Application of a Knowledge-based Systems Approach in Participatory Technology Development: Developing Soil and Water Management Interventions for Reducing Nutrient Losses in the Middle Hills of Nepal[1]

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Introduction

The middle hills (1000 to 2000m) occupy about 30% of the land area of Nepal (Carson 1992). Agricultural landholdings in the hills are very small – about 46% of farmers own less than 0.5 ha of land – and highly fragmented with about 4 parcels per holding (CBS 1996). Crops are cultivated mainly on rain-fed upland, locally called 'bari'. Bari constitutes 64% (1,717,000 ha) of the cultivated land in Nepal, and 61% of it lies in the middle hills (Carson 1992). The bari soils are particularly vulnerable to soil losses through a combination of natural factors such as sloping topography, heavy seasonal rainfall, and predominance of erosion-prone soils; and human factors such as intensive cultivation of land and erosion-prone farming practices (Sherchan and Gurung 1992; Tripathi 1997). Various studies conducted in Nepal show that soil loss through surface erosion from agricultural land in the hills varies from less than 2 t/ha per year to as much as 105 t/ha per year (Gardner et al. 2000). A recent study has revealed that nutrients are also lost through leaching and that such loses exceed those from runoff and soil erosion by up to an order of magnitude (Gardner et al. 2000). This soil loss has been regarded both by scientists and farmers as the major reason for declining soil fertility and crop productivity in the middle hills of Nepal (Carson 1992; Turton et al. 1995; Vaidya et al. 1995). Similarly, a recent study (Gardner et al. 2000) revealed that nutrient losses, especially of N and P, through leaching are higher than those due to runoff and soil erosion, and require more attention in soil fertility management.

This paper discusses the use of a knowledge-based systems approach in documentation and analysis of farmers' knowledge and the subsequent use of this knowledge in developing soil and water management interventions for the middle hills of Nepal.

Knowledge-based Systems Approach

The knowledge-based systems (KBS) approach to technology development involves the systematic collection, analysis, and use of farmers' local knowledge in the design, experimentation, and evaluation of new technology. The KBS methods discussed here have been developed by the Agricultural Research Centre, Pakhribas, in Nepal in collaboration with the University of Wales, Bangor, in the UK.

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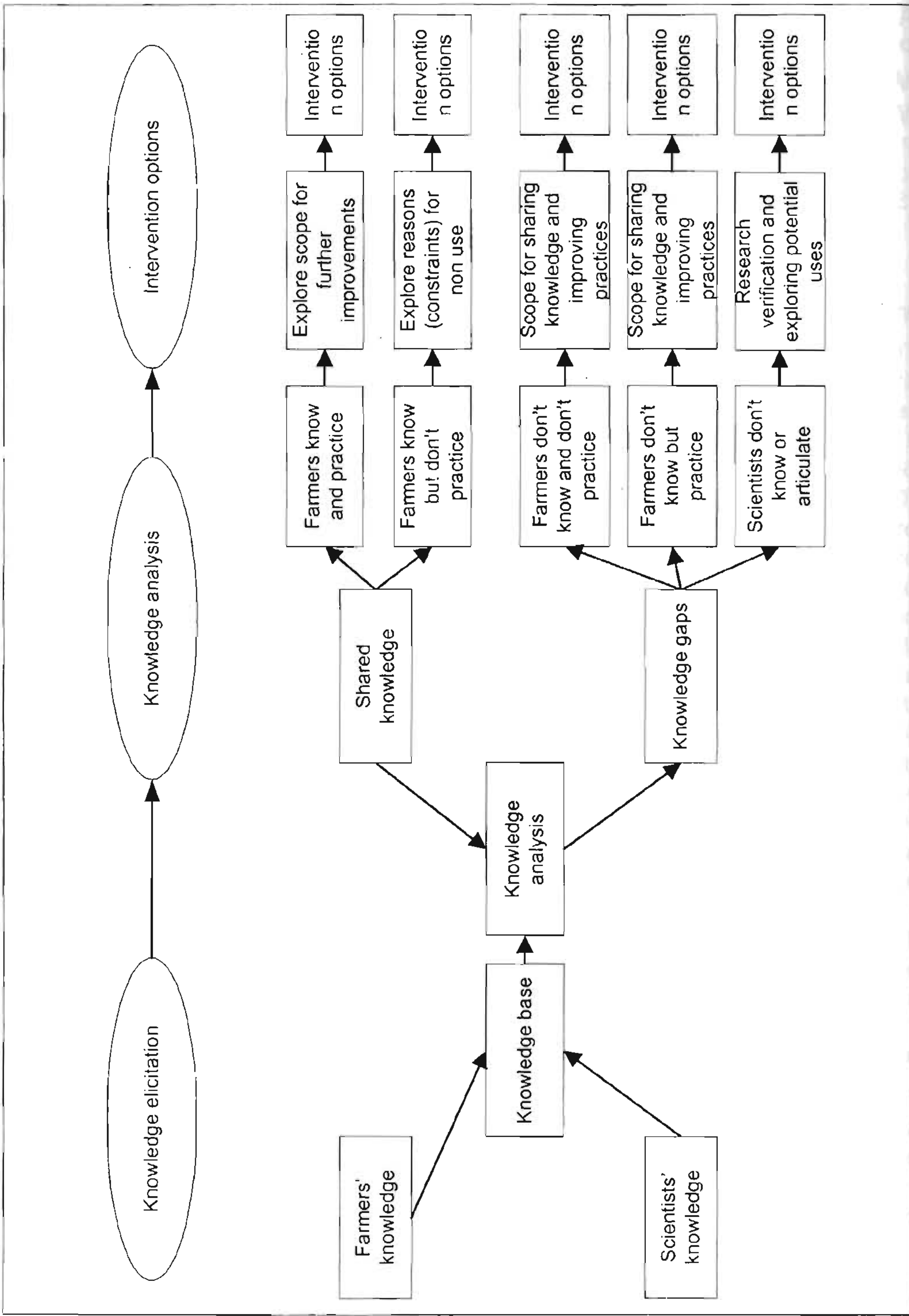

Figure 1: A framework for knowledge analysis and identifying intervention options for participatory techology development

Knowledge Elicitation: Analysis and Identification of Intervention Options

The KBS approach to technology development starts with elicitation of farmers' and scientists' knowledge relevant to soil and water management, followed by analysis of the resulting knowledge base to identify potential options for intervention that can be tested through a Participatory technology development (PTD) process. The framework for the process is shown in Figure 1.

For this study, farmers' local knowledge on soil and water management was elicited from selected farmers at three project sites: Bandipur in Tanahun, Nayatola in Palpa, and Landruk in Kaski district all in the western hills of Nepal. More than 20 men and women farmers, at each site were repeatedly interviewed. The results showed that the farmers possess a wide range of knowledge about soil and water management on their farms as well as in their communities, and have more knowledge about above-ground soil and water-related ecological processes than about below-ground processes. The knowledge generated by research scientists at these sites through a collaborative project between the Agricultural Research Centre, Lumle, and Queen Mary (Westfield) College, University of London, UK, was also collected. The knowledge was archived in an electronic knowledge base called 'soilwater', using WinAKT computer software. The WinAKT software is programmed with a powerful automated reasoning capacity and as a result it facilitates instant and iterative analysis of the knowledge base. The method and the software were developed at the University of Wales, Bangor, UK (see Dixon et al. 1999 for details) and have been used extensively in a number of projects in Nepal.

The analysis revealed a large set of knowledge that was common to farmers and scientists, and some knowledge known or articulated by only farmers or scientists – a knowledge gap. The analysis also examined the causal relationships among different aspects of knowledge and used the resulting information to evaluate farmers' soil and water management practices. The causal analysis has clearly established that the farmers' knowledge and their practices are quite different things and should not be spoken of interchangeably. Some knowledge has not been translated into practice, while a number of practices have been followed without much understanding of the underlying knowledge. Analysing knowledge and practices in this way provided clues for the identification of potential intervention options, which were then tested through the PTD process.

Participatory Technology Development Process

The participation of farmers at various stages of technology development is the essence of a participatory technology development (PTD) process. As a process, PTD has to be flexible to accommodate local variation in farmers' sociocultural environments and needs. The PTD process discussed here is modelled to empower farmers to design and experiment with improved soil and water management interventions by combining their local knowledge and practices with scientific understanding of the problem. The major steps used in this study are outlined in Figure 2.

Knowledge acquisition, sharing, and motivation

Village workshops were organised with the participating farmers at all three research sites to share findings of the knowledge acquisition survey and scientists' information on soil and nutrient losses and water management at these sites.

STEPS	PROCESS
1. Knowledge acquisition sharing and motivation stage	
1. Knowledge acquisition and analysis	Iterative interaction with farmers and use of WinAKT for storing and analysis of knowledge
2. Sharing knowledge with farmers and the farming community	Village workshop - share farmers' & scientists' knowledge
3. Identification/selection of research farmers	Selected by farmers themselves with common consensus in the village workshop
4. Formation of research farmers' committee and agreement on roles and responsibilities	Discuss and agree on these during village workshop
5. Exposing research farmers to R&D on soil and water management	Take research farmers to a week long study tour to R&D sites
2. Trial design and installation stage	
6. Facilitating farmers to conceptualise and design intervention trials	Research farmers' meeting - shared learning during tour, concept of systematic research, and discussion of other options
7. Selection of parcels/terraces for installation of trials	Scientists visit the possible parcels identified for the trial with the individual research farmer
8. Facilitating farmers in installing trials	Scientists estimate the trial area and required trial materials while farmers install trial with facilitation from scientists
3. Monitoring and evaluation stage	
9. Determining indicators for M&E of trials and agreeing on mechanisms of implementation	Meeting with research farmer, agreement on their own indicators for observation and recording
10. Facilitating research farmers in monitoring changes in trials using their indicators	Research farmers and scientist visit trial plots and make observations on agreed indicators
11. Synthesis and sharing findings of M&E among research farmers and community members, and planning activities for next season	Village workshop - share results of trial, discuss necessary changes, and explore prospects of dissemination of technology

Figure 2: **Eleven steps in incorporating farmers' knowledge into the participatory technology development process**

Farmers and village leaders who participated in the village workshops were asked to identify and select farmers to undertake research on soil and water interventions suitable for these farmers and the community. To facilitate communication and support among each other as well as with the farming community and with research scientists, these farmers were called 'research farmers', and their group the 'research farmers' committee'.

The experiences of this study show that taking the acquired local knowledge back to the farming community and sharing scientists' knowledge with them have motivated farmers to undertake new research initiatives.

Trial design and installation

A meeting of research farmers was called and facilitated by the research scientists to discuss the design and installation mechanisms of new soil and water management interventions at their respective project sites. The meeting started with a review of the knowledge shared in the first village workshop and the learning gained during the study tour to the research and demonstration sites. It helped farmers to conceptualise and identify potential soil and management interventions for farmers' experimentation. The concept of systematic research, including role of control and replication, was also shared with the research farmers. This helped them to:

- realise that whatever new intervention they would like to experiment with requires testing for several seasons to draw meaningful conclusions;
- visualise that the intervention trials they would experiment with need to be compared with their current practices to evaluate their effectiveness (the concept of control);
- think over the selection of land for intervention trials to enable comparison;
- think over means/indicators for judging the effectiveness of new interventions; and
- realise the need to test the interventions in different environments to judge their robustness or reliability (the concept of replication).

After thorough discussion, farmers came up with four intervention designs at each research site, and based on their interest divided into four groups of three farmers each to experiment with the identified interventions. These interventions included the use of legume and non-legume forage species, fruit trees, and water harvesting structures laid out in a way that conserves nutrients and water in the farmland. The next day of the meeting, the research scientists visited individual research farmers, made joint observations of the plots selected for the trial, and measured the trial plots to estimate the materials required. Farmers decided to begin the trials once they started to receive regular rain.

Monitoring and evaluation

- The interaction with farmers during knowledge acquisition and at other times revealed that they use a number of criteria to indicate soil erosion and the state of soil quality. Some of these include: changes in the number of stones exposed on the surface, exposure of base of terrace risers, changes in the height of the terrace risers, formation of rills/gullies, changes in soil depth, exposure of crop and tree roots, changes in plant vigour and health, changes in crop yields, changes in outward slope of terraces, turbidity of runoff water,changes in soil colour, and changes in soil structure.

After the farmers' trial begins, a meeting of the research farmers is to be facilitated by the research scientists to agree on the farmers' criteria/indicators for monitoring and evaluation of trials as well as mechanisms for implementing them. Farmers are provided with a notebook and a calendar to note the events and observations they will make during the year. In addition to this, research scientists also help research farmers to conduct joint monitoring and evaluation of farmers' trials at least twice during the summer season. The research scientists are to independently monitor and evaluate the farmers' trials, particularly on changes in soil quality, to supplement farmers' monitoring and evaluation.

At the end of the summer season crop, during which the effect of new interventions is more prominently observable, a village workshop is to be organised at each research site. This will give research farmers and scientists a chance to share their experiences of new soil and water management interventions with each other and with the farming community at large. The workshop aims to provide a forum to disseminate the findings of the farmers' trial to their fellow farmers in the community and to motivate others to try the new interventions on their own farms. The workshop also acts as a means to explore and monitor adoption or adaptation of the farmers' interventions by the research farmers as well as inside and outside the farming community at the research site.

Conclusions

The PTD process initiated in the study has provided some important and useful learning to the research scientists. The experiences so far suggest that application of the KBS approach not only ensures incorporation of farmers' knowledge and perspectives in the technology development process but also improves farmers' empowerment and participation in the technology development process.

The knowledge elicitation strategy and the knowledge analysis process ensure a systematic acquisition of farmers' knowledge, explore causal links between knowledge and practice, explain the rationale of current farming practices, and identify gaps in knowledge and articulation among farmers as well as scientists.

Sharing of farmers' and scientists' knowledge with the farming community and exposing research farmers to research and demonstration sites helps farmers to visualise the positive and negative aspects of their practices, to conceptualise the new interventions, and to motivate them to undertake their own research.

Involving the farming community and village leaders at various stages of the technology development process ensures their continued support in the smooth running of the research activities. The farming community and village leaders also feel an obligation to keep an eye on the process and provide feedback for further improvement. Similarly, their involvement in the selection of research farmers gives research farmers a feeling that they represent the community and that they should be committed to their experiment and share information and findings with other farmers in the community.

Farmers are usually keen to try out new ideas and technologies on their farms, especially when they see benefits from them. Such interest and motivation are even high when they are supported with technical information and material support from outside. The partnership and collaboration between farmers and scientists appear to target better research and to produce more useful outputs than work done by farmers or by scientists in isolation. The application of the KBS approach in the participatory development of soil and water management interventions is certainly effective in establishing and promoting such partnership and collaboration.

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References

Carson, B. (1992) *The Land, the Farmer and the Future: A Soil Management Strategy for Nepal.* ICIMOD Occasional Paper No. 21. Kathmandu: ICIMOD

CBS (1996) *Nepal Living Standards Survey Report 1996: Main Findings. Volume 2.* Kathmandu: Central Bureau of Statistics

Dixon, H.; Doores, H.J.; Joshi, J.W.L.; and Sinclair, F.L. (1999) *Agroforestry Knowledge Toolkit for Windows: Methodological Guidelines, Computer Software and Manual for WinAKT.* Bangor (UK): University of Wales, School of Agricultural and Forest Sciences

Gardner, R.; Mawdesley, K.; Tripathi, B.P.; Gaskin, S.; Adams, S. (2000) *Soil Erosion and Nutrient Loss in the Middle Hills of Nepal (1996-1998).* Lumle: Soil Science Division, NARC; Queen Mary and Westfield College, University of London, UK

Sherchan, D.P.; Gurung, G.B. (1992) *Soils and Nutrient Losses Under Different Crop Husbandry Practices in the Hills of East Nepal.* Paper presented at the National Workshop on Watershed Management, August 24-27, 1992, Bhopal, India. Kathmandu: Pakhribas Agricultural Centre

Tripathi, B.P. (1997) *Present Soil Fertility Research Status and Future Research Strategy in the Western Hills of Nepal.* LARC Seminar Paper No. 92/2. Lumle: Lumle Agricultural Research Centre

Turton, C.; Vaidya A.; Joshi., K.D.; Tuladhar, J.K. (1995) *Towards Fertility Management in the Hills of Nepal.* Chatham Maritime (UK): NRI

Vaidya, A.K.; Turton, C.; Tuladhar, J.K.; Joshi, K.D. (1995) 'An Investigation of Soil Fertility Issues in the Hills of Nepal with Systems Perspective.' In Joshi, K.D.; Vaidya, A.K.; Tripathi, B.P.; Pound, B. (eds) *Formulating A Strategy for Soil Fertility Research in the Hills of Nepal*, pp. 83-103. Lumle (Nepal): Lumle Agricultural Research Centre