LOCAL ECOLOGICAL KNOWLEDGE FOR HEALTHY AGRICULTURE

Laxman Joshi[1] and Pratap Shrestha[2]

[1]ICRAF SE Asia, P O Box 161, Bogor 16001, Indonesia
[2]LIBIRD, PO Box 324, Mahendrapool, Pokhara, Nepal

Abstrak

Pengetahuan adalah kekuatan dan dasar untuk perkembangan manusia, serta perbaikan pertanian. Pengetahuan itu merupakan kapasitas manusia untuk memahami dan menginterpretasi apa yang dialami dan apa yang dilihat, serta memampukan manusia untuk memprediksi dan membuat keputusan. Pada saat yang sama, pengetahuan bersifat dinamis dan selalu berkembang. Seperti sistem pengetahuan lain, pengetahuan ekologi lokal (*LEK : local ecological knowledge*) atau sistem pengetahuan petani telah terbentuk dan berkembang seiring dengan waktu. Sebagai bagian dari keseluruhan sistem pengetahuan lokal termasuk aspek sosial dan budaya, LEK dapat berasal dari berbagai sumber yang beragam. Sekalipun demikian LEK merupakan bagian yang mutlak penting dalam perkembangan pertanian.

Tanah bersifat fundamental bagi semua produksi pertanian, dan peranan penting LEK tentang bagaimana mengelolanya secara efisien tidak diragukan lagi. Beberapa aspek pengetahuan ekologi lokal tentang tanah; klasifikasinya, konsep lokal tentang kesuburan tanah, dan pandangan lokal tentang proses ekologi dalam medium tanah diuraikan dalam makalah ini. Makalah ini menyediakan contoh dari tipe dan kedalaman LEK yang dimiliki dan digunakan petani untuk membuat keputusan. Namun, sekalipun terdapat sistem pengetahuan yang canggih, masih terdapat kekurangan dan ketidak-lengkapan sistem pengetahuan lokal. Kami sangat yakin bahwa pengetahuan yang berasal dari penelitian ilmiah dapat menambah nilai dan memperkaya sistem pengetahuan lokal, yang dengan demikian meningkatkan kemampuan petani untuk mengelola sistem pertanian dengan cara yang lebih efektif.

Abstract

Knowledge is power and basis for human development as well as agricultural improvements. It is human capacity to understand and interpret experience and observations and enables prediction and decision-making. At the same time, it is dynamic and evolving. Like any other knowledge system, local knowledge or farmers' knowledge systems have developed and evolved over time. As a part of overall local knowledge system including social and cultural aspects, local ecological knowledge (LEK) may derive from diverse sources. Nevertheless, it is a linchpin in agricultural development.

Soil is fundamental to all agricultural production systems and LEK about how to manage it efficiently is undoubtedly crucial. Some aspects of local ecological knowledge about soil, its classification, local concept of soil fertility and local perception of some ecological processes in the soil medium are described in the paper. This provides examples of type and depth of LEK that farmers have and use in making agricultural decision. However, despite existence of such sophisticated knowledge system, there are obvious gaps and inadequacies in local knowledge systems. We firmly

believe that knowledge generated through scientific investigations can add value to and enrich local knowledge systems thereby enhancing farmers' capability to manage their agriculture system in a more effective manner.

1. Local Knowledge and Its Dynamism

Knowledge is an output of learning, reasoning and perception; it is people's understanding and interpretation based on some explainable logic. It is not necessarily only absolute 'truth'. A set of knowledge and understanding about a specific domain constitutes a knowledge system. Understandably, different groups of people have different knowledge systems. Even individuals may differ in terms of their knowledge systems as their encounter with natural and super-natural processes as well as their method and interpretation may vary.

Figure 1 represents a knowledge system of farmers that is used in management of their natural resources. The natural resource knowledge circle comprises of knowledge about ecological processes, and descriptive knowledge about properties of various elements in agro-ecosystems. This knowledge sphere contrasts with the supernatural knowledge consisting of rules, norms and values assigned by culture, religion or individuals. Some supernatural knowledge may overlap with natural knowledge implying some supernatural knowledge may have an explanation based on natural science.

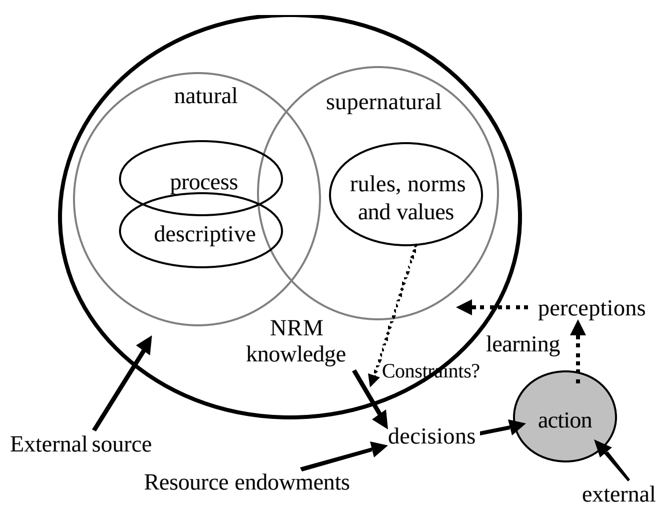

Figure 1. Conceptual diagram of a local knowledge system and link to management decisions.

Knowledge alone does not lead to action. Conditions and constraints due to cultural norms or religious obligations can influence farmers' decisions despite a sound ecological knowledge basis. External factors such as market forces, pertinent policy issues, households financial status may force farmers to opt for ecologically sub-optimal management actions. Farmers, on the other hand, learn from outcome of their actions that enrich or refine their overall knowledge. At the same time, farmers' careful observations of outcome from external actions, such as from research and demonstration farms, neighbours, can also enrich their knowledge systems. Moreover, additional knowledge may also be acquired by farmers from external sources such as radio, television, neighbours, and government extension services. Clearly, any knowledge system is far from static as it is constantly changing and dynamically evolving with time.

In natural resource management existing knowledge systems can be broadly distinguished into two categories: scientific knowledge and local knowledge (Berkes *et al.*, 2000). Scientific knowledge comprises of knowledge generated through scientific investigations carried out mostly by research institutions through carefully designed investigations. Local knowledge on the other hand is mostly derived from farmers' careful observations of various factors and processes and their logical interpretation. The process of deriving local knowledge may be seen as less "formal" than that of scientific knowledge. Ford and Martinez (2000) call this type of farmers' knowledge about their farm and ecology Traditional Ecological Knowledge, a term used to describe the knowledge held by indigenous cultures about their immediate environments and the cultural practices that build on that knowledge. The use of term Local Ecological Knowledge (LEK) is more appropriate as the term "traditional" denotes static; but local knowledge is far from being static.

LEK consists of knowledge locally derived from real world observations, farmers' experiences and their often deliberate experimentation. Local understanding typically differs from scientific knowledge in its level of aggregation. Whereas science has emphasised reductive analysis, farmers tend to think more holistically, with limits imposed on their analysis by what they are able to observe and experience. This creates regularities in local knowledge of natural processes across cultures and regularities in how local knowledge contrasts with scientific understanding. In any particular locality local ecological knowledge is a dynamic resource based upon farmers' observations and experiences of structure and function, related to their priorities and practice. Farmers make decisions and take actions as well as develop new innovations progressively based on their knowledge. In many marginal agro-ecosystems, many resource-poor farmers have developed complex, problem-solving, technical knowledge (Fujisaka, 1997) as well as in conservation of biodiversity and ecosystems (Berkes *et al.,* 2000).

In the following some aspects of local ecological knowledge about soil are highlighted and its implications for developing a healthy agriculture.

2. Local Soil Classification System

In agriculture soil is the basic natural resource farmers rely on and manage for growing their crops. Local knowledge about soil has evolved among farmers through management and long-term association with it. Lack of or insufficient knowledge of local soils can lead to misery and hardship for farmers. Farmers generally use observable characteristics of soil – colour, texture, smell and taste to differentiate between different soil types. The use of below ground soil features and processes by farmers in local soil classification and/or explaining the underlying mechanisms of such classification schemes are, however, normally limited to a few easily observable interactions. Sandor and Furbee (1996) in their study among Lari community in the Colca Valley of Southern Peru, finds that, though farmers are good in textural classification of their soil, there is no evidence of any deeper knowledge.

Scientific studies of local soil knowledge have been predominantly targeted at documenting how farmers classified their soils. Soil colour and texture are the most dominantly and commonly used soil properties across region, agro-ecological zones and culture (Tamang, 1992; Joshi *et al.,* 1995b; Shah, 1995, Talawar and Rhoades, 1998; Shrestha, 2000; Turton and Sherchan, 1996). Hence the use of terms to refer to soil types based on colour (such as black, red, yellow, white soils) and texture (such as sandy and clayey) are almost ubiquitous. Moreover, despite the use of different local terms to name the same soil type, there is in general much similarity in local about important soil properties, such as fertility, drainage, erosivity, manure requirement and moisture retention. Also the classification based on soil-vegetation combination and workability of soils is widespread although actual classification schemes are determined by locally occurring soils and their use.

In the hills of Nepal, farmers use the terms ***malilo*** and ***rukho*** for fertile and unfertile soils. ***Malilo*** soils have high organic matter with few or no stones; are soft and friable; retain moisture for long; absorb and hold nutrients added through manure; can be easily ploughed; and produce good and healthy crop with high yield. On the other hand, ***rukho*** soils are largely sandy usually with a large number of stone, have little or no organic matter, often shallow in depth, retain moisture for short period, do not easily absorb and hold nutrients, difficult for ploughing and produce poor crop with low yield. Farmers know that some soils are inherently ***rukho*** but they have no apparent explanation for this. *Kamere mato* (white calcareous soil with large amount of mica), *Jogi mato* (reddish mixed coloured soil with mottling) and yellow clayey soil fall into this category. Farmers know that crop growth and yield is poor on these soils even a large quantity of animal manure is applied and the availability of other production inputs are adequate.

In southern Rwanda, farmers cited nine major soil types using criteria of soil fertility, depth, structure and colour (Habarurema and Steiner, 1997). More experienced or older farmers used additional parameters such as indicator plants, texture, consistency and parent material. The authors could not detect any correlation between farmer and scientific classification systems. This they explained based on the different ways of appraising soils. Farmers are interested in soil productivity and appropriate management practices and take into account only the topsoil or the arable layer. On the contrary, scientists include deeperlying soil horizons and soil genesis. However, it is important to note that farmers' soil classes correspond to soil suitability classes and these are more relevant for land evaluation purposes.

Sandor and Furbee (1996) report that farmers in Lari community in the Colca Valley of Southern Peru express soil properties as edaphic phrases or functional attributes, such as soils that are wet and "rot roots" (clayey soils), that "need much water" (excessively drained, coarse-textured soils), that are "weak" or "lazy", that "need ash or fertiliser" or that do or do not "grow maize". According to the authors, this knowledge system is widespread in the eastern Andes although variation in name and knowledge exist even within the Colca Valley. Similarly Zuni Indians in New Mexico use soil terms that emphasise surface condition or water infiltration and transport of parent material (Norton *et al.,* 1998).

Indonesian rubber farmers in Jambi classify their soils as *tanah panas* (hot soil) and *tanah dingin* (cool soil). This classification is based on the heating property of soil again related to its physical properties (Table 1). Heating potential is an indicator of sand content in soil. Higher the sand content, faster the soil gets heated under sun, hence the term *tanah panas*. *Tanah dingin,* on the other hand, with higher organic matter and less sand content, remains relatively cool is considered a better soil for crops and trees. The concept of hot and cool soil also exists among farmers in South Sumatra (Hairiah *et al.,* 2000).

Table 1. Farmers' knowledge about soil types in jungle rubber agroforests.

Attribute (comparative)	Tanah dingin	Tanah panas
Speed of heating under sun	Slow	Fast
Sand content	Low	High
Sand particle size	Small	Large
Organic matter content	High	Low
Colour	Dark	Light
Porosity	Low	High
Water holding capacity	High	Low
Fertility value	High	Low
Location (usually)	Forests and hill bottoms	Hill slopes
Erosiveness (under rain)	Low	High

3. Farmers' Perception of Soil Fertility

Soil fertility is an integrated concept of physical, chemical and biological properties, but normally expressed in terms by its agricultural potential. Local perception of soil fertility is generally associated with the production of such soils - how well plants grow and produce in the medium. Understandably, soil nutrients and texture and water availability are not the only determinants of soil fertility. The role of sunshine, weeds, soil pests and diseases as well as how easy or difficult it is to work the soil are embedded within the concept of soil fertility.

Using the *malilo-rukho* attributes of soils, Nepalese farmers perceive that soils of different textural forms interact differently with various factors of production. *Malilo* soil has good ability to absorb and retain nutrients of the applied manure and readily makes available when there is adequate water. The clayey heavy soils are even good in exhibiting this property than sandy light soils. Farmers know different water requirements of light and heavy soil and relate this to availability of soil nutrients for crops. For this reason, farmers rank fertility of light and heavy soil differently based on the amount of rainfall, i.e. fertility of light soil is high when rainfall is moderate and low when rainfall is high as excessive rainfall easily washes away nutrients in the soil. On the other hand, heavy soils require large amount of water to wet before soil nutrients are made available to crops.

Soil fertility concept is also influenced by choice of crop. In Nepal, light soils of unirrigated upland is considered more fertile and suitable for maize cultivation while heavier soil in the irrigated paddy fields are more suitable for paddy cultivation. Crop and varietal selection based on soil fertility is a common practice among many farming communities. Even for paddy, farmers in west Nepal use different varieties to suit different parts of a field that differ in soil fertility (Joshi *et al.*, 1995a). *Guruda*, a local rice variety is planted in poor soils, *Pakhe jarneli* in medium soils and *Battisara* in more fertile soil. Likewise, the farmers prefer less fertile and light soils to very fertile and heavy soil for planting legumes such as beans, cowpeas, peas and soybean as they have observed that vegetative growth is high at the expense of pod production yield in very fertile soils.

Farmers in Don Cao village in Vietnam plant white variety of cassava on fertile slopes while in the same field but in less fertile patches red variety is preferred. This is because farmers know that both red variety, although of lesser quality, in less fertile soil produces as much as the white variety in more fertile soil. Variation to response of crops to fertility of soil is also well known among farmers in slash and burn system in Jambi (Ketterings *et al.*, 1999). This knowledge is employed in the growing a number of crops (chilli, maize, paddy, vegetables and fruit trees) on suitable micro-sites.

Animal manure is the main source of soil fertility in upland hills in Nepal. Quality and amount of animal manure, therefore, is of paramount importance. Farmers report that well decomposed manure is soft and friable, easily mixes with soil and provide nutrient immediately after application like that of awell digested food. Partially decomposed manure, on the other hand, does not mix well with soil and forms cake upon drying. It also increases infestation by insect pests. Again fast decomposing crop residues also influence soil fertility. Wheat root, for example, is very tough and difficult to decompose and may take a year or more to decompose fully. It makes soil *rukho* or infertile hence affects following crops; hence farmers in western Nepal often up-root whole wheat plants instead of harvesting wheat by cutting plant stems near the base.

The knowledge about effects of chemical fertilizers on soils and crops is significant among farmers in west Nepal (Tamang, 1992; Joshi *et al.*, 1995b). Continued application of chemical fertilizers alone hardens soils. This affects crop germination and growth, as well as requires more labour for land preparation. The general perception among farmers is that chemical fertilizers promotes rapid extraction of residual nutrients from soils, hence the soils require increasing quantify of fertilizers each year. On the long run, soil inherently becomes less fertile and "dry" and develops an "addiction" to fertilizers. However, farmers report that the negative aspects of chemical fertilizers can be reduced by mixing chemical fertilizer with animal manure (Shrestha, 2000).

Farmers also relate soil fertility with soil temperature. In the hills of Nepal, weather is generally cold, crop seed germination and plant growth is good only when the soil gets some warmth. Soil temperature decreases with altitude. Soil temperature remains low if soil receives low or no sunshine either because of shade or the slope is north facing (Nepal is in the northern hemisphere, mostly the north facing slopes receive little sunlight). Farmers in high altitudes of western Nepal perceive that application of animal manure increases soil temperature, hence applies more animal manure at higher altitude than at lower altitude fields. Ploughing to expose sub-soil to sun (locally referred to as *mato pakaune* or ripening soil) is another common practice. Burning crop residues in the field is another practice believed to increase soil temperature.

4. Lack of Knowledge about Below Ground Processes?

Local knowledge is often limited to what can be visually observed. Among Nepalese hill farmers, knowledge about root structures of fodder trees is relatively less compared to knowledge about over-ground interface. Farmers in Honduras were unaware of the existence of parasitoids (small, solitary wasps and flies whose larval stages are parasitic on insects that damage crops) and entomopathogens (fungal, bacterial and viral diseases that infect and kill insects) because they could not see them. But the same farmers were able to manipulate natural enemy populations and enhance biological pest control (Bentley, 1994).

Farmers are able to articulate knowledge about below ground interaction to some degree. As stated earlier the terms ***rukho*** and ***malilo*** are used quite generically in the hills of Nepal and trees are also classified based on their effect on soil and other vegetation in the surrounding. The concept of ***malilopan*** (or property of making soil more fertile with positive impact on the surrounding vegetation) includes both the atmospheric interaction and the below ground interaction. Above ground interaction is primarily through shading and water drip effect of which sophisticated understanding of the determinants of these are already known (Thapa *et al.*, 1995). Knowledge about below ground interaction is based largely on an understanding of attributes of plant root system, primarily the depth and spread of roots, rate of litter decomposition. Representation of local knowledge about below ground interaction is shown in Figure 2. The allelopathic effects of different plants through root secretion are not well known to the farmers.

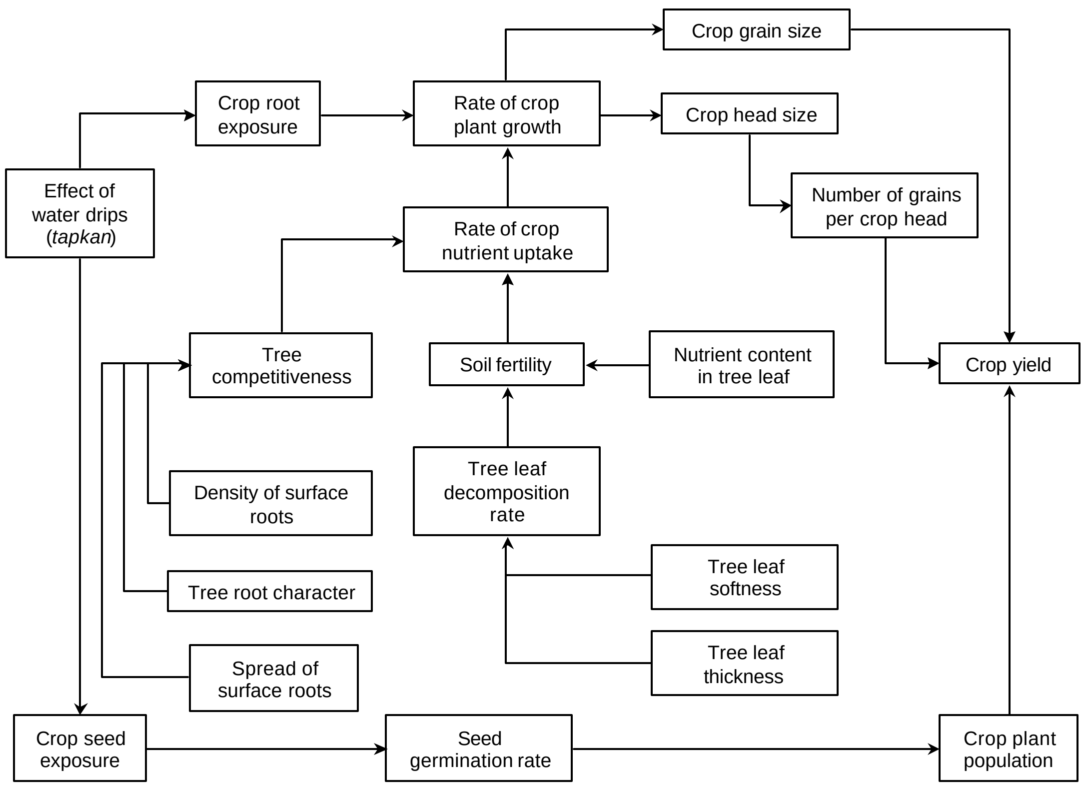

Figure 2. Nepalese hill farmers' knowledge about tree-crop interface below ground level. Nodes represent attributes of trees and other components as recognised by farmers. Arrows represent causal influence.

5. So what?

Despite growing interest and recognition of local knowledge in research and development initiatives, it is important, however, not to over-romanticise over local knowledge. Although some local ecological knowledge about soils and below ground interactions exist among farming communities, this type of knowledge is still less developed compared to above ground interactions. It is clear that there are still large gaps and conflicts in farmers’ local knowledge are common. Science investigation can partially fulfil these gaps and help separate facts from myths. To exemplify, several years of scientific research in west Nepal revealed that much greater nutrient loss is taking place through leaching than had been previously realised (Gardener *et al.*, 2000). Farmers in general have less knowledge about the leaching process and its implications. Sharing of knowledge on this subject with the farmers has motivated them to experiment with hedgerow planting of deep rooted crops to trap and recycle the leached nutrient, which otherwise was very difficult to convince them to adopt.

Below ground interactions and soil studies require careful and strenuous efforts; carefully designed equipment and methods are often necessary. Average farmers neither have the resources nor the capability of doing such detailed process. Formal scientific investigations have enriched our understanding of soils, the underlying processes, nutrient flows and other below ground interactions. Bringing together farmers' local ecological knowledge and scientific observations will lead to a fuller and faster understanding of critical underlying principles and processes in soil and its interactions with other elements of the agricultural production systems. Modelling tools to represent scientific understanding as well as farmers' mental constructs are currently available. The next challenge is to bring these two knowledge systems to complement each other.

It is imperative that advances can be made by scientific investigation of ecological phenomena while cashing on the wealth of local knowledge that has developed through times and believed by farmers. However, it is also equally important that outcome of such scientific investigations are appropriately tested and translated into a form that commensurates with farmers' perceptions and mental constructs. This will both facilitate knowledge exchange between farmers and professionals; and ensure that scientific research has a positive impact on livelihoods of farmers through development of a healthy agriculture.

References

Bentley JW. 1994. Science and people: Honduran campesinos and natural pest control inventions. *Agriculture and human values* 11(2/3): 178-182.

Berkes F, Colding J and C Folke. 2000. Rediscovery of traditional ecological knowledge as adaptive management. *Ecological Applications* 10(5): 1251-1262.

Ford J and D Martinez. 2000. Traditional Ecological Knowledge, Ecosystem Science, and Environmental Management. *Ecological Applications* 10(5): 1249-1250.

Fujisaka S. 1997. Research: Help or hindrance to good farmers in high risk systems? *Agricultural Systems* 54(2): 137-152.

Gardener R, Mawdesley K, Tripathi BR, Gaskin S and A Stuart. 2000. Soil erosion and nutrient loss in the Middle Hills of Nepal. (1996-1998). ARS, NARC, Lumle, Soil Science Division, NARC, Khumaltar, and Queen Mary and Westfield College, University of London, UK.

Habarurema E and KG Steiner. 1997. Soil suitability classification by farmers in southern Rwanda. *Geoderma* 75: 75-87.

Hairiah K, Utami SR, Suprayogo D, Widianto, Sitompul, SM, Sunaryo, Lusiana B, Mulia R, van Noordwijk M and G Cadish. 2000. *Agroforestry on Acid Soils in the Humid Tropics: managing tree-soil-crop interactions*. ICRAF SEA, Bogor.

Joshi KD Sthapit BR and A Vaidya. 1995a. Indigenous methods of maintaining soil fertility and constraints to increasing productivity in the mountain farming systems. *In* Joshi KD, Vaidya A, Tripathi BP and B Pound (eds.), *Formulating a Strategy for Soil Fertility Research in the Hills of Nepal*. Workshop Proceedings, 17-18 August. Lumle Agricultural Research Centre, Pokhara, Nepal and Natrual Resources Institute, Kent, UK, pp. 20-29.

Joshi KD, Tuladhar JK and BR Sthapit. 1995b. Indigenous soil classification systems and their practical utility: A review. In Joshi, K D, Vaidya, A, Tripathi, B P and B Pound (eds.), *Formulating a Strategy for Soil Fertility Research in the Hills of Nepal*. Workshop Proceedings, 17-18 Augut. Lumle Agricultural Research Centre, Pokhara, Nepal and Natrual Resources Institute, Kent, UK, pp. 36-42.

Ketterings QM, Wibowo TT, van Noordwijk M and E Penot. 1999. Farmers' perspectives on slash-and-burn as a land clearing method for small-scale rubber producers in Sepunggur, Jambi Province, Sumatra, Indonesia. *Forest Ecology and Management* 120: 157-169.

Norton JB, Pawluk RR and JA Sandor. 1998. Observation and experience linking science and indigenous knowledge at Zuni, New Mexico. *Journal of Arid Environments*, 39: 331-340.

Sandor JA and L Furbee. 1996. Indigenous knowledge and classification of soils in the Andes of Southern Peru. *Soil Sci. Soc. Am. J.* 60: 1502-1512.

Shah PB. 1995. Indigenous agricultural and soil classification. *In* Schreier H, Shah PB and S Brown (eds.): *Challenges to mountain resource management in Nepal: processes, trends and dynamics in middle mountain watersheds*. Workshop proceedings, April 22-25. ICIMOD, Kathmandu, Nepal, pp. 203-210.

Shrestha PK. 2000. Synthesis of the participatory rural appraisal and farmers' knowledge survey at Landruk, Bandipur and Nayatola. LI-BIRD, Pokhara, Nepal.

Talawar S and RE Rhoades. 1998. Scientific and local classification and management of soils. *Agriculture and Human Values* 15: 3-14.

Tamang D. 1992. Indigenous soil management practice in the hills of Nepal: Lessons from east-west transect. HMG Ministry of Agriculture - Winrock International, Research Report Series No. 19, pp. 59.

Thapa B, Sinclair FL and DH Walker. 1995. Incorporation of indigenous knowledge and perspectives in agroforestry development. Part 2: case study on the impact of explicit representation of farmers' knowledge. *Agroforestry Systems* 30: 249-261.

Turton C and DP Sherchan. 1996. The use of rural peoples' knowledge as a research tool fro soil survey in the eastern hills of Nepal. PAC Occasional Paper No. 21. Pakhribas Agricultural Centre, Dhankuta, Nepal.