfer of soils knowledge. Despite these heroic efforts, the question remains, "is available soil information adequate for the task"? Success depends on the extent to which soil classification provides a measure of similarity and variability of soil properties between locations. The aim is to map soil units such that the variation remaining within units should be substantially less than the variation between them (White, 1997). There are inherent limitations in this approach since any classification system depends upon the choice of diagnostic criteria. It is argued (White, 1997) that storage of soils data in modern information systems allows the user to avoid this problem by allowing retrieval of primary data. However, we must recognise the problem of availability of data at an appropriate scale.

Individual farmers are concerned with variations at the 1 hectare scale; village-level land-use planners need to operate at the 1km^2 scale. Soils data is often not available at these scales. In Uganda (as in most of sub-Saharan Africa) only reconnaissance level (1:250,000 (1:250,000 scale) surveys are generally available. At this scale an entire village is likely to be mapped as a single unit on the basis of probably less than one sample point.

There is clearly a need for a strategy that will fill gaps in soil survey over the appropriate spatial extent. One possible approach is to use remote sensing technology. In Australia large areas have been mapped at a scale of 1:250,000 using Landsat imagery together with a digital terrain model to derive data for 250m pixels. Automated soil mapping rules were derived from existing conventional soil maps at 1:100,000 scale (Bui and Moran, 2003). An alternative low-cost strategy that is appropriate for smaller areas is to access 'indigenous' or 'local' knowledge[1]. Such a strategy is consistent with the participatory approach and reflects the increased interest shown by soil scientists in the potential of indigenous soils knowledge to inform or modify the application of conventional scientific methodology to soils investigations (Pawluk et al, 1992; Sandor and Furbee, 1996; Kundiri et al, 1997; Habarurema and Steiner, 1997; Sillitoe, 1998; Gobin et al, 2000; WinklerPrins and Sandor, 2003).

In undertaking soils research which aims to integrate both scientific and local knowledge systems, it is important to consider the character of local knowledge, the advantages of combining the two approaches and appropriate methods by which integrated studies should be undertaken (Payton et al, 2003). Early attempts to integrate local knowledge were often little more than appropriation of local soil names for scientifically derived soil units, as applied in early studies of soil catenas in Tanzania by Milne (1947). More recent research has included in-depth investigations of what these terms mean to local people (Sandor and Furbee, 1996). WinklerPrins (1999) stresses that research needs to move towards linking local soils knowledge with sustainable land management. However, the research literature largely fails to address the methodology for how to integrate the two knowledge systems. This paper reports the results of field research over 3 years on sites in Uganda and Tanzania which aimed to test the hypothesis that indigenous knowledge and scientific soil assessment can both be represented within a common spatial frame and can therefore be usefully integrated. The work is seen as a step towards development of a method that will allow agricultural researchers and planners to understand and use local knowledge in combination with scientific understanding of soil and land resources.

Method

Environmental and agricultural setting

Project fieldwork was focussed on the semi-arid to sub-humid lowlands in the Lake Victoria catchment of Tanzania and the Lake Kyoga catchment of Uganda.

The four research sites, two in Katakwi District, Uganda (Wera and Toroma) and one each in Kwimba and Misungwi Districts, Tanzania (Mahiga and Iteja), were planned to correspond with village administrative boundaries (25 to 58 km^2 area). Climates are seasonally dry with a highly unpredictable bimodal rainfall pattern that shows large spatial and temporal variations. Mean annual rainfall varies from 700 to 900mm in Tanzania and up to 1300mm in Uganda. Evapotranspiration exceeds rainfall in most months outside the rainy periods of November-December and February-April, resulting in a pronounced dry season when soil water deficits are a major constraint to cropping.

At all sites the landscape extended from broad rises with moderate to gentle slopes over deeply weathered Precambrian granites and gneisses, into extensive, seasonally waterlogged footslopes and valley bottoms over colluvium and Quaternary lacustrine sediments. Soil distribution is strongly related to slope, giving soil catenas recognised by previous researchers (Milne, 1947; Meertens et al, 1995). Cropping is limited by seasonal soil moisture deficits, combined with low fertility soils on the higher ground. The main crops are maize, sorghum, cowpeas and groundnuts, with rice and cotton grown locally in favourable conditions.

The research sites were selected to represent the hinterland of agricultural research institutes that were established during colonial times. In Tanzania, indigenous knowledge of soil and land resources was thought to be particularly well-developed, having been described in early reconnaissance soil surveys (Milne, 1947) and further investigated in the context of recent farming systems research (Meertens et al, 1995). In Uganda, local soils knowledge and agricultural practices were thought to be well developed (Jameson, 1970), but the recent history of insecurity had adversely impacted on farming systems and the influence of the research institute was less evident.

Rationale

The main thrust of research activities (Figure 1) involved fieldwork for scientific soil surveys and assessment of soil variability together with parallel investigations of indigenous soils and land resource knowledge. In order to allow for objective comparison between local and scientific knowledge, particular efforts were made to avoid "cross-contamination". These investigations at each site were therefore conducted separately by different groups within the research team. The scientific soil survey team comprised soil scientists and agricultural engineers, while the local knowledge team comprised anthropologists, farming systems specialists and extension specialists. Information was not exchanged between these teams during fieldwork so that the "purity" of the results was guaranteed.

Subsequently, emphasis shifted to the comparison of information derived from these separate exercises at each of the four research sites using a geographical information system (GIS) as an integration domain (Figure 1).

This led to consideration of methodologies for an integrated approach to soil and land resource assessment.

Scientific soil surveys

Conventional soil survey methodology was employed, starting with a reconnaissance based on air photograph interpretation (at 1:22,000 scale) supported by ground truthing along soil toposequence transects to define the principle soil catenas, which involved a sampling intensity of 2-3 soil auger borings per km^2. Subsequent semi-detailed (1:50,000 scale) soil mapping elaborated soil boundaries using free survey methods (Dent & Young, 1981) with a sampling intensity of 4-10 auger inspections per km^2. Detailed grid surveys (sampling intensity 25 per km^2) to examine soil variability within semi-detailed soil map units allowed for further refinement of soil boundaries and resulted in mapping of 20% of the total area at a scale of 1:12,500.

Site details and soil properties were systematically recorded at soil inspection points (soil auger borings to 120cm depth) and geo-referenced using GPS. Soils were classified according to the FAO-ISRIC-ISS (1998) World Reference Base for Soil Resources and the US Soil Taxonomy (1998). Soil map units were named after the dominant FAO soil sub-unit.

Soil profile pits representative of each of the main soil mapping units were described and sampled. Laboratory analyses were carried out on soil samples to characterise their main chemical and physical properties.

Indigenous knowledge surveys

The methodology for investigation of local soil knowledge followed an iterative process involving several stages of exploration and refinement, which allowed for progression from a broad descriptive approach to more detailed analysis. The initial stage involved techniques commonly used for participatory rural appraisal (PRA), such as semi-structured interviews, cognitive mapping, farmer-led transect walks, problem ranking and seasonal calendars. This stage was useful in orientating the farmers to the purpose of the research and for gaining insight into the main soil types and their distribution.

The initial participatory mapping of local soil types started with farmers drawing a free-hand village map on the ground. Typically this was done by a relatively large (20-25), middle-aged to elderly group of mixed gender. This was later transferred onto paper with soil names and boundaries being added through discussion. This initial soil map was a useful tool for starting to explore local soil classes and their distribution. It provided a basis for planning farmer-led soil transect walks, but the geographical accuracy was poor. An attempt was made to use 1:50,000 scale topographic maps blown up to the size of the farmers' sketch map as a basis for rectifying scale distortions, but this was unsuccessful as farmers were unable to recognise features on the map. An alternative approach using enlarged aerial photographs was more successful and allowed for preparation of a more geographically accurate LK soil map. This initial phase of soil mapping was followed by an exploration of farmers' criteria for distinguishing between soil types. The methodology evolved as the research progressed. In the first two villages studied (Mahiga in Tanzania and Wera in Uganda), in-depth semi-structured interviews with individual farmers about their soils were conducted in their own fields following the line of the previous transect walk. Farmers were asked to cross-check soil types and boundaries identified during the transect walk. Interview points and boundaries were georeferenced using GPS. Subsequent focus group discussions explored the variation in the meaning of soil names and included pairwise and matrix ranking of problems associated with different soil types. This led to development of the consensus LK soil map legend.

At the other target villages (Iteja in Tanzania and Toroma in Uganda) additional participatory methods were developed to elicit and then cross-check information and inconsistencies. The research started with free listing interviews in which farmers were asked to list all soil types within their fields and their village and to describe the properties that distinguished each soil type. Interviews then progressed to sorting tasks designed to elicit a deeper understanding of farmers' soil classification. Transect walks were then revisited and soil types and boundaries were reviewed and georeferenced. Final focus group discussions were used to compile and cross-check the information obtained during individual interviews.

Methodology for comparison

The scientific and vernacular soil descriptions and classification systems that were assessed independently by the methods described above were then entered into a GIS to allow comparison. This was facilitated by having previously georeferenced all scientific and participatory survey points using GPS. Scientific survey data was entered in the form of: soil maps with extended legends as attribute tables, modal profile descriptions from profile pits linked to tables of chemical and physical data, soil auger point records. Equivalent data from the LK survey was entered in the form of: farmers' soil maps with consensus soil legend entered as an attribute table linked to each map unit, georeferenced point data from interviews with farmers along transect walks.

The GIS provided a successful forum for managing, interpreting and comparing the spatial, tabular and descriptive information (Figure 1). Comparative analysis was undertaken by a multi-disciplinary research team as an open iterative process with the outcome of a particular query establishing the basis for new lines of enquiry. The analysis used the following broad approaches: spatial analysis using general summary statistics and map overlays and comparisons, overlay of point with map (polygon) data, point-to-point analysis involving queries using attribute data for both LK and scientific surveys. Summary statistics from the GIS provided an initial overview of the range and distribution of soil map units and allowed comparisons between sites for individual LK or SK maps. The degree of correspondence between LK and SK soil maps of a single village area was initially assessed using the GIS by displaying the final LK soil map and analysing the intersection of the LK soil boundaries with the 1:50,000 scale semi-detailed SK map. Spatial relationships were further explored by using a standard method available within the ARCVIEW GIS software to determine which LK soil types were entirely contained or centred within SK map units and vice versa.

Results and discussion

Survey results

The main purpose of this paper is to compare and contrast information obtained from the two separate survey methods (SK and LK) with a view to identifying scope for effectively integrating them into a single method of investigating soil resources. A full description of the separate SK and LK surveys for each site is reported elsewhere (Hatibu et al, 2000; McGlynn et al 2000a; McGlynn et al, 2000b; Oruka et al, 2000; Oudwater et al, 2000; Payton et al 2000a, Payton et al, 2000b; Tenywa et al, 2000) and a brief summary is presented here only for the two sites in Uganda.

Scientific surveys

The soil pattern at Oimai-Wera and Toroma village sites is closely related to slope and is most easily described using the model of the soil catena. Complex interfluves and midslopes are occupied by well-drained Acrisols with sandy to coarse loamy topsoils over fine loamy subsoils dominated by low activity clays. At Oimai-Wera, these are mainly Ferric Acrisols with ironstone nodules. Petroferric Acrisols with gravely ironstone at 50-100cm depth are common on summits and detailed surveys show considerable small-scale variation of depth to ironstone. At Toroma, Petric Plinthosols with ironstone at <50cm depth dominate summits, giving severely reduced rooting and water holding capacity, whilst red well-drained Rhodic Acrisols are more common. Crop yields are reduced on gravely variants with shallow depth to ironstone. Surface structure is weak where sandy topsoils are common and capping can lead to accelerated surface runoff.

Small-scale variability is highest in footslope soils that are subject to additions of runoff and subsurface flow from upslope and seasonal waterlogging by fluctuating groundwater. These areas are used for grazing but rice and sugarcane are grown locally. The soils have developed from coarse textured colluvial deposits derived from upslope and are mainly acid imperfectly drained Areni-Gleyic Acrisols or seasonally waterlogged Gleyi-Dystric Plinthosols. The former have loose sandy topsoils over mottled sandy clays or clays at depths of about 50cm, whilst the latter have poorly structured grey clayey subsoils with prominent red mottles with a potential to harden on drying at depths <30cm. Sands thicken locally to >1m to give waterlogged Gleyic Arenosols. Wide valley floors subject to seasonal flooding are dominated by neutral dark grey Mollic Gleysols with slowly permeable, high activity clays that undergo prolonged waterlogging. Some develop subsoil cracks >1cm wide in the dry season to give Molli-Vertic Gleysols. Prominent mounded micro-relief with evident earthworm activity beneath grass tussocks are a particular feature of these soils. Narrower valleys are occupied by seasonally waterlogged fine loamy over clayey Verti-Eutric Planosols with moderately acid topsoils over calcareous cracking clay subsoils. Amounts of organic matter and exchangeable calcium, magnesium and potassium all increase in the valley bottom soils relative to the convex interfluves, but the imperfectly drained sandy footslope soils with plinthite remain acid and low in exchangeable cations.

The work reported here had a utilitarian objective in that the investigation of soils knowledge was linked to a desire to use this information for land use planning and land management. An issue of particular concern was soil and water conservation and it is implicit that for any soil map unit to be useful in this application, it should be a good predictor of soil hydrological behaviour. Detailed experimental work at Mahiga and Wera sites provided measurements of in situ soil hydraulic conductivity from a nested or hierarchical sampling scheme. The results showed that soil map units classified according to the standard SK methodology adopted for this research failed to classify soils according to this property. Both sites showed greater within class variance than between class variability. It should be noted however that the measurement technique adopted for this investigation effectively samples only the upper part of the soil profile.

LK surveys

Soil maps produced by farmers at different stages of the investigation showed discernable similarities, but wide variations in location of soil boundaries, area of soil map units and frequency of soil types. At Oimai-Wera there was disagreement between the original cognitive map and subsequent LK maps in the extent and position of *Ingaroi* soils (*stoney soils not good for cultivation)* and of *Ecuwa* soils (*black sandy and sticky soils that are always moist, where water collects and sometimes floods*) on lower slopes and valley floors. Differences between the different versions of the LK maps were even more apparent at Toroma where more rigorous methods were employed to elicit and cross-check information about soil classes before the final LK soil map was produced. Many of the most widespread soil types such as *Akao* in the valleys and *Apkor* and *Aputon* on the uplands were similarly defined to soils of the same name at Wera.

The first impression might be that farmers' knowledge is inconsistent, but the variations are in part linked to the iterative methodology and ongoing learning process between farmers and the research team. Farmers' classifications are more often comparative than hierarchical, with distinctions made in terms of darker/lighter colour or greater/lesser fertility. However, there is evidence of hierarchical subgroups at both sites since farmers divided their shallow soils into different categories on the basis of soil surface texture. *Ingaroi*, *Aputon naingaroikitos*, *Apokor Naingaroikit* are all shallow soils which have ironstone gravel and indurated ironstone near to the surface. The term '*ingaroi'* is common to all and means gravel in Ateso language. Where the surface texture is sandy, the soil is mapped as *Aputon naingaroikitos*, whilst clayey surface texture leads to mapping as *Apokor naingaroikit* .

Comparative analysis of LK and SK

Summary statistics from the GIS provided an overview of the range and distribution of soil units and allowed comparison between sites on individual LK or SK soil maps. The degree of correspondence between the different methods was initially assessed by the intersection method. The percentage of an IK unit falling within an SK unit (Table 1) generally showed poor correspondence, but in some cases there was a direct relationship. Thus at Mahiga, a substantial proportion of *Mbuga* soils correspond with Pelli-Calcic Vertisols and Itogolo soils with Stagni-Sodic Vertisols. At Iteja the correspondence between *Mbuga* and Pelli-Calcic Vertisols was as high as 93%. This almost direct correspondence can be explained by the distinct landscape position in valley floors, a criterion used to define the LK soil type and to plot the SK soil unit boundary. LK soil types are frequently distinguished on the basis of surface characteristics and where the scientific diagnostic criterion is determined by topsoil properties this also leads to close correspondence

Itogolo soils do not correspond with any one scientific soil unit, but fall mainly within areas mapped as Calci-Endosodic Planosols and Stagni-Sodic Calcisols, both of which have coarse textured upper horizons of varying depth over hard-setting sodic calcareous B horizons. Both LK and SK methods recognise seasonal surface water stagnation in these soils, but the SK classification lays more emphasis on diagnostic criteria of critical depth and texture contrast of the surface and subsurface horizons.

A particularly informative method of analysis proved to be the interrogation of the GIS to investigate point-to-polygon comparisons. For example, comparison of tabulated farmers' descriptions at georeferenced points with soil descriptions derived from interrogation of the 1:12,500 scale scientific soil survey map showed that within the Calci-Endosodic Planosol and Stagni-Sodic Calcisol map units at Mahiga farmers identify five soils, but only Itogolo was shown on the LK soil map. These included *Shilugu* (*old kraal and homestead sites*) and *Shigulu* (*old termite mounds*) that were differentiated by their darker colour and greater fertility than surrounding Itogolo soils and differentiated from each other by their origin, ease of cultivation and stickiness.

Point-to-point data comparisons were also informative using georeferenced LK transect points and SK auger points within a 300m radius. This allowed the fullest possible access to variation of scientifically assessed soil properties. At Toroma, this method demonstrated that *Akao* soils with earthworm mounds and particularly prone to waterlogging and cracking were recognised as *Akao agogonit* and that all points recorded with this LK soil type corresponded with Verti-Mollic Gleysols. In this case scientific criteria for class separation agreed with many of the local criteria (eg.

Table 1: Intersection of LK soil types that fall with SK map units (Mahiga, Tanzania)

Scientific survey unit (FAO-ISRIC-ISSS, 1998)	Farmer-defined soil type Ibambasi	Ibushi	Itogolo	Luseni	Mbuga
Hapli-Ferralic Arenosols	<1%	0%	5%	18%	3%
Gleyi-Petroplinthic Arenosols	4%	0%	4%	7%	2%
Calci-Endosodic Planosols	10%	0%	36%	38%	16%
Calcic Planosol/Rock complex	4%	0%	0%	11%	5%
Stagni-Sodic Calcisols	40%	92%	45%	25%	34%
Peli-Calcic Vertisols	41%	8%	10%	2%	40%

indication of seasonal waterlogging, dark topsoil worked by earthworms, cracking when dry).

Conclusion

Soil mapping

The first impression from comparison of separately derived SK and LK soil maps might be that farmers' knowledge of soils is inconsistent and unreliable, but experience gained through this research indicates that much of the apparent variation derives from the method of investigation. In Uganda, it became clear that an apparently dominant soil type (*Eitela*) was in fact a land-use term and deeper communication with farmers led them to abandon the term and propose more specific soil names. These were then more strongly related to certain subunits of Acrisols identified in the scientific soil survey. In Tanzania, it was revealed that the term *Itogolo* was broader and less informative than suggested by its use in local farming systems and extension work (Meertens et al, 1995). Apart from such examples it became apparent after in-depth studies that the central concept of the most widespread LK soil types was in fact relatively consistent between farmers in the same village and between villages in the same cultural group.

The apparent inconsistency can be partly attributed to the problem of boundary definition. The standard PRA practice of cognitive mapping provides a useful entry point to gaining understanding of LK soil classification, but it is unrealistic to expect that boundaries can be accurately identified in this way. Trying to establish the boundaries of soil units with farmers can be difficult. Aerial photographs were adopted as a base map to aid spatial recognition, but it should be remembered that aerial photographs are distorted at their edges and this distortion is exaggerated when photographs are enlarged. Farmers then attempt to draw boundaries with lines that have a finite thickness equivalent to several hundred metres on the ground. Participatory mapping is completed in a few hours with informants sitting in one place and working from memory. A scientific soil surveyor would find it very difficult to do this with any degree of accuracy. Expecting farmers to create a cartographically faithful cognitive map from memory is bound to deliver an unreliable result.

While it is difficult to establish boundaries of soil units, it does not follow that point data is unreliable. Farmers' soil knowledge is experientially based (WinklerPrins, 1999), thus they are likely to have better knowledge of the soil that they farm, than of soil on more distant fields. A graduation in confidence in the knowledge base away from a farmer's own land is to be expected. The creation of the LK soil map required aggregation of knowledge through group discussion to arrive at a consensus. This process is bound to result in some loss of detail. It should be noted that this is the case also with SK soil mapping. Boundaries between SK soil units are often fuzzy, since transitions are rarely abrupt. Comparison of SK mapping at two scales showed discrepancies in unit boundaries on the 1:50,000 scale maps of up 100m to 300m which is the normally expected range (Dent & Young, 1981).

Soil classification

It is apparent that farmers use several criteria for classification based on intrinsic soil characteristics that have parallels in scientific soil classification, such as: soil colour, soil handling properties or behaviour when tilled (sticky, sandy, soft, hard etc) that are surrogates for soil texture or consistence classes. They also recognise tendency to drought, flooding and waterlogging in a way that is broadly equivalent to soil moisture regime. However, farmers' criteria also include concepts of 'coldness' and 'hotness' that are unparalleled in scientific systems. Moreover, their classifications are dominated by topsoil properties, whereas modern international systems of scientific classification place more emphasis on subsurface diagnostic horizons.

The consensus LK map legend developed for each survey site contained a description of each soil type under the headings: soil name, location, colour, fertility, handling properties, depth, behaviour of soil when dry and when wet. The equivalent SK map legend contained information on landform, parent material, soil depth, depth to slowly permeable layer, rock outcrops, topsoil characteristics, subsoil characteristics, soil moisture regime and drainage class. This was supplemented by laboratory data on chemical and physical characteristics.

Critics of LK and PRA methodology sometimes allude to an inherent lack of rigour according to scientific measures of data confidence. According to a 12 point framework devised by Pretty (1995) to counter such criticisms, the data derived from the research reported here are reliable. Triangulation between multiple respondents together with checking through iterative cycles of group discussions ensured that interpretations were trustworthy. Any remaining doubts about reliability of LK soils data must be set against the limitations that are also inherent in mapping derived from scientific survey. Just as map unit boundaries are fuzzy, so the units thus defined contain impurities. Comparison between SK mapping at 1:50,000 and 1:12,500 scales showed that purity of semi-detailed map units for Iteja and Mahiga at around 63%, which is within the expected range (Dent &Young, 1981). A separate investigation (Simelane, 1999) of two soil units at Wera demonstrated more successful separation of soil classes (100% purity for one unit and 93% for the other). Additional detailed investigations showed also that the semi-detailed soil map units may not be reliable indicators of soil hydrological characteristics.

Towards an integrated survey method

The research has shown that soil recognition and classification criteria used by farmers and scientists differ, but both can be represented within a common spatial frame and can therefore be usefully integrated. Scientific survey provides valuable insight into key soil properties and their spatial arrangement. SK mapping is produced according to standardised procedures, which allows for relatively easy interpretation by any trained user, but detailed mapping is not widely available. On the other hand, local knowledge of soils is fine-tuned to the particular locality, but is not immediately accessible to outsiders. It is concluded that there is much to be gained in combining SK and LK survey procedures.

The research project reported here set up a scenario in which good quality SK soil survey products were available at semi-detailed scale (1:50,000) and soils were reliably classified to FAO-ISRIC-ISSS (1998) sub-unit level for each of the four study sites. This allowed for effective comparison with local soils knowledge at a scale appropriate for village-level and farm-level technical interventions. This is a relatively favourable scenario; for most of Uganda (and sub-Saharan Africa generally) only reconnaissance level mapping (at 1:250,000 scale) is available. Soils of the study area in Uganda were mapped by Ollier (1959) and Aniku (2001) proposes analogue FAO-UNESCO (1994) soil classes. This will in general be the starting point and the real challenge is to develop a method that will allow agricultural researchers and planners to understand and use this scientific knowledge and to combine it with local knowledge to provide village level validation and spatial detail.

Much of what has been learned from this detailed research effort can be used as a starting point for the development of a practical field-based combined survey procedure. The combined approach offers a possible solution to the time and cost constraint inherent in detailed scientific soil survey. However, it can also be problematic, as researchers or non-specialist extension staff must learn new skills to allow them to explore local knowledge without imposing their own conceptions. It is important to sort out differences between specific names given to areas of village land, general land use terms and specific types of soil. It is important also to understand how farmers distinguish between their soils, but in doing so the predetermined SK classification criteria must not be imposed.

Drawing upon the research experience, a recommended approach to LK survey can be proposed as follows:

1. Depending on familiarity with the target area, a basic description of the farming system and problems perceived by farmer groups;
2. Community mapping of land systems and perceived soil types is important to introduce the topic and select routes for subsequent transect walks with farmers;
3. Transect walks to explore farmers' designations of different soil/land types; record farmers' descriptions at points;
4. Discussion of crop management in relation to locally recognised soil types and landscape position;
5. Revisit community map for discussion and clarification; agree consensus classification

Existing research experience does not permit firm conclusions on the most effective way to combine the LK survey with available SK soils knowledge. Further fieldwork is required to develop a pragmatic approach that can be adopted by non specialists on the basis of limited training. The catena model has been shown to be useful at the village scale and provides initial SK prediction, which can be validated and refined on the basis of SK transects. It is likely that a combined approach will depend on the use of simple soil keys based on selected diagnostic properties, which can be developed from the best available SK mapping for the target area. Joint observation of soil types on a transect basis with farmers offers the most attractive way to combine SK and LK. This would follow the emerging consensus classification and would be informed by in-depth questions generated from interpretation of the pre-existing SK mapping.

References

Aniku, J.R.F., 2001. Soils classification and pedology. In: Mukiibi J.K. (ed), *Agriculture in Uganda*. Vol. 1. Fountain Publishers/ CTA/ NARO, pp 66-103.

Bui, E.N. and Moran, C.J., 2003. A strategy to fill gaps in soil survey over large spatial extents: an example from the Murray-Darling basin of Australia. *Geoderma,* 111, 21-44.

Dent, D. and Young, A., 1981. *Soil Survey and Land Evaluation.* Chapman and Hall, London.

FAO-ISRIC-ISSS, 1998. *World Reference Base for Soil Resources*. World Soil Resources Report 84, FAO, Rome.

FAO-UNESCO., 1994. *Soil map of the world.* Revised legend from FAO world resources report no.60. ISRIC, Wageningen.

Gobin, A., Campling, P., Deckers, J. and Feyen, J., 2000. Integrated toposequence analysis to combine local and scientific knowledge systems. *Geoderma* 97: 103-123.

Habarurema, E. and Steiner, K.G., 1997. Soil Suitability Classification by Farmers in Southern Rwanda. *Geoderma,* 75, 75-87.

Hatibu, N., Mahoo, H., Kajiru, G., Mulengera, M. and Machibya, M., 1999. A study of indigenous knowledge of soil and water, Mahiga village, Sukumaland, Tanzania. Natural Resources Institute, University of Greenwich, UK. 40pp.

Jameson, J.D., 1970. *Agriculture in Uganda* (2nd edition). London, Oxford University Press.

Kundiri, A.M., Jarvis, M.G. and Bullock, P., 1997. Traditional Soils and Land Appraisal on Fadama lands on Northeast Nigeria. *Soil Use and Management* 13: 205-208.

McGlynn, A., Isabirye, M. and Payton, R., 2000a. Soil survey for Toroma village, Katakwi district, Uganda. University of Newcastle, UK.

McGlynn, A., Deckers, J., Isabirye, M. and Payton, R., 2000b. Soil survey for Wera village, Katakwi district, Uganda. University of Newcastle, UK.

Merteens H.C.C., Ndege L.J. and Enserink H.J., 1995. *Dynamics in farming systems: changes in time and space in Sukumaland, Tanzania*. Royal Tropical Institute, Amsterdam, The Netherlands.

Milne G., 1947. A soil reconnaissance journey through parts of Tanganyika territory. *Journal of Ecology,* 35, 192 - 265.

Oruka, F., Oudwater, N. and Martin, A., 2000. A study of indigenous knowledge of soil and water, Toroma village, Katakwi district, Uganda. Natural Resources Institute, University of Greenwich, UK. 48pp.

Oudwater, N., Martin, A. and Kajiru, G., 2000. A study of indigenous knowledge of soil and water, Iteja village, Sukumaland, Tanzania. Natural Resources Institute, University of Greenwich, UK. 52pp.

Pawluk, R.R., Sandor, J.A. and Tabor, J.A., 1992. The role of indigenous knowledge in agricultural development. *Journal of Soil and Water Conservation,* 47, 298-302.

Payton, R.W., Banda, D., Kaihura, F. and Mulengera, M., 2000a. Soil survey of Mahiga village, Kwimba district, Tanzania. University of Newcastle, UK.

Payton, R.W., Banda, D., Kaihura, F. and Mulengera, M., 2000b. Soil survey of Iteja village, Missungwi district, Tanzania. University of Newcastle, UK.

Payton, R.W., Barr, J., Martin, A., Sillitoe, P., Deckers, J., Gowing, J., Hatibu, N., Naseem, S., Tenywa, M. and Zuberi, M., 2003. Contrasting approaches to integrating indigenous knowledge about soils and scientific soil survey in East Africa and Bangladesh. *Geoderma*, 111, 355-386.

Pender, J., Jagger, P. and Nkonya, E., 2004. Development pathways and land management in Uganda. *World Development*, 32: 767-792.

Pretty, J.N., 1995. Participatory Learning for Sustainable Agriculture. *World Development*, 23, 1247-1263.

Sandor, J.A. and Furbee, L., 1996. Indigenous Knowledge and Classification of Soils in the Andes of Southern Peru. *Soil Science Society America Journal*, 60, 1502-1512.

Sillitoe, P., 1998. Knowing the Land: Soil and Land Resource Evaluation and Indigenous Knowledge. *Soil Use and Management*, 14, 188-193.

Simelane, Q.G.S.N., 1999. *A critical assessment of the predictive value of soil maps for on-farm research in Eastern Uganda.* MSc dissertation, University of Newcastle, UK.

Soil Survey Staff., 1998. *Keys to Soil Taxonomy 8th edition*. United States Department of Agriculture Natural Resources Conservation Service, US Government Printing Office, Washington DC.

Tenywa, M., Amamure, J. and Oruka, F., 2000. . A study of indigenous knowledge of soil and water, Wera village, Katakwi district, Uganda. Natural Resources Institute, University of Greenwich, UK. 18pp.

White, R.E., 1997. *Principles and practice of soil science (3rd edition).* Oxford, Blackwell Science, pp. 306-323.

WinklerPrins, A.M.G.A., 1999. Local Soil Knowledge: A Tool for Sustainable Land Management. *Society and Natural Resources,* 12, 151-161.