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Using Indigenous Knowledge to Improve Agriculture and Natural Resource Management

BILLIE R. DEWALT

Scientific knowledge systems have received increasing criticism within the social science literature while indigenous knowledge systems are often over-optimistically presented as viable alternative ways of knowing. This paper argues that we need to search for more effective and creative interactions between indigenous knowledge and scientific knowledge systems. I discuss the strengths and the weaknesses of both scientific and indigenous knowledge systems, then use three examples to illustrate the strengths and limitations of indigenous knowledge systems. I then draw on these examples to indicate in what situations we should look for guidance and ideas from indigenous knowledge systems. The paper closes with a discussion of how scientists, social scientists and people with local knowledge can better work together to improve agricultural and natural resource management systems.

Key words: agriculture, indigenous knowledge systems, natural resource management, philosophy of science

RECENT YEARS have seen an increasingly polemical debate concerning how well agricultural science and technology have performed in developing solutions to problems of increasing agricultural production and alleviating world hunger. On the one hand are those individuals who argue that agricultural science has been extraordinarily effective in increasing food production, thus staving off Malthusian predictions of mass starvation. These individuals argue that further applications of science are needed because of continuing population growth.

Especially among humanists and social scientists, however, there is an increasing questioning of agricultural science and technology because their application has not led to socially just or ecologically sustainable societies. The world is producing far more food per capita, but much of this food has been used to provide those with economic means to have an increasingly affluent diet while there are still masses of starving people. Further, there is a growing recognition that the technologies used for this increased production are not sustainable and, in many cases, environmentally damaging (Brown 1989, Commoner 1971, Hightower 1973).

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Construction (or in many cases, reconstruction) of a more sustainable and socially just agriculture has led many individuals to argue that we need to give greater attention to indigenous knowledge systems (Brokensha, Warren, and Werner 1980; Richards 1985; Thrupp 1989; Warren 1991a). Their arguments are based on: 1) the need to create more appropriate and environmentally friendly technologies; 2) empowering people like farmers to have greater control over their own destinies; and 3) creating technologies that will have more just socioeconomic implications.

This literature has often been ignored by agricultural scientists because of the sometimes missionary fervor with which proponents preach the virtues of indigenous knowledge systems.[1] Scientists are blamed for the ecological and inequality problems that exist and the implication made is that all we need do is learn the local knowledge systems of farmers and we will have many of the answers to development ills. Agricultural scientists are understandably wary of such perspectives.

My purpose in this paper will be to establish a framework for creating more effective and creative interactions between indigenous knowledge and scientific knowledge systems. I will first discuss the strengths and the weaknesses of both scientific and indigenous knowledge systems, then use three examples to illustrate the strengths and limitations of indigenous knowledge systems. I will draw on these examples to indicate in what situations we should look for guidance and ideas from indigenous knowledge systems. I will close with a discussion of how scientists, social scientists and people with local knowledge can better work together to improve agricultural and natural resource management systems.

"Traditional" Scientific Knowledge Systems

Table 1 summarizes, based on a diversity of positive and negative critiques, the means by which scientific knowledge systems work, the implications of these systems for utilization of resources such as land, labor, and capital, and the outputs of such systems. While it might be argued by scientists that their methods do not necessarily imply the kinds of resource utilization and goals found in Table 1, many analysts of trends in world agriculture see these as potential problems (e.g., Brown 1989, Commoner 1971, Hightower 1973, NRC 1989, Pimentel and Pimentel 1979). Most of them can also be found in the currently fashionable "post-modernist" critiques of scientific knowledge systems.

Following many other critiques of science, for example, Kloppenburg argues that the approach used to produce scientific facts is Cartesian reductionism, or the process of ". . . breaking a problem down into discrete components, analyzing these separate parts in isolation from each other, and then reconstructing the system from the interpretations of the parts" (1991:530). Further, he follows Latour in suggesting that the goal of science is to produce "immutable mobiles" (Latour 1986:7–14)—information that can be transferred without transformation to any spatial or social location. That is, science searches for knowledge that does not change depending on the context (i.e., is immutable), thus it should be possible to easily relocate knowledge from the specific circumstances in which it is created to other contexts (i.e., make it mobile).

The strengths of scientists are that a) they come to know an extraordinary amount about very limited areas of knowledge; b) they become very savvy about the principles or mechanisms by which things work (through the construction of theoretical knowledge); c) they have a very effective means—the scientific method—by which to approach problems and to engage in explanation; and d) the knowledge that is produced is transferable across time, space and societal setting.[2]

As practiced, these strengths have also created problems for science. The reductionism of science often leads to a woeful ignorance of the wider context within which the particular phenomena under study occur. One problem is that the selection of phenomena to be studied is determined by the ability to break it down to "researchable pieces." Complex systems and those characterized by myriad interactions are likely to be ignored. A second problem is that scientists often advocate the change of one part of the system without paying attention to the results for the overall system.[3] A third problem is the tendency to focus only on the short term, not looking at what the potential long term implications of a change in technology might be.

More problematic perhaps is that science has created a certain hubris among those who practice it. Many scientists have lost touch with the ultimate goals of what they are trying to accomplish because of their isolation. As Kloppenburg (1991:530) puts it: "As Cartesian science is elaborated and institutionalized in laboratories, it loses touch with the local knowledge and everyday experiences . . ." At its worst, this attitude leads to an assertion that research is value-free and that scientists need not be concerned about the ethical, social, or ecological consequences of their research. More benign, but potentially as dangerous, is that scientists denigrate the knowledge and experience of non-scientists.

Thus, the applications of science to agriculture and natural resource utilization have led to the characteristics listed in Table 1. Agricultural systems all over the world are increasingly dependent on high inputs of external resources (e.g., fertilizer, machinery, pesticides), increasingly specialized (e.g., monoculture is dominant), oriented to satisfying the needs of a fickle market (creating the familiar boom and bust cycles in agricultural products like bananas, coffee, sugar, cacao, cotton, and a host of others), and labor-saving and land-intensive (Ruttan and Hayami 1990). The consequences of these systems that search for profit as the ultimate goal are relatively low productivity for energy inputs (Pimentel and Pimentel 1979), cultural disjunctions as corporate interests and enterprises replace family and community-based production systems, and potentially dangerous degradation of ecological systems. Because of the high energy inputs and natural resource destruction caused by these systems, there is an increasing recognition that they are not sustainable.

TABLE 1 Current Knowledge System Characteristics

Traditional scientific knowledge systems	Traditional indigenous knowledge systems
Means used to study phenomena	
Specialized, partial	General, holistic
Based on experimentation	Based on observation
Immutable mobiles	Mutable immobiles
Resource utilization characteristics	
Dependent on external resources	Dependent on local resources
High input	Low input
Land intensive	Land extensive
Labor saving	Labor demanding
Market risk	Environmental risk
Specialized adaptive strategies	Diverse adaptive strategies
Outputs	
Low productivity for energy inputs	Low productivity for labor inputs
Cultural disjunctions	Culturally compatible
Profit goals	Subsistence goals
High potential for degradation	Low potential for degradation
Not sustainable	Sustainable with low population densities

"Traditional" Indigenous Knowledge Systems

As part of the general criticisms that have been made of science in recent years, some philosophers of science (e.g., Feyerabend 1975) and social theorists (e.g., Lyotard 1985) have asserted that science is just one among many ways of knowing about the world. It has also become fashionable to imbue indigenous or local knowledge systems with a sanctity or "truth" that can inform us about ways to solve the world's problems (Brokensha, Warren, and Werner 1980; Richards 1985). Some characteristics of indigenous knowledge systems that can assist in this realm have been summarized as follows:

> Some features of indigenous knowledge which give it salient relevance to sustainable development planning are its conformity to high labor and low capital demands; dynamics, having evolved over centuries; locally appropriate nature; cognizance of diversified production systems; emphasis on survival first and avoidance of risk; rational decision-making; various adaptive strategies for use at times of stress (e.g. drought and famine); ingenious system of intercropping; integration with social

institutions; and flexibility, with considerable potential entrepreneurial abilities (Vanek 1989:167).

As with science, however, we need to recognize the potential strengths and weaknesses of indigenous knowledge systems. Table 1 includes a summary of the characteristics of indigenous knowledge systems.

Perhaps the greatest strength, as well as the greatest weakness of these knowledge systems, is that they are local. As Kloppenburg has pointed out, local knowledge produces what he calls "mutable immobiles"—relatively malleable knowledge that is finely tuned to the continually changing circumstances that define a particular locality (1991:531). That is, the comparative advantage of local people is that: a) they are very savvy about their local environment and have accumulated a lot of experience concerning those things that affect their existence; b) many of them have a keen awareness of the interconnectedness of plants, animals and soils—their interrelationships and ecology; and c) they have become very ingenious at making do with the natural and mechanical resources at their disposal.[4] The problem is that indigenous knowledge is very rich in contextual detail but is immobile, having little utility outside of particular places (Kloppenburg 1991:531).

In terms of resource utilization, indigenous knowledge systems are likely to be much more dependent on local rather than external resources. People generally employ a diversity of adaptive strategies in order to survive. Agriculture is generally low-input, land-extensive (although in parts of China, Indonesia, the Philippines and some other regions this is not the case), and heavily dependent on family and community labor. Environmental risks (e.g., rainfall, floods, frosts, etc.) pose the main risks for these systems. In terms of outputs, these systems generally have evolved in concert with culturally compatible forms of organization. Most of them have relatively low labor productivity, because their main goal is provisioning of the family; they are, however, sustainable at low population densities.[5]

Using these contrasts, we can now examine several cases that elucidate these strengths and weaknesses of science and indigenous knowledge systems. These cases will demonstrate the complementary and productive relationship that should exist between scientific and indigenous knowledge systems.

The Langosta *in Honduras: The Limits of Indigenous Knowledge Systems*

An interesting example concerning the limits of indigenous knowledge systems comes from southern Honduras, a region in which the International Sorghum/Millet (INTSORMIL) Project has been working since 1981. In 1981 and 1982, I and a team of researchers conducted a baseline study in this region, especially focusing on farming systems used by small farmers. One of our objectives was to identify, from the farmer's perspective, the most important constraints to production especially on sorghum, an essential component of their production and dietary systems (K. DeWalt and B. DeWalt 1989).

Our research found that farmers had evolved a very sophisticated intercropping system of maize (a crop indigenous to the Americas) and sorghum (a crop indigenous to Africa and India) that fit well with the climatic and subsistence needs of the region and its people (DeWalt et al. 1982). This system must have had its roots in experimentation by farmers that produced a maize variety with a very short growing season and a sorghum with a very long growing season. In spite of this refinement in terms of varieties, the local farmers were unable to cope with some of the major insect pests in the region. We reported the following:

> The major insect pest mentioned by farmers in Pespire was the *langosta* (locusts). The *langosta* seems to come in waves and to leave most fields untouched while wreaking major destruction on other fields. Farmers report that they have no way of knowing when and where an outbreak of *langosta* will occur. Consequently, few farmers take any precautionary methods against the insects, which generally do most of their damage when the plants are quite small (B. DeWalt et al. 1982:42).

From a personal perspective, the above description was unsatisfactory for a number of reasons. For one, descriptions of the damage and habits of the insects made me skeptical that the problem really was due to locusts (*langosta* in Spanish means either locust or lobster). Second, none of the agricultural extension agents in the region could give me a scientific name for the insect involved. Third, the farmers were pretty vague about the insect, could not tell me anything about its life cycle, and had no local technologies for controlling it. So, indigenous knowledge among both farmers and extensionists in southern Honduras was quite inadequate.

Farmers in the region considered it a problem, however, and so it was fortunate that INTSORMIL scientists in the region developed an interest in the *langosta*. Their subsequent research has found that the *langosta* in fact is a complex of noctuids that includes at least four distinct species—*Spodoptera frugiperda* (J. E. Smith), *Metaponpneumata rogenhoferi* (Moschler), *Spodoptera latifascia* (Walker), and *Mocis latipes* (Guenee) (Portillo et al. 1991:288).

On-farm research was done in 1988 and 1989 to investigate the influence of intercropping practices on insect pest populations (Portillo et al. 1991). The research has determined that these various pests affect important cultigens like maize and sorghum at different times in the cultivation cycle and differentially. S. frugiperda, M. rogenhoferi and S. latifascia showed a distinct preference for maize and M. latipes infested both species equally. Depending on rainfall and other climatic conditions, the pests may shift their feeding habits between weeds and the cultivated crops. Insecticide spraying by farmers had little effect on the pest complex.

Portillo et al. (1991:295) concluded that:

> The occurrence of the lepidopterous pest complex (*langosta*) on sorghum and maize creates the biological illusion that the component species coexist conjointly. Actually, the complex is the product of a fine-grained mosaic of different micro-habitats, each supporting a well-adapted successful species. Because of the geographical and biological diversity involved by the complex, controlling the langosta is a formidable challenge. Although many farmers spray their crops after the langosta has arrived, this has no effect on the core population of at least two of the species, nor does it reduce their subsequent generations since these species are unable to complete or appear to have difficulty in completing their life cycle on maize or sorghum.

The authors indicated that a much greater understanding of the ecology of each of the pests is needed before effective strategies to combat the complex can be developed. Their perspective is that an array of integrated pest management practices offers the greatest possibilities for controlling the complex.[6]

This case illustrates the limitations of indigenous knowledge systems. Despite having been identified as a significant limitation to production at least as early as the beginning of the 19th century (del Valle 1804), farmers have been unable to develop any significant understanding of the problem or ways to control it. There still have not been any demonstrated means to mitigate the damage of the *langosta* complex, but careful research by scientists has so far identified the different pests involved in the complex. The research has also suggested the future directions that must be taken for effective control. Because several of the insects breed primarily on weeds rather than the cultivated crops, chemical controls are likely to be too costly and ineffective. Integrated pest management techniques are felt to be more promising as a solution and farmers and scientists must continue working together to develop these intervention strategies.

Tropical Forest Management: The Limits of Scientific Research

The second example is an area in which indigenous knowledge systems have much greater potential. Perhaps the most critical agricultural research issue of the next century will be to determine effective, sustainable management systems for the humid tropics of the world. Science and technology have thus far had little success in providing viable solutions for these regions. Intensive resource extraction like tropical logging, mining, or petroleum extraction is clearly destructive for these important ecosystems. Livestock schemes, where the tropical forest is replaced by pasture, and large scale agroforestry schemes, such as the infamous Jari project in Brazil (Fearnside and Rankin 1982), have so far also not proven to be sustainable alternatives. It is unfortunate that very little agricultural research has been done in such regions of the world.

It may be argued that the humid tropics do not lend themselves to the kind of reductionistic agricultural research that breaks problems down into their constituent parts. The extreme biodiversity of the humid tropics, with little concentration of plant, insect or animal life within any delimited area, argues for a greater need for research on ecological systems. It is in such situations that indigenous knowledge systems may be maximally useful as a guide for scientific research.

There are many examples of extensive studies that demonstrate the sophisticated knowledge that native peoples have of their ecological circumstances (e.g., Conklin 1957, Posey 1985) but the example I will discuss is based on research by Dominique Irvine (1987) who studied the Runa of the Ecuadorian Amazon. The Runa of San José obtain food through gardening, hunting, and fishing. Maize, coffee, and cacao are grown as market crops, while manioc gardens provide a large part of their consumption needs. These gardens are cleared using slash and burn techniques.

Much of the effectiveness of their subsistence, however, comes from knowledge of how to manage the succession within this shifting cultivation system. Rather than simply abandoning a field during its fallow period, Irvine argues that the Runa engage in management for what she calls resource enhancement. Management includes selectively "weeding" naturally occurring pioneer species, protecting (or occasionally transplanting) desirable fruit, palm, and other trees, and planting of trees such as coffee and cacao. These fallows are also managed to serve as game attractors to enhance hunting success. The fruit trees that are protected in the fallows serve as food sources for such game as caviomorph rodents. The result, in comparison with unmanaged fallows, is greater diversity of species and greater economic and subsistence value in the new forest canopy (Irvine 1987:85–101,140).

Irvine's research was not just intended to show the wisdom of indigenous techniques of managing the forest under conditions of low population density. Instead, she wanted to show how their technology was changing in response to growing population density. These communities are not among those whose traditions limit them to survival only under invariant ecological and social conditions. She concluded that:

> My study of succession management suggests that the "seeds" of agricultural intensification are found in the agroforestry cycle. Rather than being bound by the problems of soil management inherent in continuous root crop cultivation, people can supplement these staples and extend the agricultural cycle by augmenting tree crop production. There is considerable variation within San José in the degree and manner of fallow management. I would argue that this variability indicates that intensification is an option for increasing land productivity. . . . [P]opulation pressure resulting from prolonged settlement has encouraged a degree of resource enhancement through succession management (Irvine 1987:188–89).

It is unfortunate that the little agricultural research that is now occurring in the Amazon of Ecuador is focused mainly on "traditional" western agriculture—producing row crops or trees in pure stands. Little work is being based on working with the resource-enhancement strategies of the local people, an exception being that of Redford and Padoch (1992). Instead, their forest management practices are being threatened by public policies that have promoted the expansion of the agricultural frontier, especially the conversion of forest to pastures (Uquillas n.d.).

Several years ago, the Bruntland Commission report that provided the big impetus for the current focus on sustainability commented on the importance of indigenous knowledge systems like those of the Runa. They indicated that:

> These communities are the repositories of vast accumulations of traditional knowledge and experience. . . . Their disappearance is a loss for the larger society, which could learn a great deal from their traditional skills in sustainably managing very complex ecosystems. It is a terrible irony that as formal development reaches more deeply into rain forests, deserts, and other isolated environments, it tends to destroy the only cultures that have proved to thrive in these environments (WCED 1987:114).

The cultural diversity that has been produced by the human experience is being eroded faster than the biological diversity of the planet. In my estimation, this is cultural wasting—the systematic process by which the unique social, technological, moral, expressive, and other indigenous knowledge of groups is lost as people become absorbed and incorporated within the world system (DeWalt 1984:261, 1988).

No-tillage Farming in Kentucky: Indigenous Knowledge Pushing Science

The final case illustrates a blending of indigenous and scientific knowledge systems. In the early 1960s, farmers in western Kentucky had reached what for most farmers in developing countries would be an enviable level of agricultural technology. Use of the tractor with its weeder and harrow attachments, large combines, and intensive use of fertilizer had created a system of agriculture in which maize yields of over 100 bushels per acre and wheat and barley yields of about 50 bushels per acre were common. These farmers had extensive contact with a research and extension system that provided them with good technical assistance. Their farming systems largely conformed to the recommendations of that research and extension system.

Some farmers, however, regarded the plow-plant-tillage system as problematic for three reasons. One was that the intensive tillage needed was contributing to problems of soil erosion. Tillage made the soil vulnerable precisely during the time of year that rainfall and wind velocity make erosion most likely. Second, wet weather during the planting season often delayed establishment of crops and reduced yields. Farmers were interested in techniques that would save time in establishing their crops. The final, and related, concern was that the short growing season in the area made multiple cropping impossible using the technology recommended by researchers and extension agents. The most common rotation was to grow maize for one or two years, followed by barley.

In 1962, a local farmer who had earned BS and MS degrees from the University of Kentucky decided to try no-tillage techniques. At the time, the herbicides 2,4-D and atrazine were available to control weeds. Using his knowledge of scientific experiments occurring in the southern and midwestern areas of the United States, Harry Young rigged an ordinary planter with extra weight to make it cut deeply into untilled soil. With this adapted machinery, he planted 7/10ths of an acre of maize. When a good harvest convinced him that the experiment had succeeded, he began promoting the benefits of no-tillage cultivation to other farmers and to researchers and extension workers. Several extension workers at the University of Kentucky, who had simultaneously been doing applied research and on-farm trials, decided to work with Young and other farmers to further develop the technology.

At the University of Kentucky, a team of people including agronomists, agricultural engineers, entomologists, and extension workers turned a part of their research effort toward investigating the feasibility of no-tillage systems. Their work was, in many ways, similar to the farming systems research and development approach; it involved multidisciplinary collaboration, included farmers as active participants in developing and evaluating the system, and included annual on-farm trials.

Most farm machinery companies were resistant to the no-till effort because they were interested in selling larger tractors and tillage instruments (Phillips and Phillips 1984:5). Allis-Chalmers, however, did not have a conventional-tillage planter and saw the opportunity to fill a new market niche. In 1965, Allis-Chalmers introduced a no-till planter. By 1967, paraquat, a superior knockdown herbicide, also became available and further stimulated the movement toward no-till.[7]

Research findings and on-farm research demonstrated that no-tillage farming resulted in greater production because it made double-cropping possible (Phillips and Young 1973:28–32). It was possible to plant soybeans following wheat. In addition, there was ". . . better soil moisture retention, savings in labor, less soil damage from machinery, better timing in planting and harvesting, and reduction of some weather risks" (Choi and Coughenour 1979:2). Most farmers also reported that there was a substantial savings in energy cost.

These developments proved the feasibility of no-tillage technology and farmers all over the upper midwest began adopting it. By 1971, it was estimated that 420,000 acres of land in Kentucky were being planted using no-tillage techniques. Over 600,000 additional acres in other states and Canada were being planted using the technique (Phillips and Young 1973).

This case illustrates one in which local farmers in the early 1960s essentially adapted techniques that were still seen as only "promising" by agricultural scientists. Scientific research was being done in various southeastern states on no-tillage or minimum tillage technology but farmers themselves decided that they needed the technology right away rather than at some distant date in the future. Farmers began using home-produced equipment and began experimenting (as they always have been) with techniques they felt would improve their operations.[8] Once farmers began showing the utility of the no tillage method and promoting it, researchers and extension workers felt obliged to work more intensively on the technology. It is to their credit that they listened to and decided to work with farmers rather than insisting on following their own priorities for research.

This case is a good example of how indigenous and scientific knowledge systems can interact to advance agricultural technology.[9] Farmers were aware of the scientific work on minimum tillage systems. Frustrated by the lack of progress, some farmers began experiments of their own. These farmer experiments were transferred *to* the extension workers, scientists, and corporations, which then modified and improved on the farmer techniques. These improvements were then transferred back to farmers who quickly adopted no-tillage technology.

An interesting parallel to the no-tillage case is now occurring in US agriculture. Because of the increasing concerns about rising input costs, damage to the resource base, and the potential health hazards of what has now become "traditional" US agriculture, there is a search for alternative agriculture (or more correctly, alternative agriculture*s*). Rather than ask agricultural researchers to provide guidelines for these alternative agricultures, a National Research Council panel did case studies of 14 farms that were being efficiently managed (NRC 1989). In other words, in seeking alternatives to the status quo in US agriculture, the NRS sought out *local knowledge* to provide guidelines concerning possible productive new directions.

Some have concluded that the NRC ". . . had little choice but to seek out farmers who had themselves developed alternative practices since the agricultural science establishment had virtually nothing to offer" (Kloppenburg 1991:523). Yet as the NRC report itself makes clear, these farms were being operated using a mix of alternative and conventional practices. Farmers had incorporated many research findings into their operations but they had combined them with their own experience and experiments. "Farmers and other innovators often develop, through their own creativity, new approaches to solving common farming problems" (NRC 1989:247).

Discussion and Conclusions

The cases discussed show that we should not *solely* rely on the findings of agricultural scientists or on the indigenous knowledge of farmers but that we should take advantage of the creativity and innovativeness of both groups. It is important that we see indigenous knowledge systems and scientific knowledge systems as complementary sources of wisdom. In some cases, such as that of the Honduran *langosta*, a scientific knowledge system with a developed methodology for determining the ecological habits of insects was able to determine the complex of pests that has been causing damage to crops. Such an understanding is the first step in designing appropriate solutions. In the case of management of agriculture in humid tropical regions, science has thus far made little progress. To be sure, ecologists and others have come to an understanding of the interactions in such ecosystems but this knowledge has yet to be systematically applied to designing sustainable agricultural systems for human use. Indigenous knowledge systems such as those of the Runa provide some useful guidelines concerning potential future directions of scientific research. In the case of no-tillage systems in Kentucky, farmers took a leading role in adapting and applying some of the scientific research findings that had remained in the realm of journal articles and experiments. The subsequent pairing of scientific research with farmer experience was able to lead to a technology that became widely adopted though the system continues to undergo modification and improvement.

We must recognize that both those who use and develop indigenous knowledge systems (mutable immobiles) and those who develop and apply scientific knowledge systems (immutable mobiles) are constrained by the way in which they have been trained to think and the contexts in which they live. The key is to provide both knowledge systems with more opportunities in which they can inform and stimulate one another.

Beginning with local knowledge of problems and solutions can be an important first step in agricultural research. The work of Thurston (1992), who has examined indigenous systems of plant disease management is an excellent example. The Mathias-Mundy and McCorkle (1989) work on ethnoveterinary practices; that of Reij (1993) on soil and water conservation; and Redford and Padoch (1992) on lowland tropical forests are others. At the same time, we have to recognize that farmers know much less about some aspects of agriculture than others. Some of the life stages of insect pests or differences among plant diseases, for example, can only be perceived with microscopes or other scientific instruments (Bentley 1989).

Scientific knowledge systems have the advantage that they can broaden the base of understanding and provide a much greater array of options to farmers. In order to be effective, the results of scientific knowledge systems must ultimately be incorporated into indigenous knowledge systems. At their roots, the iterative feedback between farmers and scientists is what the farming systems research and development, farmer first, and participatory development perspectives try to accomplish (Chambers 1983, Richards 1985, Rhoades and Booth 1982).[10]

Table 2 includes the means, resource utilization strategies and outputs that should be our goals in creating new, more effective knowledge systems that merge the positive aspects of indigenous and scientific knowledge systems. In terms of means, we need to try to achieve the holistic understandings that are characteristic of indigenous knowledge systems. The strengths of observation of these indigenous knowledge systems, however, need to be combined with the experimental method of scientists. We should aim for knowledge that falls somewhere between immutable mobiles and mutable immobiles. Our task should be to try to identify what may be called "mutable mobiles"—that is, contextualized, holistic knowledge that can be adapted and applied to similar phenomena in other circumstances.

TABLE 2 Productively Merging Indigenous and Scientific Knowledge Systems

Means used to study phenomena
Holistic and general
Mixture of observation and experimentation
Mutable Mobiles
Resource utilization characteristics
Dependent on local resources with moderate mixture of exotic and external resources
Low input with addition of minimal critical inputs
Land intensive
Labor demanding but not labor onerous
Risk averse (to climate and market)
Flexible adaptive strategies
Outputs
High productivity for labor and energy input
Culturally compatible
Food security and comfortable level of living
Sustainable with high population densities
Regenerative

Resource utilization strategies should not completely exclude external inputs. Pesticides, fertilizers, and machinery may be important, but we should seek ways to identify the minimal critical inputs that are needed to make systems more sustainable. Given the world's growing population, it will be necessary to employ land-intensive strategies, but we also need to search for knowledge and technology that is labor demanding to create employment opportunities. Risk averse, flexible adaptive strategies should be attuned to ameliorating the vagaries of weather *as well as markets*. The outputs from these agricultural and resource utilization strategies should be culturally compatible, have food security and a comfortable level of living for producers and consumers as a goal, achieve high productivity for both labor and energy inputs, and finally be both sustainable and, if at all possible, regenerative. That is, we should work to create knowledge that will restore and enhance the properties of ecosystems.

Social scientists can become a part of the process of both mediating between indigenous and scientific knowledge systems and orienting research toward accomplishing these more socially just and ecologically sustainable systems. The three examples discussed in the body of the paper suggest some of the roles that social scientists have played in previous research. In the *langosta* case, the role was simply to identify the problem as significant to farmers. In the case of the no-tillage systems, social scientists were involved in documenting that the system was profitable and was being adopted widely by farmers. In the Runa case, Irvine's research identified the resource management strategies of indigenous people. She and others are now working with federations of indigenous groups to try to improve these management practices (Uquillas n.d.).

The role of social scientists, however, can be even greater and more creative in promoting the complementary nature of indigenous and scientific knowledge systems. In many ways, social scientists are an example of what Turner has called "liminal personae" (1969:95). That is, we are "betwixt and between"—coming from the society and culture of scientists but often identifying with or focusing on the needs and goals of those we study. There are a number of steps that we can take, however, in order to be more effective in filling this liminal role and promoting the complementarity of these knowledge systems.

First, we should look for solutions that will benefit small farmers, or that will help to create more egalitarian societies. Because we depend on others to create the knowledge and technology base to make this possible, we have to work closely with biological agricultural scientists to identify the kinds of technologies and policies required (Warren 1989). In order to do so, social scientists must better learn how to communicate with biological scientists. Some social scientists have been able to speak the language of both scientists and the people on whom development efforts are focused. These efforts have resulted in fruitful collaborations (e.g., Ashby 1987, Lightfoot 1987, Warren 1991b). Further efforts are needed.

Finally, social scientists must recognize that the knowledge that we create or report is often very particularistic and only tangentially transferable to understanding other systems. In our work, we can facilitate the discovery and transfer of mutable mobiles from one local system to another. Social scientists have been only peripherally involved, but a good illustration of this point comes from the Amazon region of Ecuador. One of the indigenous federations there has asked technical assistance from the Kuna people of Panama for designing a natural resource management plan for their territories. They have also sent a group of trainees to the Peruvian Amazon to learn from the Yanesha about forest management (Uquillas n.d.).

It is important that anthropologists and other social scientists encourage and support such efforts whenever possible. It is not enough, I believe for us to simply engage in post-modernist criticisms of industrial (and industrial agricultural) society. We should also be willing and able to apply the wisdom we obtain from studying indigenous knowledge systems to assisting in the transfer of this knowledge to other similar circumstances and situations.

NOTES

[1] I would prefer to use the term local knowledge systems rather than indigenous knowledge systems. The reason is that the term "indigenous knowledge" carries the connotations of "native peoples' ideas and beliefs" and of "traditional knowledge." All people, irrespective of whether they are indigenous to a given area, have developed understandings of the world that are based on their observations of their immediate surroundings. It is this understanding that we are trying to capture through the study of their knowledge systems. The term indigenous knowledge systems, however, has become standardized in the literature. The term is used in a substantial number of publications, there are national and regional indigenous knowledge resource centers, and there is an international newsletter (*Indigenous Knowledge and Development Monitor*) that uses the term. For this reason, with the proviso that we mean all local knowledge systems, I will retain the term here using McClure's (1989:1) definition:

> Indigenous knowledge systems are learned ways of knowing and looking at the world. They have evolved from years of experience and trial-and-error problem solving by groups of people working to meet the challenges they face in their local environments, drawing upon the resources they have at hand.

[2] Latour attributes the great power of science to what he calls "inscriptions"– the ability to produce images, and to read and write about them. Because these images can be superimposed, reshuffled, recombined and summarized, and because they are able to be communicated to others, they acquire substantial importance. "By working on papers alone, on fragile inscriptions which are immensely less than the things from which they are extracted, it is still possible to dominate all things, and all people. What is insignificant for all other cultures becomes the most significant, the only significant aspect of reality" (Latour 1986:32).

[3] A simple example is the search for a hybrid seed variety that satisfies the goals of greatly increasing productivity – but whose organoleptic qualities make it a less desirable food.

[4] Many individuals talk about indigenous knowledge as though it were a highly codified system. Indigenous knowledge, however, is very unevenly distributed among the individuals who make up communities; there are exceptionally knowledgeable individuals and there are often "specialists" who have a great deal of knowledge of certain realms. Identifying these specialists or gifted informants is an important first step in learning about local knowledge.

[5] It is difficult to construct a synthetic view of a typical indigenous knowledge system because any group of people in any kind of setting may share derived wisdom about agriculture, natural resources, or other knowledge domains, all of which are local or indigenous. As one of the examples used later in the paper illustrates, even farmers who are part of modern industrial agriculture have an indigenous knowledge system. In this section of the paper, I am mainly contrasting characteristics of societies that have had little contact with scientific knowledge systems with those that depend mainly on science for the construction of their knowledge systems.

[6] Daniel Meckenstock has recently discovered an interesting document that reflects the historical nature of the *langosta* as a problem throughout Central America. José del Valle, a famous writer of the early 19th century, published a pamphlet in 1804 entitled *Instrucción sobre la plaga de langosta: Medios de Exterminala, o de Disminuir sus Efectos, y de Precaber la Escasez de Comestibles* (Instruction about the *Langosta* Problem: Means to Exterminate It, or Diminish its Effects, and to Prevent the Scarcity of Foodstuffs). The pamphlet reports that the *langosta* cause substantial damage to crops thus increasing the threat of hunger. It indicates some understanding of the ecology of the pest(s) reporting that the female lays her eggs in untilled (*inculto*) areas. The integrated pest management techniques recommended by del Valle included trying to destroy the eggs by plowing, burning fields, or letting pigs loose to root them out (1804:3).

[7] One of the concerns many people have about no-tillage systems is their reliance on chemical herbicides. A recent newspaper article on no-till farmers in Ohio reported, however, that farmers do not use more chemicals than they would in conventional tillage systems. Furthermore, with less soil erosion occurring, phosphorus pollution of rivers and of Lake Erie has decreased substantially (Bell 1992).

[8] I have written about a similar case in Mexico in which local farmers created a seed drill to fit their own circumstances. In this case, the "traditional" technology used by poorer farmers was to use the digging stick for planting. The "traditional" technology used by wealthy farmers was a seed drill pulled by a tractor. Local farmers, and ultimately local blacksmiths, developed a seed drill that could be pulled by horses, mules or oxen. The implement was within the economic reach of poor farmers and resulted in a substantial savings of labor compared with planting with the digging stick (DeWalt 1978).

[9] This case exemplifies the farmer-back-to-farmer model that Rhoades and Booth (1982) have advocated. They argue for the necessity for research to begin and end with the farmer. As scientists (or farmers) identify potential solutions to problems, these techniques need to be tested on farms. The results are then fed back to scientists and farmers who can work on fine-tuning the technology or creating better solutions. The essential idea is that there is constant communication and feedback among scientists and farmers.

[10] It is important, however, that we recognize that establishing mutual respect among scientists and producers of local knowledge will not necessarily resolve the problems of creating more just and ecologically sustainable systems. Local farmers with intimate and intricate understandings have not been immune to the destruction of their own ecosystems (Eckholm 1976). In the same vein, farmers are not above exploiting their neighbors so technology they create or participate in developing will not necessarily create a more just socioeconomic system

(Flora 1992:96). Within the process of cultural evolution, technology and science are only parts of our society's adaptive strategies—whether they fit with our goals for society or whether they are ecologically sustainable is a different set of issues. Means for accomplishing these ends should become part of the system of scientific investigation and technology development (DeWalt 1991).

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