Ethnopedological research: a worldwide review

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Abstract

Ethnopedology, a hybrid discipline nurtured by natural as well as social sciences, encompasses all empirical soil and land knowledge systems of rural populations, from the most traditional to the modern ones. The current status of ethnopedology in a worldwide perspective is assessed from a compilation of 895 references with respect to the abundance, distribution, diversity and findings of ethnopedological studies (EPS). EPS are distributed over 61 countries, mainly in Africa, America and Asia, referring to 217 ethnic groups. Geographic density of EPS is positively correlated with linguistic and biological diversities. Most EPS have been carried out in fragile agro-ecological zones, where communities living from limited resources have developed complex land and water management systems to compensate for resource scarcity. Ethnopedological research covers a wide range of topics, centered around four main subjects: (1) the formalization of local soil and land knowledge into classification schemes, (2) the comparison of local and technical soil classifications, (3) the analysis of local land evaluation systems, and (4) the assessment of agro-ecological management practices. From the three main components of ethnopedology, more attention has been given so far to the local cognitive systems (Corpus) and the local management systems (Praxis) than to the local belief and perception systems (Kosmos). Shifting the research emphasis onto the cosmovision of local peoples would improve the contribution of EPS to the formulation and implementation of rural development programmes.

Keywords: ethnopedology, local people, local soil knowledge, worldwide review

Introduction

Ethnopedology aims to understand the indigenous approaches to soil perception, classification and appraisal. Despite thousands of years of validation of practical ethnopedology by indigenous peoples, this has not been historically reflected in soil science research. Often, indigenous soil and land knowledge appears as an exotic corpus of primitive human experience and attitudes related to the soil resource. However, complex pedological wisdom developed more than 2000 years ago in places such as China, Egypt, India and Mexico, which are intimately related with the major centres of plant domestication in the world. In many tropical and subtropical areas, remarkable examples of soil knowledge from non-occidental civilizations still maintain contemporary and potential validity. Since the 16th century, foreign travelers, missionaries and explorers have accounted for vast, complex and sophisticated perceptions of nature, pedological wisdom and land management systems possessed by the colonized 'noble savage' societies of Africa, America, Asia and Australia. However it was only recently that ethnopedology was recognized as a comprehensive discipline. The first structured attempts to acquire soil and land information from indigenous peoples came from social and cultural anthropologists. Cultural and environmental geographers, a few agronomists and some soil scientists have also contributed to the rapidly increasing collection of ethnopedological studies in diverse geographic entities, agro-ecological zones and ethnic territories of the world (e.g. Niemeijer, 1995; Sillitoe, 1998; Barrera-Bassols and Zinck, 1998; Talawar and Rhoades, 1998; Niles, 1999; WinklerPrins, 1999).

To assess the current status of ethnopedology in a worldwide perspective, published papers and grey documents were compiled in a large database of 895 references (Barrera-Bassols and Zinck, 2000). From the reviewed references, 432 (48%) correspond to ethnopedological studies proper (EPS), which specifically focus on the analysis of local soil perception, knowledge and management as the core subject; the other references correspond to studies of broader interest, which provide ethnopedological data within a wider research context. The following conclusions can be drawn from this collection of references with respect to the abundance, distribution, diversity and findings of ethnopedological studies.

Geographic Distribution of EPS

During the last two decades, the number of ethnopedological studies considerably increased. Since 1989, the average production is 33 studies per year. Some specific cultural areas already have an extensive literature on indigenous soil and land knowledge. Middle America (Guatemala and Mexico) and the Andean region (Bolivia, Colombia, Ecuador and Peru) are the most important of such areas in America. West sub-Sahelian Africa, West Africa, East Africa, the Himalayas, India and Southeast Asia also have plentiful EPS. The studied cultural cores cover seven of the major areas of plant domestication and several countries with the highest biological and/or cultural diversity of the world. They have a set of relevant features in common: (1) they form an important part of the major food-producing regions of the world; (2) they are among the major rural regions of the world; (3) they form part of the areas with the highest demographic growth rates; and (4) they are facing increasing human-induced soil degradation. In general, the recent multiplication of EPS is related to an increasing interest in better understanding of non-western societies and local communities as emerging subjects, the failure of conventional rural development as the paradigm of modernization, and the search for local sustainable production systems in traditional rural cultures to counteract the negative effects of globalization.

The 432 EPS of the references database are distributed over 61 countries of which 35% are in Africa, 34% in America, 26% in Asia, 4% in Europe and 1% in the Pacific area (Figure 1). Africa has the highest number of EPS (41%), followed by America (23%), Asia (23%), Europe (8%) and the Pacific (5%). As continents have variable numbers of countries, in fact Africa, America and Asia have been equally addressed by ethnopedological research, with about 50% of the countries in each continent having one or more EPS. In contrast, Europe and the Pacific area have been less studied. Of all tropical areas, the Pacific is the most neglected, although it has an important rural population, many ethnic groups and the highest linguistic diversity. From a worldwide total of 5000 endemic languages, 1600 are spoken in the Pacific islands.

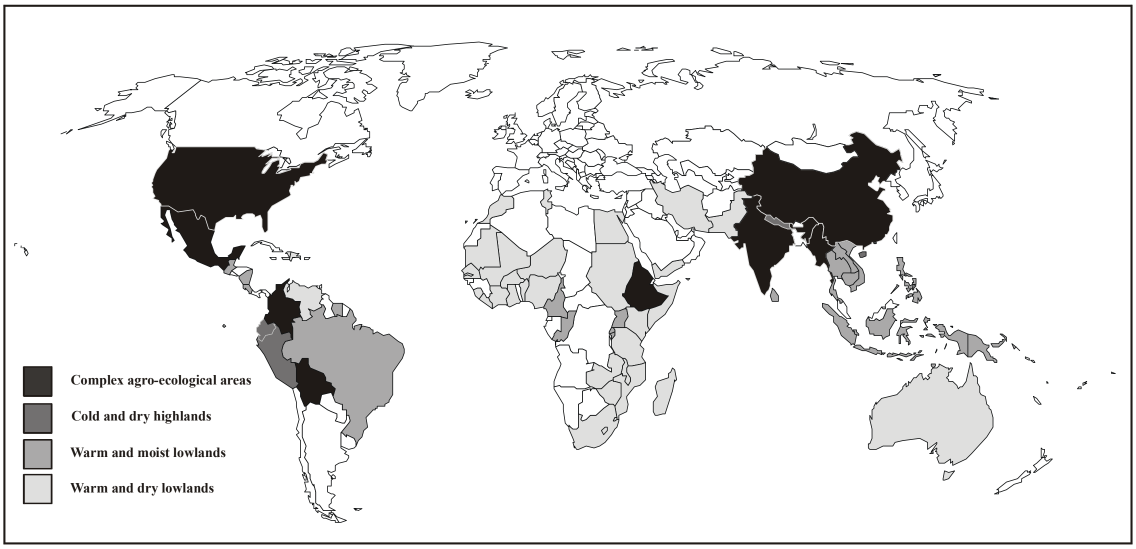

Figure 1 Worldwide distribution of ethnopedological studies per main agro-ecological zones.

Among individual countries, Mexico, Nepal, Peru, Nigeria and India are the most studied, having more than 20 EPS each and concentrating 41% of all EPS recorded in the collection. The current EPS abundance figures do not necessarily reflect intrinsic differences in ethnopedological richness between countries, as access to grey literature, NGOs promoting EPS in some privileged countries and other factors play a role as well.

Agro-ecological zones, broadly defined from a loose combination of elevation, topography and climate, are appropriate environmental units to assess the abundance of EPS. This is the case since local peoples have developed, over time, knowledge and abilities to efficiently exploit and manage the ecological heterogeneity of the landscape. To a large extent, these peoples live in three of the most fragile ecological zones of the world: (1) warm and moist lowlands, (2) warm and dry lowlands, and (3) cold and dry highlands. A remarkable feature is that dry (arid and semi-arid) areas have attracted more ethnopedological research than humid areas. About 66% of the EPS recorded in the database have been carried out in dry-cold highlands and dry-warm lowlands. Semi-arid areas alone account for 37% of the EPS. From a total of 232 studies, which provide specifically agro-ecological information, 29% are located in dry areas. A few selected regions have received particular attention, including the Sahel and sub-Sahelian Africa, semi-arid India and northern Mexico. In these areas, local peoples have developed sophisticated land and water management practices to overcome water scarcity and unpredictable rainfall variability. These areas are also exposed to severe land degradation because of intensive land pressure following rapid population growth, resources depletion through uncontrolled over-exploitation, and mismanagement of irrigation schemes. Furthermore, dry environments are particularly sensitive to global climate change and therefore strongly famine-prone.

Comparatively, the tropical warm and moist lowlands have received less attention, concentrating 34% of the EPS, with 21% in the humid tropics and 13% in the sub-humid ones. Even less attractive so far have been the temperate environments, with only 13 EPS (mainly from Mexico), representing 5% of the studies recorded. Similarly, cold areas account for only 16% of the EPS, concentrated in the Himalayan and Andean highlands. Altogether, the tropical zone has by far the highest number of EPS (186 studies, 72%). Within this general context, the most frequently studied areas include (1) the dry tropics in Africa, Asia and America, and (2) the moist tropical lowlands in Brazil, West Africa, Mexico and Southeast Asia. The 15 countries with the highest numbers of EPS cover the most fragile agro-ecological zones of the world and correspond to the countries with high indices of extreme poverty and severe land degradation.

Peoples and Ethnopedological Diversity

In total, 217 ethnic groups have one or more EPS, 35% in America, 33% in Africa, 28% in Asia and 4% in the Pacific area. Mexico and India together cover 18% of all ethnic groups having ethnopedological information. In Mexico alone, 41% of the country's ethnic groups (56 in total) have been studied from an ethnopedological point of view. Taking into account the existence of about 5000 endemic languages, barely 5% of the global ethnopedological knowledge has been addressed. About 90% of ocal languages, now used by small ethnic groups, are likely to vanish during the next century. Since oral tradition conveys the local wisdom and know-how from generation to generation, ethnopedological richness parallels linguistic diversity. As many endemic languages are threatened with disappearance, ethnopedological knowledge will also get lost. This highlights the magnitude of the effort needed to make the inventory of and analyze the peculiar forms of perception, knowledge and management of the soil and land resources by indigenous peoples before they disappear altogether. It is expected that the loss of linguistic diversity will be 500 times larger than that of biological diversity. This means that the loss of ethnopedological knowledge might be of considerable proportions, qualitatively as well as quantitatively. Eight of the 15 countries with the highest numbers of EPS (from 9 to 71) belong to the 19 countries with the largest linguistic diversity. Linguistic diversity is extremely high (megadiversity) in Indonesia and Papua New Guinea, very high in India and Mexico, and high in Brazil, the Philippines, Tanzania and Nepal (Figure 2). There is thus a clear relationship between linguistic and ethnopedological diversities.

A similar high correlation links ethnopedological richness to biological diversity. Countries with extremely high and very high biological diversity and having, at the same time, large numbers of EPS include Brazil, Indonesia, Mexico, Peru, Papua New Guinea, India and the Philippines (Figure 3).

There is also a strong relationship between the original centers of plant domestication in the world and the density of EPS. Eleven out of 15 countries with large numbers of EPS match six of the 12 early domestication centers. They include Mexico (South Mexico–Central America center), Peru and Bolivia (South America center), Brazil (Southern Brazil–Paraguay center), Nigeria (West Africa center), India and Nepal (India–Burma center), and Indonesia, Thailand, Papua New Guinea and the Philippines (Indo–Malaya center). These same countries also belong to the major food production areas of the world

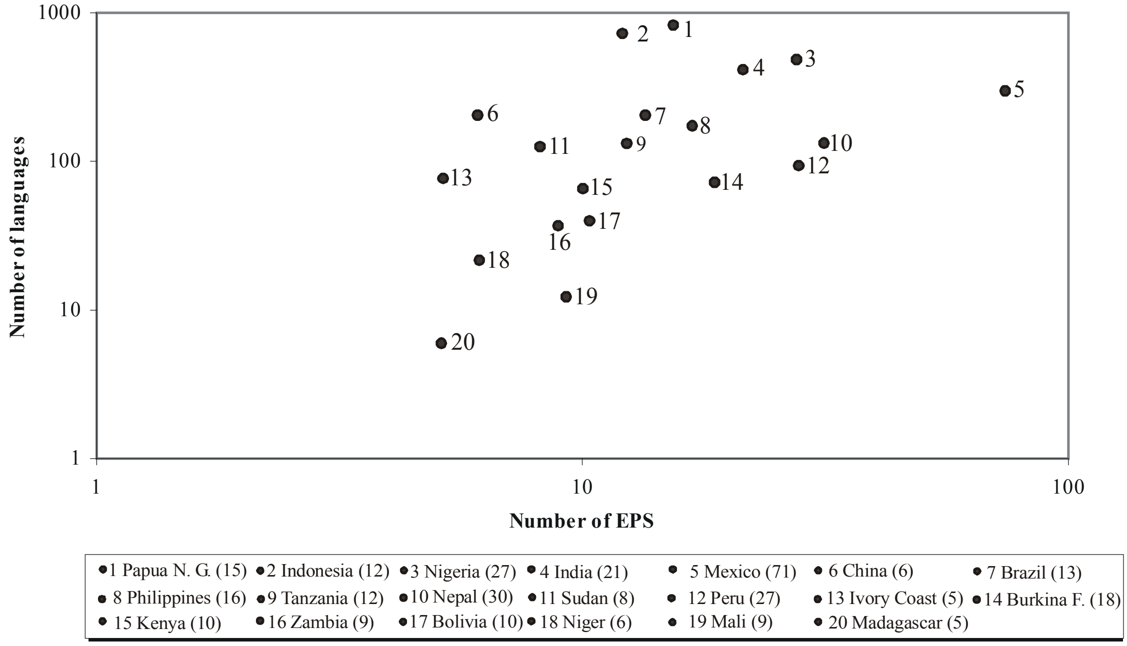

Figure 2 Relationship between variety of local languages and abundance of ethnopedological studies (EPS), considering 20 countries with the highest linguistic diversity and with 5 or more EPS (from 5 to 71 EPS).

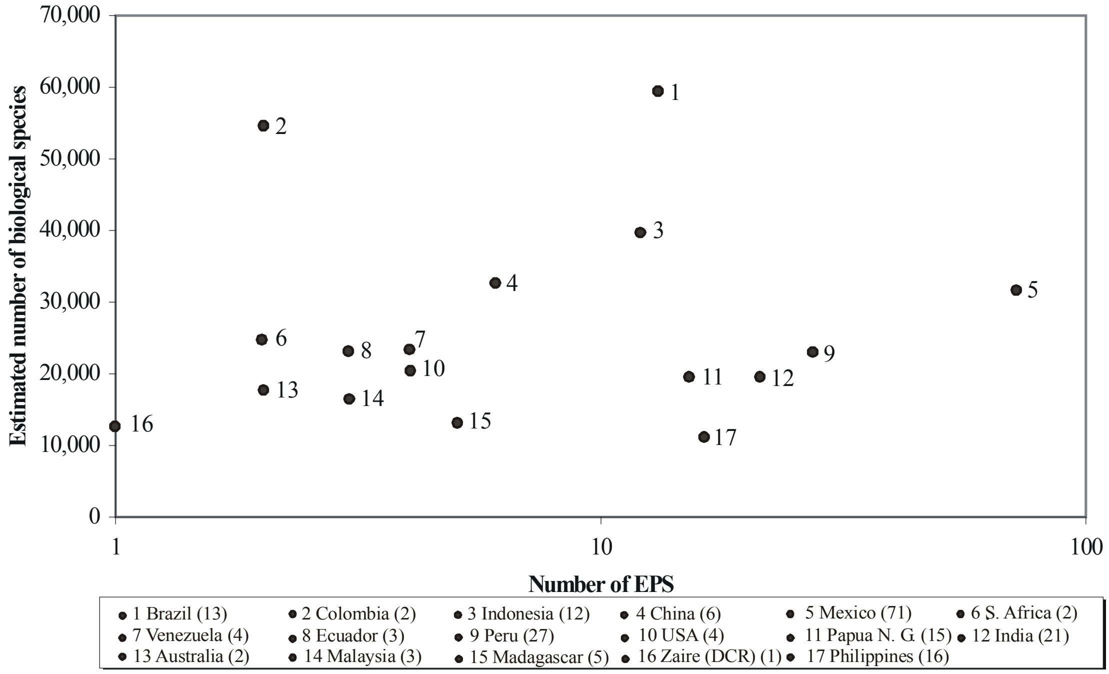

Figure 3 Relationship between variety of biological species (mammals, birds, reptiles, batrachians, and vascular plants) and abundance of ethnopedological studies (EPS), considering 17 countries with highest biodiversity and with ethnopedological information (from 1 to 71 EPS).

Research fields and Topical Diversity of EPS

Ethnopedology encompasses all empirical soil and land knowledge systems of rural populations, from the most traditional to the modern ones. It analyzes the role of soil and land in the natural resource management process as part of given ecological and economic rationale. Soil and land are explored as (1) polysemic cognitive domains, (2) multiple-use natural resources, and (3) objects of symbolic meanings and values. Perception (Kosmos), knowledge (Corpus) and management practices (Praxis)-the K-C-P complex-articulate the empirical wisdom of local people about the soil resource. Synonymous terms include traditional, folk, local, indigenous, farmers' and peoples' soil knowledge systems (Ettema, 1994). The main research fields of ethnopedology include:

- Beliefs, myths, rituals and other symbolic meanings, values and practices related to land management and soil quality evaluation;
- Local classification nomenclatures, and soil and land taxonomies;
- Local soil and land resource perception, and explanation of the structure, distribution, properties, processes and dynamics of the soil mantle;
- Local knowledge on soil and land relationships with other biophysical factors, elements and processes;
- Local land uses and soil management practices;
- Local adaptation, renewal and transformation strategies of soil properties and land qualities;
- Co-validation of ethnopedological knowledge, abilities and skills with modern soil science, geopedological survey, agroecological strategies, agricultural and other rural practices, to promote participatory land evaluation and land use planning procedures for endogenous sustainable development.

The EPS review shows a lack of method and technique integration, contrasting with the holistic nature of the traditional knowledge. Initially, classic ethnographic studies focused on the linguistic analysis of local soil and land classification systems, while the comparative approach aimed at establishing similarities and differences between local knowledge and scientific information. More recently, interest has shifted towards a more integral approach, which emphasizes the cultural context to support sustainable land management modeling with the participation of the local actors.

Peoples' cosmovision, including beliefs, perceptions and rituals (the Kosmos sphere) has been approached in only 69 out of 432 EPS (16%). This reflects relatively little interest for the subjective component of indigenous knowledge. The latter is, however, of fundamental importance when formulating development projects and planning rural land use. Neglecting cultural context and rules has led to the failure of many development programmes in the Third World. A large number of EPS (245 studies, 57%) addresses, among other topical fields, the analysis of the local cognitive systems, including knowledge and classification (the Corpus sphere). A significant research domain (158 EPS, 36%) is on ethnopedological taxonomies and the comparison of local and scientific soil and land classifications. A similar dominant trend exists in ethnobiological studies and other ethnosciences. A third field of interest in EPS focuses on the inventory and analysis of local management practices (the Praxis sphere). This topic is not restricted to EPS and comes up frequently in studies of broad ethnopedological interest as well (in total 532 out of the 895 recorded references). Of note in this context is the importance devoted to the indigenous soil and water conservation practices (ISWC) in 113 EPS, carried out mainly in arid and semi-arid areas including the cold and dry highlands. These EPS focus on the inventory and implementation of local practices, mechanical as well as biological ones, but often neglect to scrutinize the cosmovision context that could explain why and when the practices are used. Finally, a growing number of EPS deals with soil fertility management (72 EPS), soil conservation and erosion control (72 EPS), and soil management in general (92 EPS). This reflects an increasing concern for the land degradation issue and the importance of soil management at field level. Also, more and more attention is given to spatial soil variability as related to the genetic diversity of cultivars, the pattern of intensive polycultural land use, and the management of specific agro-ecological niches.

Main Research Findings

Ethnopedological research findings center around four main subjects: (1) the formalization of local soil and land knowledge into classification schemes, (2) the comparison of local and technical soil classifications, (3) the analysis of local land evaluation systems, and (4) the assessment of agro-ecological management practices.

Classification Principles, Categories and Classes

Major approaches to soil and land classification by indigenous peoples were derived from the comparative analysis of a set of ethnopedological studies, which record traditional taxonomic systems implemented by 62 ethnic groups located in 25 countries in Africa, America and Asia.

- In spite of methodological inconsistency among the studies, making the comparative analysis cumbersome, some general principles can be identified, including: (1) the existence of complex systems of indigenous knowledge about the hierarchical organization of the soil mantle; (2) the recognition and implementation of morphological attributes for soil classification, which are at the same time dynamic, utilitarian and symbolic; (3) the use of similarities and differences between soil bodies for constructing multi-categorical classification systems; and (4) the existence of universal criteria in all ethnopedological classification systems.
- Although indigenous knowledge about soil and land resources is widely shared by all members of a community, there are differences in wisdom among people according to age, gender, social status and experience. The same questions about the soil system might be given different answers by local people, which together constitute the ethnopedological knowledge of a community and its social theory of the soil system.
- The multipurpose character of the ethnopedological classifications implies variable ways to organize and distribute the soil classes within a multi-level system. The inclusion or exclusion of given soil classes, their variable positioning in the categories of the system, all depend on the classification criteria assigned, which might be ecological, morphological, productive or symbolic, among others.
- Four sets of classification criteria are used by the sampled ethnic groups. The proportion of the groups implementing a given criterion is indicated as a percentage of the total number of groups. The four sets are: (1) color (100%) and texture (98%); (2) consistence (56%) and soil moisture (55%); (3) organic matter, stoniness, topography,

land use and drainage (between 34% and 48%); and (4) fertility, productivity, workability, structure, depth and soil temperature (between 2% and 26%).

- The diagnostic attributes most frequently used to label soil classes are morphological ones. Among these, color and texture are the most representative. More comprehensive attributes, such as fertility or workability, which are in fact land qualities, are less implemented. Of note is that there is no clear-cut distinction between soil and land characteristics.
- Unlike the ethnobotanical and ethnozoological classifications, the ethnopedological classifications generally start, at the higher level of the system, with a comprehensive realm concept including all “soils”, the equivalent of Plantae or Animalae in the other natural realms.
- Unlike the ethnobiological taxonomic systems, which cluster only selected species occurring locally, the ethnopedological classifications generally include all or most of the soil classes encountered locally.
- Considering all studies included in the inventory, the number of taxa (soil classes) belonging to the different systems recorded varies from 3 to 24. The average number of taxa recognized per ethnic group is 12. More than half (56%) of the sampled groups work with 8 to 14 taxa.

Comparison of Local and Technical Soil Classifications

There are some significant similarities and complementarities between indigenous and scientific soil taxonomic systems showing potential synergism, especially for solving problems related with soil and land management. A few examples are provided to illustrate this potentially fertile research area.

A cluster analysis of related soil morphological attributes highlights a close correspondence with an indigenous soil classification system from Northeastern Brazil. Thus, the empirical soil classification could be a useful framework for objectively grouping morphologically similar soils. The clustering of non-morphological attributes around key parameters, such as moisture and pH, and the comparison with main indigenous soil classes also show that indigenous soil taxonomy provides a reasonable framework for the preliminary stratification of soils for management purposes (Stacishin de Queiroz and Norton, 1992).

Ten years of ethnopedological research findings in the Himalayas demonstrate a close correlation between indigenous and conventional soil taxonomies (Tamang, 1993). Most of the indigenous classes can be readily converted into commonly used scientific classification schemes. Also, a close correlation between indigenous soil colour classes and soil chemical conditions reveals that farmers are well aware of the unique differences between soil colour and associated properties. Furthermore, there is a strong correlation between indigenous land classes and soil fertility. Local land quality classes for agricultural purposes correlate well with selected chemical properties (e.g. levels of cation exchange capacity and exchangeable cations), particularly in those soils which have not been altered by chemical fertilizers (Shah, 1995).

Indigenous and conventional knowledge systems are equally limited in their abilities to mitigate and prevent actual soil erosion hazards in the Himalayas. Both, however, also have extensive complementarities, considering the time frame and spatial scale of the responses provided by each system. Indigenous knowledge responds primarily over the long-term and takes into account off-site effects of soil loss. Complex soil-landscape management and land use planning strategies constitute local responses to each specific erosion event over a decadal perspective. In contrast, conventional science primarily formulates general responses to individual erosion events and operates fundamentally on the site and over the short-term. Structural and vegetative techniques are implemented to reduce downstream sedimentation. The complementation of local and conventional approaches and techniques in the Shivalik Himalayas in India promotes increased productivity and drastically reduces sedimentation in eroded agricultural lands (Scott and Walter, 1993).

One of the main issues mentioned in several ethnopedological reports is the inconsistency of indigenous soil knowledge at a regional scale. Indigenous soil and land classes are often named and characterized differently by members of the same ethnic group but from different villages, while technical soil surveys indicate a regional distribution of the same soil classes. This could result from the application of unsuitable research techniques or from real historical or cultural differences. Indeed, examples of ethnopedological research in Mexico reveal the existence of a region-wide soil knowledge among Maya, Nahua, Otomi and Purhépecha peoples. The naming and characterization of soil and land classes are relatively homogeneous over thousands of square kilometers, forming a regional "folk soil culture". Over the last 15 years, a methodological approach was developed in Mexico to map indigenous soil units at plot, local and regional scales; this contributed to strengthening the ethnopedological survey and rural land use planning (Ortíz-Solorio *et al.,* 1989). The combination of photo-interpretation and ethnopedological survey has revealed, in some cases, close correspondence between conventional soil map units and ethnopedological map units.

Local Land Evaluation Systems

Many ethnic groups have created their own land evaluation systems for agricultural purposes. Assessment criteria, requiring a sophisticated micro-environmental knowledge, are used to establish multiple cropping systems (Lawas and Lunning, 1997). In general, land use decisions made by local people are more accurate and better adapted than the technical recommendations forwarded by extensionists. The integration of both knowledge sources, using geographic information systems-GIS-(Brodnig and Mayer-Schönberger, 2000) and knowledge-based systems-KBS-(Furbee, 1989; Guillet, 1992) for land evaluation and land use planning, is a promising new stream of research and application.

Agro-Ecological Management Practices

Land and water management by indigenous groups varies in accordance with the conditions prevailing in each ecological zone. In the warm and moist lowlands, the indigenous perception, knowledge and management of land center on fertility conservation or restoration using complex agro-ecological systems. Farming strategies mobilize an accurate knowledge of the micro-local soil conditions to select a variety of adapted crop associations. Usually, agricultural fields are densely covered with plants to maintain soil productivity. Color changes in the topsoil are used to monitor the fertility status and for early identification of potential productivity decline.

In the warm and dry lowlands, the main issue of crop production is the scarcity and irregularity of rain water supply. Local techniques have been developed for water harvesting and soil moisture conservation, especially in Africa (Reij *et al.,* 1996). Common indigenous land management strategies include soil protection from erosion, salinization control, moisture maintenance in the arable layer, and disposal of sediments carried by intermittent streams.

In the cold and dry highlands, indigenous wisdom concentrates on protecting the soil from erosion and mitigating the effect of natural hazards on soil fertility. A variety of ethnopedological studies has been carried out in the Andes (Sandor and Eash, 1995) and in the Himalayas (Tamang, 1993) to investigate the local techniques used for terrace and bench construction.

Relevant Issues to be Tackled

To overcome the traditional controversy between utilitarian and scientific, or between relativist and universalistic knowledge, some relevant issues have still to be tackled:

- There is a need to surpass the classificatory approach as the main or only ethnopedological research aim. More important than classifying is focusing on the management of the soil and land resources.
- There is a need for an interdisciplinary integration of natural and social sciences, that surpasses the cognitive studies of soil and land as ‘perceived natural objects’ and focuses on the different ways social subjects engage symbolically, cognitively and practically with soil and land resources. In this sense, the narrow notion of ‘indigenous technical knowledge’ cannot be abstracted from its cultural context.
- There is a need to fully understand the local context as a complex, dynamic and open system where soil and land knowledge is applied in diverse ways according to ever-changing individual and social realities.
- There is a need for establishing a participatory appraisal aimed to link local actors and researchers in a mutual exchange, negotiation and continuing learning process.

Conclusion

Peoples’ knowledge about soils and their management constitutes a complex wisdom system, with some universal principles and categories similar or complementary to those used by modern soil science. Although an integral ethnopedological approach needs still to be developed, by combining the current trends, a promising bottom-up approach is gaining interest among scientists and farmers. Synergism could be strengthened by the implementation of GIS and KBS to integrate modern scientific and technical advances with historical wisdom and local needs.

At a worldwide scale, EPS are unevenly distributed. Some geographic entities, from continental to village levels, have been privileged, others neglected. The frequency of studies decreases from Africa to America, Asia, the Pacific and Europe. Large differences in study density occur within subcontinents, countries and subdivisions of countries. Individual countries, which have particularly attracted the interest of researchers and provided a substantial number of the references, are Mexico, Nepal, Peru, Nigeria and India. Within countries, the village is the preferred study level, as the majority of EPS focuses on the perception, knowledge and management of the soil resource at the local level. Since most EPS are concentrated in a few countries, the result is that some ethnic groups have received more attention than others.

Communities living in harsh environments, with limited resources, have developed complex land and water management systems to compensate for resource scarcity. Surviving indigenous communities are often restricted to marginal lands, while the better soils are devoted to large-scale, market-oriented, mechanized agriculture. Therefore, EPS concentrate in a few broadly defined agro-ecological zones. Highest densities of EPS occur in dry lowlands and highlands, where the need for efficient handling of scarce natural resources has fostered intimate co-evolution of eco- and socio- systems.

The present imbalance of topical research between the Kosmos, Corpus and Praxis spheres, respectively, suggests that more emphasis should be given to analyzing the role of beliefs, perceptions and rituals in decision-making by local peoples about land use management. Shifting the research emphasis onto Kosmos needs the support of and interaction with the local communities, especially those which are still able to maintain their K–C–P systems active for the preservation of the soil quality and that of the agro– and biodiversity. Without the participation of the local actors in the formulation and implementation of rural development programmes, the EPS would loose their practical relevance, as is often the case with conventional soil inventories.

References

Barrera-Bassols, N. and J.A. Zinck. 1998. The other pedology: empirical wisdom of local people. *In* Proceedings of 16th World Congress of Soil Science. ISSS/AFES, Montpellier, France: CD-ROM.

Barrera-Bassols, N. and J.A. Zinck. 2000. Ethnopedology in a Worldwide Perspective. An Annotated Bibliography. ITC Publication 77, Enschede, the Netherlands.

Brodnig, G. and V. Mayer-Schönberger. 2000. Bridging the gap: the role of spatial information technologies in the integration of traditional environmental knowledge and Western science. The Electronic Journal on Information Systems in Developing Countries Vol. 1 (January 2000): 16 p. (www).

Ettema, Ch. H. 1994. Indigenous Soil Classifications. What are their Structure and Function and How do they Compare with Scientific Soil Classifications. Institute of Ecology, University of Georgia, Athens, Georgia, USA. (www).

Furbee, L. 1989. A folk expert system: soils classification in the Colca Valley, Peru. Anthropological Quarterly 62 (2):83-102.

Guillet, D.W. 1992. Crop choice and soil management, pp. 67-84. *In* D.W. Guillet (ed.). Covering Ground: Communal Water Management and the State in the Peruvian Highlands. The University of Michigan Press, Ann Arbor, Michigan, USA.

Lawas, M.C. and H.A. Luning. 1997. Capturing resource user's knowledge in a geographic information system for land resource management. Geographical Studies of Development and Resource Use 1997-2: 27.

Niemeijer, D. 1995. Indigenous soil classifications: complications and considerations. Indigenous Knowledge and Development Monitor 3:20-21.

Niles, R.K. 1999. Indigenous Knowledge for the Classification, Management and Conservation of Soil. Bibliography and Selected Abstracts. Natural Resource Ecology Laboratory, Colorado State University, Fort Collins, Colorado, USA. (www)

Ortíz-Solorio, C.A., D. Pájaro and V. Ordaz. 1989. Manual para la cartografía de clases de tierras campesinas. Cuadernos de Edafología 15: 62.

Reij, C., I. Scoones and C. Toulmin, eds. 1996. Sustaining the Soil. Indigenous Soil and Water Conservation in Africa. Earthscan, London, UK.

Sandor, J.A. and N.S. Eash. 1995. Ancient agricultural soils in the Andes of southern Peru. Soil Science Society of America Journal 59(1):170-179.

Scott, C.A. and M.F. Walter. 1993. Local knowledge and conventional soil science approaches to erosional processes in the Shivalik Himalaya. Mountain Research and Development 13(1):61-72.

Shah, P.B. 1995. Indigenous agricultural land and soil classifications. *In* H. Schreier, P. B. Shah and S. Brown (eds.). Challenges in Mountain Resource Management in Nepal. Processes, Trends and Dynamics in Middle Mountain Watershed. IDRC/ICIMOD, Kathmandu, Nepal.

Sillitoe, P. 1998. Knowing the land: soil and land resource evaluation and indigenous knowledge. Soil Use and Management 14(4):188-193.

Stacishin de Queiroz, J. and B.E. Norton. 1992. An assessment of an indigenous soil classification used in the Caatinga region of Ceará State, Northeast Brazil. Agricultural Systems 39:289-305.

Talawar, S. and R.E. Rhoades. 1998. Scientific and local classification and management of soils. Agriculture and Human 15:3-14.

Tamang, D. 1993. Living in a fragile ecosystem: indigenous soil management in the hills of Nepal. International Institute for Environment and Development, Gatekeeper Series 41:23.

WinklerPrins, A.M.G.A. 1999. Local soil knowledge: a tool for sustainable land management. Society and Natural Resources 11(7):151-166.