4 USING LOCAL KNOWLEDGE TO DEVELOP SOIL AND WATER MANAGEMENT INTERVENTIONS FOR MINIMISING SOIL AND NUTRIENT LOSSES IN THE MIDDLE HILLS OF NEPAL[1]

Pratap Shrestha[2], Morag McDonald[3], Anna Lawrence[4], and Fergus Sinclair[3]

Abstract

The middle hills range in altitude from 1,000 to 2,000m above sea level and occupy about 30% of the land area of Nepal. Upper-slope, rain-fed land (locally called bari) constitutes a major proportion of cultivated land in the middle hills and is particularly vulnerable to nutrient losses through surface soil losses and leaching. These nutrient losses have been regarded as one of the major causes for declining soil fertility and crop productivity in the middle hills. Despite years of efforts, there are very few technological options available to farmers that are effective in reducing such losses. Although some technologies have been found effective in controlling soil erosion, farmers' adoption of these technologies has been low. As a result, increased emphasis is now being given to a process that combines farmers' local knowledge and practices with their needs and resources in the development of appropriate soil and water management technologies.

This chapter presents experiences of a research project on soil and water management in the middle hills of Nepal. It applies a participatory technology development (PTD) approach to generate appropriate soil and water management interventions that reduce nutrient losses from bari land. The core of the approach lies in combining farmers' local knowledge and practices with scientists' knowledge and findings and supporting farmers' experimentation in developing soil and water management interventions. The process includes four stages: problem identification; knowledge analysis and sharing; farmers' experimentation; and participatory monitoring and evaluation. The results obtained so far suggest that incorporation of farmers' knowledge and perspectives in the technology development process, and giving farmers and the farming community a leading role in experimentation and decision-making, not only ensures development of appropriate technologies, but also increases farmers' empowerment and participation in the whole development process.

1 This publication is an output from a research project funded by the Department for International Development (UK) (DFID) for the benefit of developing countries. The views expressed are not necessarily those of DFID. [NRSP-R7412].

2 Local Initiatives for Biodiversity Research and Development (LI-BIRD), P.O. Box 324, Pokhara, Nepal (pratapshrestha@hotmail.com)

3 School of Agricultural and Forest Sciences, University of Wales, Bangor, Gwynedd, UK

4 Environmental Change Institute, University of Oxford, UK

Introduction

The hills of Nepal account for about 51% of the total agricultural land of the country and are home to about 52% of the total population. The average agricultural land holding is less than 1 ha with nearly half of the population owning less than 0.5 ha (CBS 1996; 1999). The middle hills, which range in altitude between 1,000 and 2,000 m above sea level, occupy about 30% of the land area of the country (Carson 1992). The agricultural landholdings in the hills are highly fragmented, with about 4 parcels per holding (CBS 1996). Crops are cultivated mainly on rain-fed upland, locally called bari. Bari constitutes 64% of the cultivated land in Nepal, a little over 1.7 million ha, of which 61% lies in the middle hills (Carson 1992).

Bari soils are particularly vulnerable to soil losses through a combination of natural factors, such as sloping topography and heavy seasonal rainfall, as well as 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 high as 105 t/ha $year^{-1}$ (Gardner et al. 2000). A recent study has revealed that nutrients, especially nitrogen (N) and phosphorous (P), are also lost through leaching at rates exceeding those from runoff and soil erosion by up to an order of magnitude (Gardner et.al. 2000). The soil and nutrient losses occurring in these ways have been regarded as the major reason for declining soil fertility and crop productivity (Carson 1992; Vaidya et al. 1995; Turton et al. 1996).

At present, there are few technological options available that are effective in reducing soil losses and that farmers' have access to and that suit their needs and environments. The interventions that have been directed at controlling soil erosion, including sloping agricultural land technology (SALT) (Partap and Watson 1994), have not been widely adopted by farmers, although they are effective in reducing surface runoff and controlling soil erosion (Carson 1992; Tang Ya 1999). One of the main reasons for this has been the inadequate consideration of farmers' knowledge and practices and their needs for soil and water management.

A number of studies have now revealed that farmers in the middle hills of Nepal possess detailed knowledge about ecological processes related to soil and water conservation and that they often make rational use of this knowledge in the practices that they use to combat soil erosion and declining soil fertility (Gill 1991; Tamang 1991, 1992; Carson 1992; Joshi et al. 1995; Nakarmi 1995; Shah 1995; Subedi and Lohar 1995; Turton et al. 1995; Turton and Sherchan 1996; Joshy 1997). This has drawn the attention of research scientists and development workers towards the value of farmers' knowledge and its potential use in technology development. These studies, however, are mainly limited to documenting farmers' knowledge and practices at a general level. There have been few attempts to explicitly incorporate farmers' knowledge into the research process. Drawing from the experiences of a DFID-funded project, this chapter presents the experiences of a participatory technology development (PTD) approach that combined farmers' knowledge and practices with scientific research in developing soil and water management interventions to minimise the soil and nutrient losses from bari in the middle hills of Nepal.

Research Process: PTD Approach

The participation of farmers at various stages during technology development is the key element of a PTD process. PTD occurs in a number of different forms worldwide and the degree of farmers' participation in the process ranges from a simple consultation to empowering farmers to design and experiment with new technologies themselves. The PTD process discussed here aims to enable and empower farmers to innovate and experiment with new soil and water management interventions by combining their local knowledge and practices with scientific knowledge and understanding of the problem in question. The process was not designed in advance but evolved through the interaction with the farmers and their community structures during the implementation of the project. The whole process was divided into four interlinked stages with a number of steps as shown in Figure 4.1.

Stage 1: Problem identification

Conceptualising the problem and research approach and sharing this with institutional stakeholders

The PTD process started with the identification and conceptualisation of the problems and issues relevant to soil and water management prevalent in the middle hills of Nepal. In this case, the loss of soil and nutrients from bari and the low adoption rate of technical interventions by farmers had already been widely identified as major research and development issues by front-line research and extension agencies. However, re-visiting these problems from the perspectives of stakeholders and building a common consensus was important before undertaking any research and development activities. A workshop of all potential stakeholders was organised for that purpose. About 15 participants from 10 different research and development organisations, both government and non-government, participated in the workshop. The project team and the participating stakeholders shared their views and experiences about the problem and then the concept and methods of the PTD process to be adopted were developed. The mechanisms and means to communicate amongst stakeholders were also discussed and agreed. All the stakeholders showed a keen interest in the proposed research and agreed to participate throughout the research process.

Selection of research sites

The last step of the first stage was to identify suitable and representative research sites. To take advantage of the previous research on soil erosion by Gardner et al. (2000), the same three villages used in that research were selected. These were Landruk, in Ward 9 of Lumle Village Development Committee in Kaski district; Bandipur in Wards 3, 4, and 6 of Bandipur Village Development Committee in Tanahun district; and Nayatola in Wards 4 and 5 in Kushumkhola Village Development Committee in Palpa district, all in the western hills of Nepal. There were three main reasons for the selection of these villages. First, a good amount of baseline data and information about soil and nutrient losses had already been collected at those sites, which enabled the assessment of the

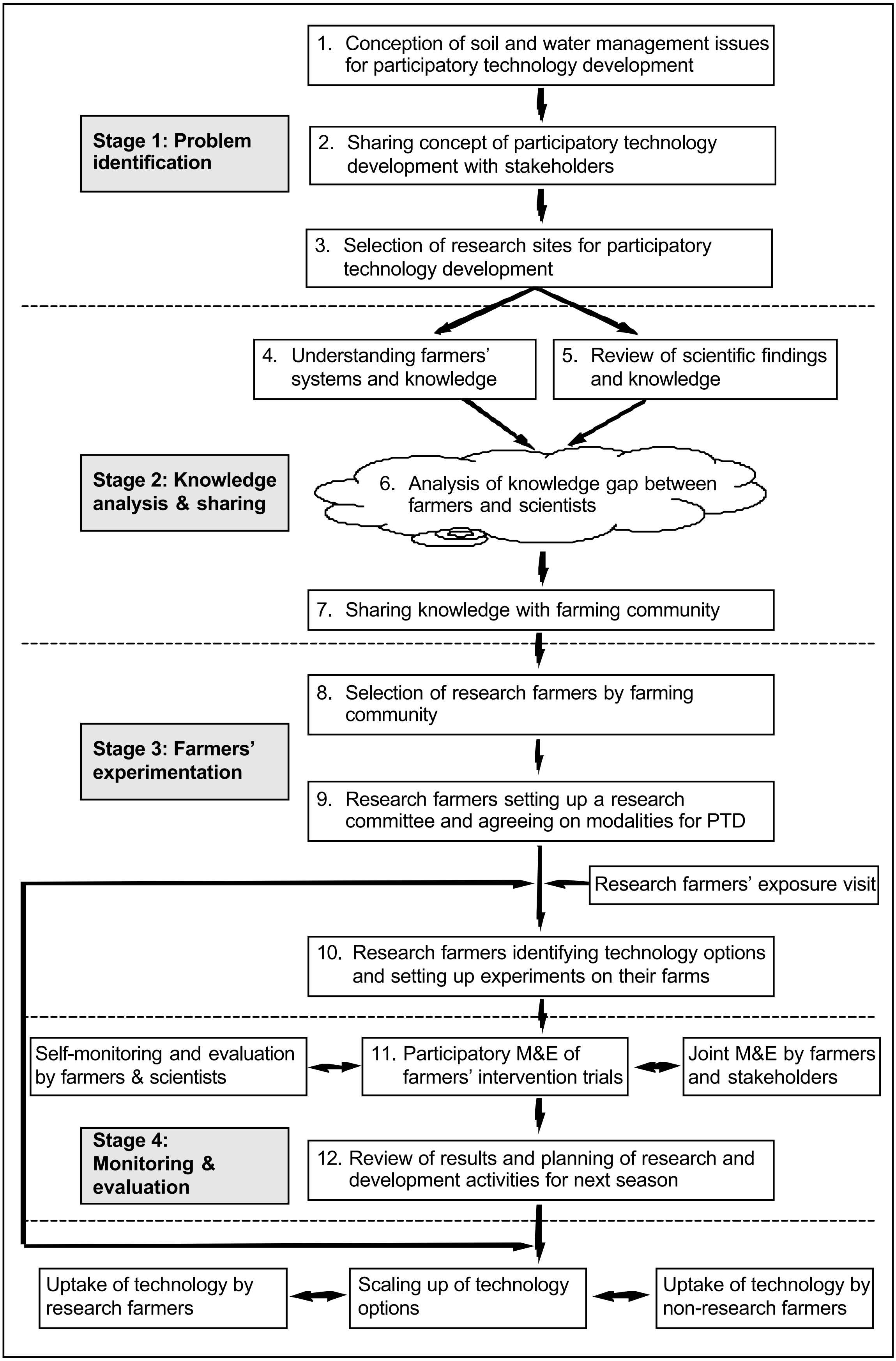

Figure 4.1: The participatory technology development (PTD) process adopted in Nepal

effectiveness of the new research programme. Second, a good relationship had already been established with the local farmers, so the programme could begin immediately. Third, the three locations were representative of the existing ecological and cultural diversity in the middle hills of Nepal.

Stage 2: Knowledge analysis and sharing

Documentation of farmers' and scientists' knowledge

The second stage of the PTD process began with the documentation and understanding of farmers' local knowledge and practices related to soil and water conservation. The collection, storage, and analysis of farmers' knowledge was done using the agroecological knowledge toolkit (AKT5) developed by the University of Wales, Bangor, UK (see Dixon et al. 1999 for details). The AKT methodology uses an ethnographic approach to knowledge acquisition and applies artificial intelligence and computer technology to storing, retrieving, and assessing knowledge (Thapa et al. 1995; Walker et al. 1995; Walker et al. 1997; Sinclair and Walker 1998; Walker and Sinclair 1998). Farmers' local knowledge is elicited using various participatory rural appraisal (PRA) tools and semi-structured interviews with individual farmers, tailored to suit available resources and local circumstances.

The elicitation of farmers' local knowledge on soil and water management was done at the three research villages. More than 20 farmers, both men and women, were selected at each site. These farmers were interviewed informally by both male and female project staff who were living with the farmers in their village. It took about 3-4 weeks for 3 people to complete the knowledge elicitation in each research village. Similarly, the knowledge generated by scientists through earlier research at these sites and elsewhere was also documented. The knowledge documented was then represented in an electronic knowledge base, using the AKT5 computer software. The analysis of knowledge gaps between farmers' and scientists' understanding was done using the automated reasoning capacity built into the AKT5 software (Kendon et al. 1995). The creation of electronic knowledge bases and their subsequent analysis for consistency took about 1 month for the principal investigator. Characteristic of the ethnographic studies, the process was relatively resource intensive but generated valuable insights about the wealth of farmers' knowledge that, because it is durably recorded, will be available for future as well as the present purposes.

Analysis of knowledge gaps

The analysis revealed that farmers possessed a wide range of knowledge about soil and water management on their farms as well as at larger scales in the community. Farmers' knowledge was largely explanatory and experiential and was commonly held. There was also a large amount of knowledge that was commonly held by both farmers and scientists that we refer to as shared knowledge. On the other hand, there were some key aspects known only to farmers or only to scientists and these represented the knowledge gaps between farmers and scientists. The nature of the shared and unique knowledge showed that farmers knew more about above-ground than below-ground ecological processes. Some of the farmers' and scientists' knowledge gaps that had implications for the current research are listed below (Shrestha et al. 2001).

Farmers did not know or had very little knowledge about the following aspects:

- rainwater infiltration is greater than surface runoff;
- nutrient loss through leaching is greater than loss through surface soil erosion;
- soil texture influences the nutrient-holding capacity of soil and so influences leaching losses;
- organic matter increases the nutrient-holding capacity of soil and so minimises leaching losses;
- the role of deep-rooted plants in nutrient recycling;
- the role of legume root nodules and the mechanism of N fixation.

Scientists had very little knowledge about the following:

- multiple ploughing leads to an increase in maize yield – it mixes manure well into the soil and the resulting fine soil particles provide a good growth environment for seeds and roots;
- farmers' classification of a large number of fodder trees as 'malilo' (contributing to soil fertility and not too competitive with crops) or 'rukho' (detrimental to soil fertility and competitive with crops) – the classification is based on the decomposition of litter and competition for light and nutrients.

This analysis of knowledge gaps between farmers and scientists provided a basis for sharing knowledge with the farmers.

The knowledge analysis also looked into causal relationships and used the resulting information to evaluate farmers' soil and water management practices. The causal analysis clearly established disparities between farmers' knowledge and their practices. There was knowledge that was not translated into practice, as well as a number of practices that were followed without much understanding of why they were effective. The analysis of knowledge and practices provided a basis for the identification of potential intervention options, which were then used as ideas for designing new soil and water management interventions together with farmers in the later stage of the PTD process.

Sharing knowledge with farming communities

The last step of the second stage of the PTD process was sharing new knowledge with the farmers and the farming community. Village workshops were organised at all three research sites for this purpose. Farmers (both men and women) were informed of and invited to the workshops through their village leaders. Knowledge on soil and water management was shared with the participating farmers with the help of charts, posters, and demonstration equipment prepared by the project team of scientists. A large number of farmers participated in the workshops that lasted for 2-3hours (Figure 4.2). Additional emphasis was given to the areas of knowledge that were not well known to the farmers. For example, the concept of leaching loss of nutrients was demonstrated to the farmers by using coloured water poured into locally made glass boxes holding a soil profile similar to that used by Hagmann et al. (1997) (Figure 4.3).

Figure 4.2: **Village workshop for sharing knowledge**

Figure 4.3: **Demonstrating loss of nutrients by leaching at the village workshop**

Stage 3: Farmers' experimentation

Farmers are known to do their own research when they have access to new seeds, planting materials, animal breeds, and information (Richards 1985; Chambers et al. 1989; Haverkort et al. 1991; de Boef et al., 1993; Rhoades and Bebbington 1995). Farmers' research or innovations are largely explorative and adaptive in nature, and are influenced by their needs and resource endowment. Building on these experiences, empowering and supporting farmers to design and experiment with new soil and water management interventions by themselves form the key elements of the PTD approach discussed in this chapter.

Selection of research farmers and formation of research committees

The sharing of knowledge led to a realisation that nutrient losses occur through soil erosion and leaching and motivated farmers to participate in the technology development process. Farmers and village leaders participating in the village workshop were requested to identify farmers who would undertake research on soil and water interventions suitable for themselves and the community more generally. They selected 12 farmers at each site for this purpose. To facilitate communication and support amongst each other, as well as with the wider farming community and with research scientists, these farmers were called 'research farmers' and their group was constituted as a research farmers' committee.

Research farmers' exposure visit

The 36 research farmers from the 3 sites were taken on a week-long study tour to research and demonstration sites in different parts of the country. The places included in the study tour were:

- Paireni research and demonstration site, managed by the National Agricultural Research Council, Nepal (NARC) and the International Centre for Integrated Mountain Development (ICIMOD);
- Majhitar farming community in Dhading district, supported by the Nepal Agro-forestry Foundation (NAF);
- Godavari Demonstration and Training Centre site, managed by ICIMOD; and
- Sankhu project site of the Bagmati Integrated Watershed Management Programme (BIWMP) under the Department of Soil Conservation and Watershed Management.

Farmers acquired new knowledge and were able to see a range of new soil and water management practices. They returned to their villages highly motivated to try a number of new soil and water management practices on their own farms. During the visit, the farmers also had an opportunity to discuss and conceptualise ideas about new experiments that they would like to test on their farms.

Identifying and designing new interventions for farmers' experimentation

Meetings of research farmers were called and facilitated by the research scientists to discuss the design of new soil and water management interventions. The meetings started with a review of the knowledge shared in the first village workshop and any insights gained during the study tour to the research and demonstration sites. This helped farmers to conceptualise and identify potential soil and management interventions for their experimentation. The concept of systematic research, including the 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 required testing for several seasons to draw a meaningful conclusion;
- visualise that the interventions they would experiment with needed to be compared with their current practice to see their effectiveness (the concept of comparison with a control);
- think about the selection of land on which interventions were to be tested to enable suitable comparisons to be made;
- think about methods of observation and 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 a thorough discussion, farmers came up with four intervention designs at each of the research sites and, based on their interest in these, they were divided into four groups of three farmers to experiment with the identified interventions. These interventions included the use of legume and non-legume forage species; fruit trees and water-harvesting structures; and crop layout patterns that conserve nutrients and water in bari land. The next day of the meeting, the research scientists visited individual research farmers, made joint observations at the plot selected for establishing the experiments, and measured the experimental plots to estimate the planting materials required. Scientists supplied the new planting materials to the research farmers. With technical support from the scientists, the research farmers and their family members planted research materials in the experimental plots as they had agreed to in the meeting. At Landruk and Bandipur, sites with bench terraces, each research farmer allocated two to three terraces to establish experimental plots. Half of each terrace was used to plant research materials, as specified in the particular intervention design, while the other half was retained as control. At Nayatola, a site with sloping terraces, such an arrangement was not possible, therefore control plots were not established. The research farmers and their families provided all the care and management required for the experimental plots.

Stage 4: Participatory monitoring and evaluation

Farmers generally make careful observations of the performance of their experiments and use the information to evaluate the effectiveness of new interventions. If the results meet farmers' expectations, there is a likelihood that the new intervention will be adopted. If not, then farmers either abandon the experiment or make necessary changes in the process of adapting the new interventions to suit their farming conditions. Based on these general observations about farmers' experimentation, the present PTD process involved a participatory monitoring and evaluation approach for both new interventions and the research process as a whole. A number of methods were employed that provided a forum for research farmers, scientists, and stakeholders to make both independent and joint assessments of the new interventions.

Self-monitoring and evaluation by research farmers

As part of the PTD process, the research farmers were given a leading role in making independent observations and assessments of the effectiveness of the new interventions using their own methods and indicators. The interaction with farmers during knowledge acquisition and at other times revealed that they used a number of criteria to assess soil erosion and its effect on soil and crop production. Farmers mentioned 18 indicators of which 8 associated with positive effects and a further 5 that indicated negative effects were used by the research farmers to monitor the effectiveness of the new interventions that they were experimenting with (Table 4.1). The research farmers were requested to make close observations of the effectiveness of the new interventions during the season to obtain systematic feedback. At the end of the rainy reason, each of the research farmers was requested to assess the effectiveness of their interventions by scoring both treatment and control plots for the indicators specified earlier. Maize seeds were used for scoring and farmers were given a maximum of 10 seeds for each indicator, the number of these that they allocated indicating the score.

Table 4.1: **Farmers' indicators used for measuring effects of new interventions at the three research sites**

	Indicators of change	Landruk	Bandipur	Nayatola
1.	Plant vigour and health	*	*	*
2.	Crop yield	*	*	*
3.	Growth and vigour (orange trees)	-	*	-
4.	Orange production per tree	-	*	-
5.	Forage production on the terrace risers	*	*	-
6.	Stability of terrace risers	*	*	-
7.	Soil softness and ease of tillage	*	*	*
8.	Soil moisture	-	-	*
9.	Formation of rills on soil surface	*	*	*
10.	Exposure of stones on soil surface	*	*	*
11.	Exposure of crop roots	*	*	*
12.	Surface soil erosion	*	*	*
13.	Field rat infestation	*	-	-

The scores given to each intervention for different indicators were combined at two levels – one at the level of the intervention and another for all interventions at the site level. The combined scores at site level obtained at the end of the second year of experimentation are presented in Figure 4.4. The combined scores, both at intervention and at site level, given for indicators of positive effects were consistently higher for intervention than control plots. On the other hand, the scores obtained against indicators of negative effects were consistently higher for the control than the intervention plots. The research farmers, therefore, perceived that the new interventions were effective in reducing soil and nutrient losses, improving soil quality, increasing crop and fruit yield, and increasing forage production. In addition to this, farmers' qualitative feedbacks on the performance and adoption and/or adaptation of the new interventions

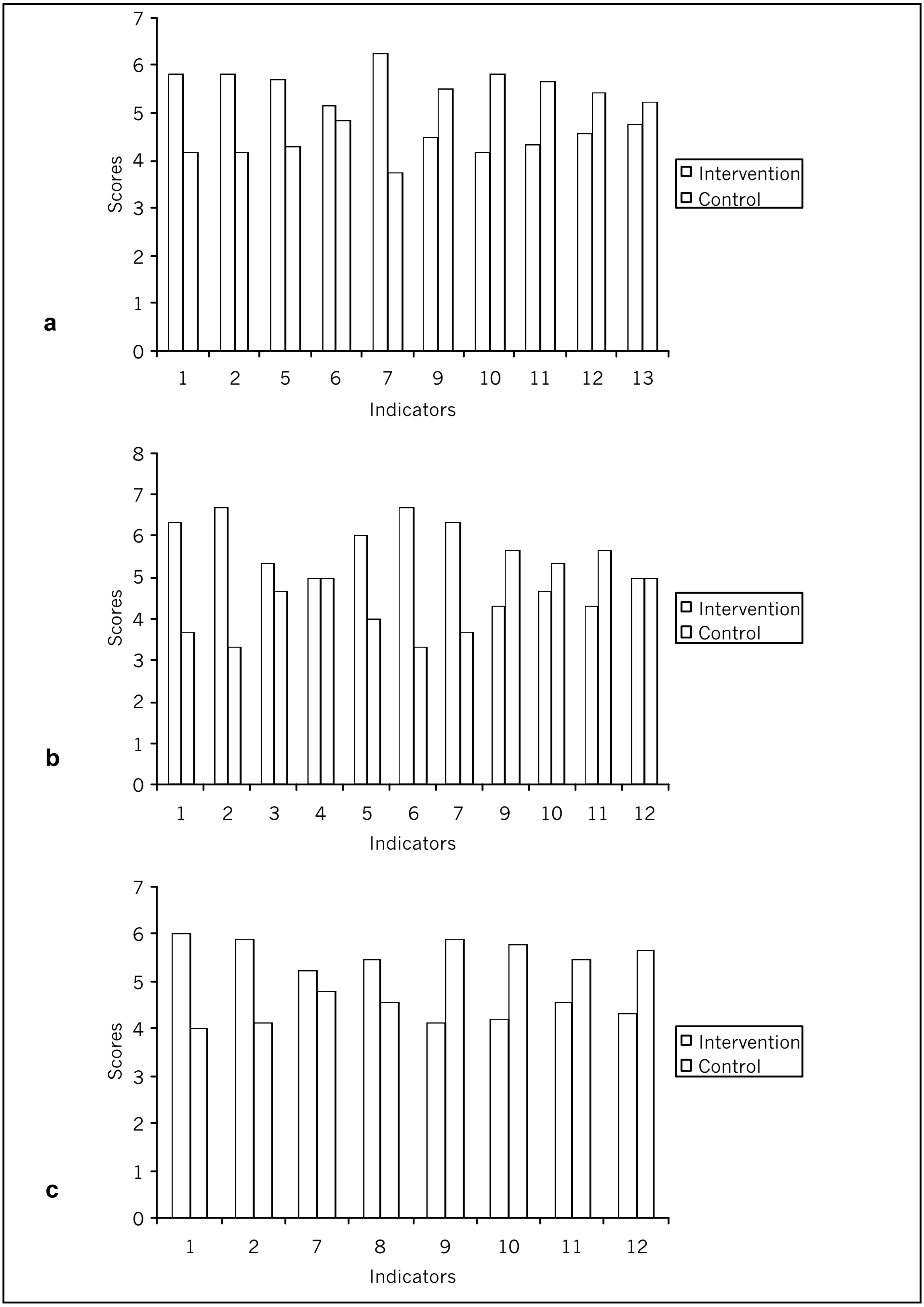

Figure 4.4: **Farmers' scores for indicators used to measure effectiveness of interventions at the three research sites, 2002: (a) Landruk; (b) Bandipur; (c) Nayatola**

1=plant vigour and health; 2=crop yield; 3=growth and vigour of orange trees; 4=orange production per tree; 5= forage production on terrace risers; 6=stabilisation of terrace risers; 7=soil softness and ease of tillage; 8=soil moisture; 9=formation of rills on soil surface; 10=exposure of stones on soil surface; 11=exposure of crop roots; 12=surface soil erosion; 13=field-rat infestation. The higher scores represent higher values for a particular indicator.

was also collected using an open-ended checklist. The analysis of this feedback further confirmed that farmers were positive about the effectiveness of the new interventions, while some of them also indicated modifications to be made in the subsequent season.

Monitoring and evaluation by scientists

The purpose of monitoring and evaluation of farmers' experiments by scientists was two-fold, firstly to provide technical feedback to the research farmers about the performance of their experiments and make necessary technical suggestions if required. For this, regular field visits by scientists were made to monitor mortality, growth, and health of the plants in the new interventions. During these visits, scientists also held discussions with the farmers about the performance of the interventions. Secondly it was to supplement research farmers' assessment of new interventions with quantitative measurements of changes brought about by the new interventions.

At the Landruk and Bandipur research sites, with bench terraces, two measurements were made: one on runoff sediments, to measure changes in soil erosion, and another on forage production from the terrace risers, to measure changes in forage supply and nutrient uses from the terrace. For this, simple techniques involving easily made observations that were manageable under farmers' conditions, were used. To measure changes in runoff sediments, small metal troughs measuring 75 cm in length, 15 cm in width, and 10 cm in depth were placed at the base of the terrace risers and sediments collected from the intervention and control plots were regularly monitored and recorded. At the end of the rainy season, the amount of sediment in each trough was calculated to get a quantitative assessment of the effectiveness of forage species planted on the terrace risers in minimising soil loss from the cultivated terrace. Similarly, to measure changes in forage production, samples of forage produced on the terrace risers of intervention and control plots were collected at regular intervals and weighed and recorded. At Nayatola, with sloping terraces, three measurements were made: soil build-up against the hedge, dhik (terrace riser) formation, and slope angle of the terrace.

The findings of the runoff sediment measurement are presented in Figure 4.5. The soil erosion as indicated by the amount of runoff sediment was more than three times higher at Landruk than at Bandipur, which is consistent with the findings of a more rigorous study done at these sites by Gardner et al*.* (2000). The difference is attributable to higher total rainfall and with it the higher cumulative kinetic energy (erosivity) at Landruk. The findings, therefore, suggest that the method can be used to derive an estimate of the extent and pattern of soil erosion and so measure the effectiveness of new interventions. At Landruk, contrary to expectations, the amount of runoff sediment from intervention plots was more than from non-intervention (control) plots (Figure 4.5a). A possible reason for this is the method of planting of new forage species. The research farmers at Landruk scraped and cleaned local grasses from the terrace risers to increase the survival rate of the new forage species. This obviously exposed more soil to runoff erosion. This finding was contrary to farmers' scoring for soil erosion and suggests that farmers perceptions may sometimes be value driven rather than based on factual information, especially in a case like this, where results are not clear at an early stage of experimentation. At Bandipur, however, the planting of new forage species on the terrace risers appeared to trap more sediment than the local practice of just maintaining natural growth of the local species (Figure 4.5b).

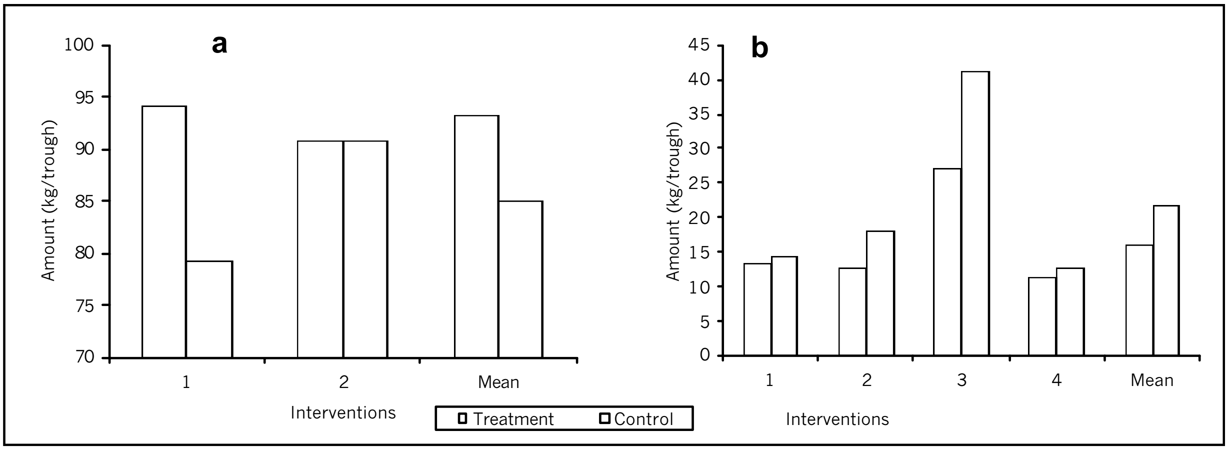

Figure 4.5: **Runoff sediment losses from experimental plots at (a) Landruk and (b) Bandipur, 2002**
The interventions at Landruk are 1=new forage species planted on the terrace risers; 2=new forage species planted on the terrace risers and fruit trees on the edge of terrace. The interventions at Bandipur are 1=new forage species on terrace risers and tree fodders on the top of terrace risers in young orange orchard intercropped with food crops; 2=new forage species on terrace risers, tree fodders on the top of terrace risers, and coffee in old orange orchard; 3=new forage species on terrace risers, and tree fodders on the top of terrace risers in the crop field; 4=new forage species on terrace risers, tree fodders on the top of terrace risers, and water harvesting pond in the crop field.

There appeared to be a trend towards higher forage production in the intervention plots but differences were small (Figure 4.6). Nutrient analysis of forage biomass from intervention and control plots was also done. The results showed that the amount of N, P, and K per unit area of forage biomass from the intervention plots was also higher than that from the control plots (Tables 4.2 and 4.3). The new forage species appeared to trap more soil nutrients and therefore were efficient in minimising leaching loss of nutrients.

At Nayatola, all three types of hedgerow intervention showed some positive effects on minimising soil losses from the sloping bari land (Table 4.4). The difference between the treatments was, however, small. The hedgerow had started to become an effective barrier to soil movement causing soil build-up against the hedge. As a result, the slope angle of the terrace was also decreasing. Similarly, soil build-up against hedge and tillage down the hedge (tillage erosion) initiated formation of dhiks (terrace risers) which gradually increased over the two years. Hedgerows of forage species alone showed larger effects on the parameters considered than other hedgerow interventions.

Joint monitoring and evaluation
At the end of the rainy season, a joint monitoring programme was organised separately at each research village involving research farmers, scientists, stakeholders from district and central level research and development organisations, and other farmers in the village. The main objective of the joint monitoring was to provide stakeholders and other farmers of the

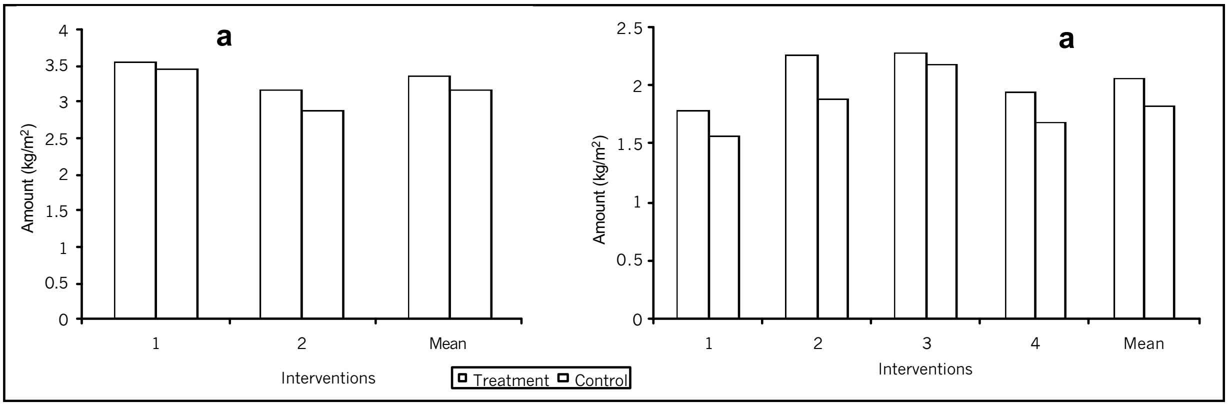

Figure 4.6: **Forage production from the terrace risers of experimental plots at (a) Landruk and (b) Bandipur 2002**

The interventions at Landruk are 1=new forage species planted on the terrace risers; 2=new forage species planted on the terrace risers and fruit trees on the edge of terrace. The interventions at Bandipur are 1=new forage species on terrace risers and tree fodders on the top of terrace risers in young orange orchard intercropped with food crops; 2=new forage species on terrace risers, tree fodders on the top of terrace risers, and coffee in old orange orchard; 3=new forage species on terrace risers, and tree fodders on the top of terrace risers in the crop field; 4=new forage species on terrace risers, tree fodders on the top of terrace risers, and water harvesting pond in the crop field.

Table 4.2: **Nutrient content of forage produced on the terrace risers of the trial plots at Landruk in 2002**

Inter-ventions	N content (g/m^2 forage)			P content (g/m^2 forage)			K content (g/m^2 forage)		
	Treatment	Control	Difference	Treatment	Control	Difference	Treatment	Control	Difference
1	18.57	15.38	3.19	0.23	0.19	0.04	15.48	12.47	3.01
2	11.91	10.77	1.14	0.18	0.16	0.02	11.09	10.10	0.99
Mean	15.24	13.08	2.17	0.21	0.17	0.03	13.28	11.29	2.00

1=new forage species planted on the terrace risers; 2=new forage species planted on the terrace risers and fruit trees on the edge of terrace.

Table 4.3: **Nutrient content of forage produced on the terrace risers of the trial plots at Bandipur in 2002**

Inter-ventions	N content (g/m^2 forage)			P content (g/m^2 forage)			K content (g/m^2 forage)		
	Treatment	Control	Difference	Treatment	Control	Difference	Treatment	Control	Difference
1	5.06	4.89	0.17	0.08	0.06	0.01	6.15	4.89	1.26
2	8.48	6.39	2.09	0.16	0.10	0.07	9.89	4.33	5.56
3	8.55	10.58	-2.03	0.12	0.15	-0.03	10.43	8.72	1.71
4	5.56	5.46	0.10	0.06	0.08	-0.01	8.89	5.19	3.70
Mean	6.91	6.83	0.08	0.11	0.10	0.01	8.84	5.78	3.06

1=new forage species on terrace risers and tree fodders on the top of terrace risers in young orange orchard intercropped with food crops; 2=new forage species on terrace risers, tree fodders on the top of terrace risers, and coffee in old orange orchard; 3=new forage species on terrace risers and tree fodders on the top of terrace risers in the crop field; 4=new forage species on terrace risers, tree fodders on the top of terrace risers, and water harvesting pond in the crop field.

Table 4.4: **Effects of new interventions on soil build-up against the hedge, formation of dhik (terrace riser), and change in terrace slope (Nayatola, 2002)**			
Intervention	**Soil build-up against hedge (cm)**	**Dhik height (cm)**	**Change in terrace slope angle[1] (°)**
Hedge of forage species	11.14	49.72	-2.17
Hedge of forage species and orange trees	11.56	45.06	-0.94
Hedge of forage species, orange trees, and coffee	8.84	44.33	-1.13

[1] Changes from base year (2001) measured in 2003. Negative sign shows a decrease in slope angle

community with an opportunity and forum to monitor and evaluate the performance of farmers' experiments; interact with research farmers, scientists, and amongst each other; collect their feedback; and assess actual and potential adoption and adaptation of the new interventions.

All the participants were first briefed about the research activities implemented in the village and about the purpose of the monitoring programme. After the introduction with the research farmers and other farmers in the village, the joint monitoring team started a village walk and made observations of all the experimental plots one after another. At each experimental plot, the owner research farmer explained the details of the new intervention to the participants. The participants then questioned the research farmer and acquired feedback on the effectiveness of the new interventions obtained so far. After about four to five hours of village walk and field monitoring a round-up meeting was held to discuss what had been observed and how the new interventions were performing. The participants also clarified experimental details and discussed possible modifications in the design of farmers' experiments that could be made in the next season.

Annual review and planning village workshop

At the end of the summer season crop, during which the effect of new interventions was more prominently observable, a village workshop was organised at each research site. Research farmers and scientists shared their experiences of experimenting with new soil and water management interventions with each other and with the farming community at large. Modifications suggested by the research farmers or farming community were discussed and the joint research planning for next season was done. The workshop also provided a forum to disseminate the findings of the farmers' experiments to fellow farmers in the community and motivated others to try the new interventions on their own farms. The workshop was also used as a means to explore and monitor adoption and/or adaptation of the farmers' interventions by the research farmers as well as inside and outside the farming community at each research site.

Adoption and/or Adaptation of New Interventions

Soil and water management interventions usually have a long gestation period and take a long time to show their effects. At the end of the second year of farmers' experimentation, it would be too early to achieve a full-scale assessment of the adoption and/or adaptation of the new interventions. Attempts, however, were made from the very beginning to monitor farmers' responses and actions that were indicative of their interest in the interventions and to measure any current or potential adoption and adaptation of the interventions. The methods employed and results obtained are discussed here.

Observation of farmers' responses and actions to new interventions

This simply involved observing and recording farmers' responses and actions to the new interventions experimented with at each research site. The observations made were of requests by farmers for planting and other research materials and distribution of such materials and types of interventions adopted by farmers. Farmers at all three research sites showed keen interest in the new interventions. Based on this interest, planting materials were supplied to each of the research sites and new farmers joined the farmers' research group in the second year of experimentation (Table 4.5). This showed that there had been a steady increase in the adoption and adaptation of the new intervention, largely within the research villages.

Table 4.5: **Number of new farmers adopting/adapting new interventions and trial materials distributed at the three research sites**

Description	Landruk	Bandipur	Nayatola
New farmers started adopting/adapting new interventions in the second year (number)	15	12	14
Trial materials distributed to farmers (number)			
Setaria grass slips	6000	7000	6000
Napier grass slips	1000	1000	-
Moth Napier grass slips	-	1000	-
NB-21 grass slips	1000	-	-
Guinea grass slips	500	-	-
Mulberry saplings	-	-	1200
Orange saplings	-	-	688
Lemon saplings	-	-	26
Coffee saplings	-	-	121

At Landruk, community action also emerged from farmers' own initiative, to construct diversion channels at strategic locations in the village to divert excess runoff water that would otherwise enter bari land or the village itself, with an objective of reducing soil erosion and landslides. This indicated that some activities were required to be implemented at landscape scales, beyond the control and management capacity of individual farmers.

Tracer study for tracking flow of information and materials

The flow of information about interventions amongst farmers is an indication of their interest in these interventions, and can be used as an indicator of potential for adoption. On the other hand, flow of materials indicates current adoption of the new interventions. Therefore, an attempt was made to trace the flow of any information and research materials from research farmers to non-research farmers and from there on to other farmers. Starting from the farmers directly involved in the research (research farmers), each farmer in the chain of information or material flow was traced and any flow of information or materials was recorded and then mapped to derive a flow network diagram. One example of a flow network diagram from the Landruk research site is shown in Figure 4.7.

The flow network analysis showed that the flow of information between farmers was higher than the flow of materials (Figure 4.7). This was obvious because the experiment was only in its second year and adequate planting materials were yet to be produced on farm for farmer-to-farmer distribution. With the increase in planting materials within the

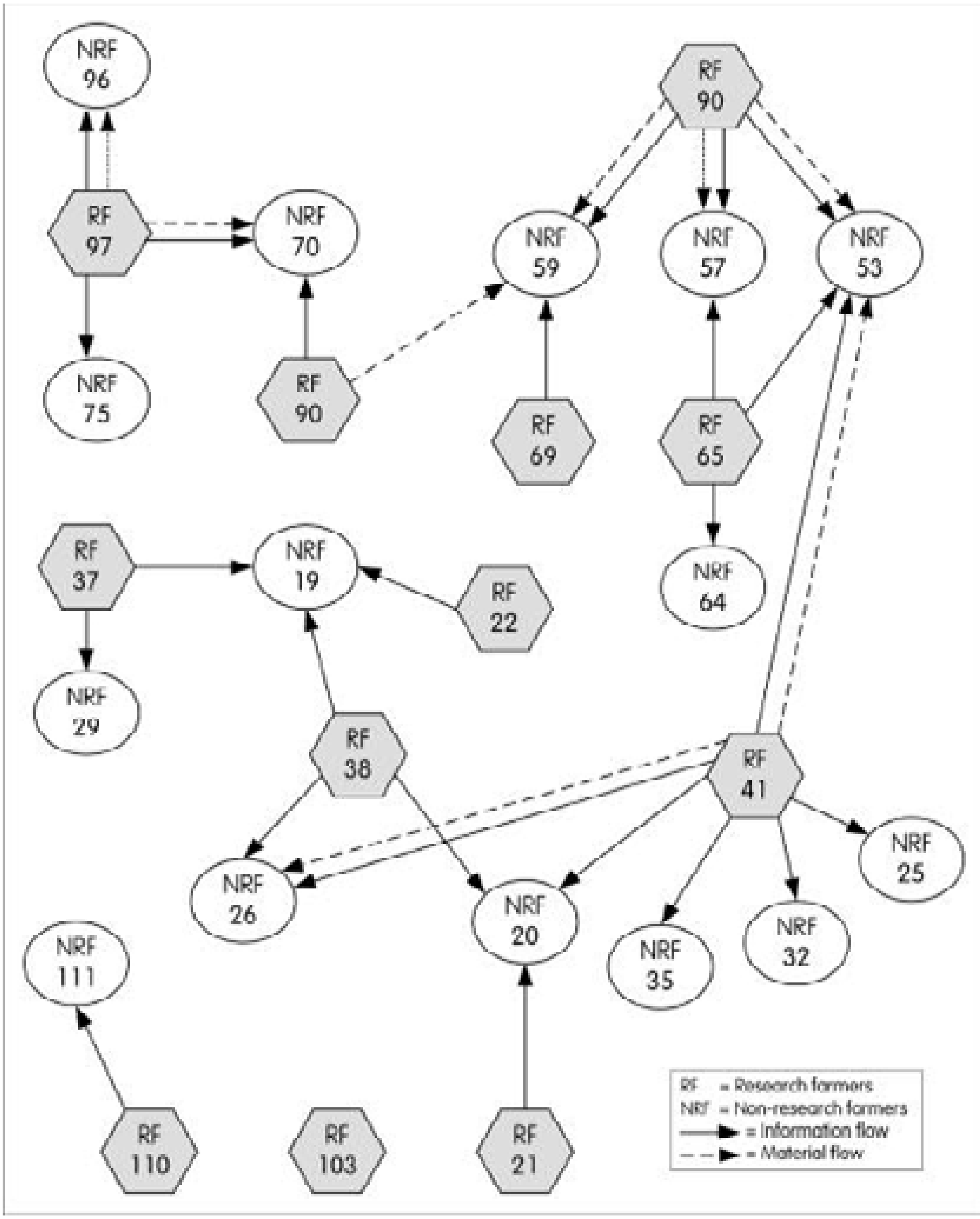

Figure 4.7: **Flow of information and materials from farmer-managed experiments at Landruk, 2002. Nodes are individual farmers; the numbers in them are simply for identification purposes.**

village in subsequent years, the potential for adoption/adaptation of the new interventions appeared to be high. Another finding from the analysis was that the flow of information and materials from research farmers to non-research farmers was higher from farmer-managed experiments (shown by a large number of inter-connected nodes) compared to scientist-managed experiments (diagram not shown as there was no flow of information and materials from research farmers). This indicated that the PTD approach to technology development was more effective in promoting flow of information and materials. It was also an indication that non-research farmers in the community were interested in what their fellow research farmers were experimenting with.

Household sample survey

At the end of the second year of the experimentation with new interventions, that is at the end of the 2002 summer crop, a household survey was conducted to monitor and evaluate the dissemination of information and interventions among the farmers in the community. A systematic sampling procedure was adopted to discern any pattern of such dissemination and to apply statistical tests to measure any significant differences. All the farmers in the community were categorised into the following three groups of farmers:

a. house neighbours of farmers involved in farmer-managed and scientist-managed interventions;
b. field (with experiment) neighbours of farmers involved in farmer-managed and scientist-managed interventions;
c. other farmers of the community selected through random sampling.

Two sets of questionnaires were developed: one to get feedback about farmer-managed interventions and another to get feedback about scientist-managed interventions (implemented concurrently to complement each other). The heads of the sample households were individually interviewed using a structured questionnaire and data analysis was done using Statistical Package for the Social sciences (SPSS) computer software. $\mathbf{C}^2$ statistics were used to test for significant differences in farmers' responses. The data obtained from interviews with farmers sampled with respect to scientist-managed interventions were used as a baseline to evaluate the effectiveness of the farmer-managed PTD approach. At the Bandipur research site, however, there were no scientist-managed experiments and therefore no such comparison was possible.

A large proportion of farmers (>70%) were aware of the farmer-managed and scientist-managed experiments on soil and water management in their village (Figure 4.8). At Landruk, farmers' awareness about scientist-managed experiments was even higher. This was mainly because of the visibility of effects of erosion plots and drums of the scientist-managed experimental plots and this was evident when farmers were asked about the details of these experiments. A higher proportion (57%) of farmers reported knowing about the details of the farmer-managed experiments than the proportion (34%) of farmers who reported knowing about the details of scientist-managed experiments (Figure 4.9). This showed that the PTD approach enhanced the flow of information.

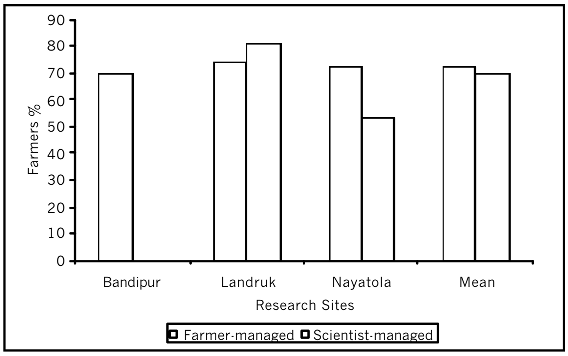

Figure 4.8: **Farmers' awareness about the existence of experiments on new interventions, 2002**

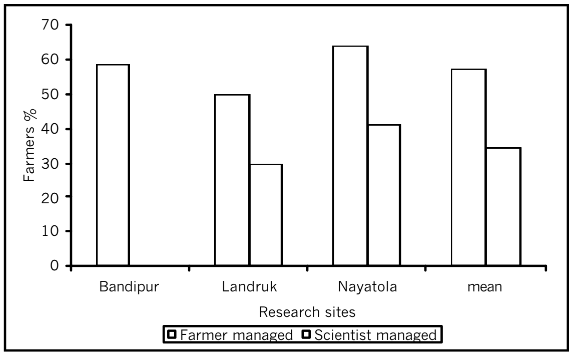

Figure 4.9: **Farmers' knowledge about the details of experiments on new interventions, 2002**

Regarding differences in awareness, no significant difference was found among farmers attributable to differences in farmer types (field neighbour, house neighbour, and other farmers) or ethnicity and wealth categories. However, a higher proportion of farmers from Brahmin, Chhetri, and Gharti groups at Landruk and from poor and medium-wealth categories at Nayatola were reported as more knowledgeable about the details of farmer-managed experiments; and a higher proportion of house and field neighbour farmers and farmers from Brahmin, Chhetri, and Gharti groups reported more about the details of scientist-managed experiments.

The adoption of new interventions by non-research farmers was also higher for farmer-managed interventions, as reported by about 25% of farmers against about 7% for scientist-managed interventions (Figure 4.10). This indicated that farmer-managed interventions were more readily adopted and adapted by farmers. The difference in adoption was found significant for ethnicity at Landruk, where a significantly higher proportion of farmers from Brahmin, Chhetri, and Gharti groups were reported to adopt or adapt new interventions than farmers from other groups. None of the farmers from Kami, Damai, and Sarki, representing a low-caste and resource-poor ethnic group, reported adoption or adaptation of any new interventions. Regarding potential adoption, more than 30% of the farmers were willing to adopt or adapt new interventions in the future (Figure 4.11).

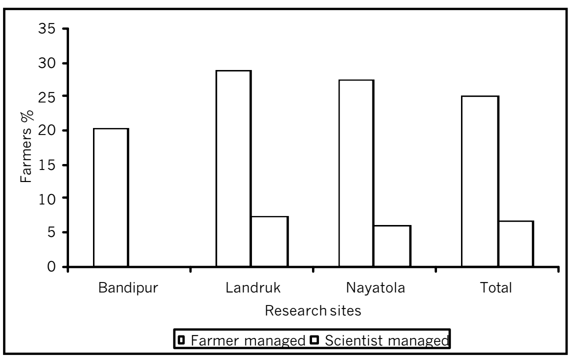

Figure 4.10: **Non-research farmers adopting/ adapting new interventions, 2002**

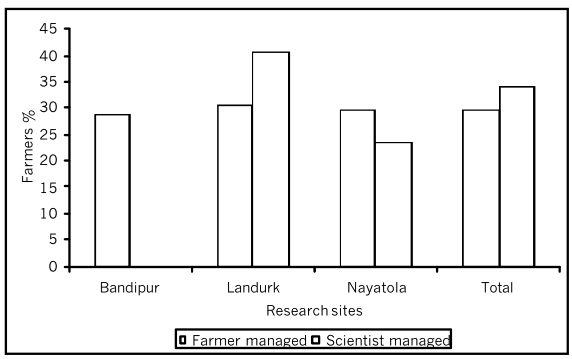

Figure 4.11: **Non-research farmers willing to adopt/adapt new interventions, 2002**

Peer assessment by visiting farmers

A farmers' visit programme to Nayatola, one of the three research sites, was organised by ARS/Lumle in September 2002, in coordination with the District Agricultural Development Offices (DADOs) of Syangja, Palpa, Gulmi, and Arghakhanchi districts. Eighteen farmers from these districts visited the site to see the on-going research activities and to interact with the research farmers. These visiting farmers were asked to evaluate the performance and effectiveness of the new interventions independently. This provided an indication of the potential for wider dissemination of the new interventions.

About 95% of the farmers visiting the Nayatola research site liked and saw benefit from the new interventions under experimentation. While about 78% liked both the hedgerow and ginger strip cropping interventions, about 11% liked only hedgerow interventions and about 6% only strip cropping. Farmers mentioned a number of reasons for liking these interventions, of which control of soil erosion was the highest, reported by about 88% of farmers. The other important reasons mentioned by more than 35% of farmers were increase in soil fertility, increase in crop yield, and increase in on-farm forage production.

Similarly, about 82% of the farmers reported that both hedgerow and strip cropping interventions would be suitable for their village while about 12% reported only strip cropping and about 6% only hedgerow interventions. A high proportion, about 94% of farmers, expressed their willingness to try out these interventions on their own farms. Of these, about 56% were interested in both hedgerows and strip cropping, about 33% only in hedgerows, and about 11% only in strip cropping.

The peer assessment by farmers from other communities provided an indication of the effectiveness and suitability of the new interventions in a wider environmental context. These farmers, however, suggested that access to seed and planting materials, multi-location demonstration of the new interventions, dissemination of information about the new interventions through audio and visual media and taking farmers to the research and demonstration sites would be useful to enhance wider scaling up of the process and therefore the use of the new interventions.

Scaling up of New Interventions

To facilitate scaling up of new interventions from research village to wider farming communities, the extension and development agencies working on soil and water conservation in the region were involved in various stages of the PTD process. The participation of these agencies in the joint monitoring and evaluation of research activities at the three research sites was very useful in terms of scaling up of the new interventions. It provided them with an opportunity to get information about the new interventions and to make a judgement on whether those interventions could be scaled up to other similar areas. A very good working relationship has now been established between the local project institutions – LI-BIRD and ARS/Lumle – and the DADO, District Soil Conservation Office (DSCO), and non-government organisations working in the region, which is the first important step in the wider scaling up of the new interventions.

One of the last meetings held with the institutional stakeholders, DADO and DSCO, in the hill districts of the Western Development Region, showed a keen interest in the new interventions and the PTD process; they were already planning some activities in their regular annual programmes. However, they pointed out strongly the need for close collaboration and technical support from the local project team in scaling up the new interventions and institutionalising the PTD process in these institutions. To start with, the following suggestions were made:

- use the existing research sites as resource villages for the supply of planting materials and as demonstration sites for farmers of other villages;
- organise farmers' visits to the three research sites;
- provide training and orientation to the staff of the extension and development agencies in the region;
- establish multi-location demonstration sites at a number of strategic locations in the region;
- disseminate information about new interventions and the PTD process;
- create conducive environments for the wider uptake of new interventions such as value addition, opening up of markets, and introducing other associated enterprises, for example, livestock production or silk rearing.

Following these suggestions, a farmer exchange visit was organised to the Nayatola research site for farmers from Syangja, Palpa, Gulmi, and Arghakhanchi districts (Nayatola is a representative site for these districts) and a 'training cum orientation' was given to the field extension workers of the DADO and DSCO of these districts. These initiatives represent a good start, but require further commitments from the project team in terms of technical and material support to widen the prospects for scaling up, especially for soil and water management interventions that require long timeframes to achieve the desired results.

Another important consideration is that the scaling up of the products of the research, that is the new interventions, should be done along with the research process used in generating those products. Often, the products, being tangible and visible, are taken for dissemination leaving behind the process that was used to generate them. This has been one of the main reasons for low adoption of new interventions. Unlike crop varieties or new seeds, which are either adopted or rejected, soil and water management interventions are management-oriented technologies and, in almost all cases, require adaptation to the new environments. The scaling up of new soil and water management interventions should, therefore, be process led, applying the PTD process that includes at least a short cycle of knowledge analysis and sharing, farmers' experimentation, and participatory monitoring and evaluation. While this process requires staff resources to implement, it is essential in order that interventions remain relevant to farmer circumstances, and is generally affordable in Nepal where constraints for extension staff lie primarily in lack of operating costs, rather than lack of staff time. Demands for additional operating costs can be minimised by re-orienting and rationalising existing development programmes to start from a small number of strategic locations, and gradually expanding from these locations to neighbouring areas by establishing a network for the flow of locally generated materials and information. The farmers involved in the programme can be used as resource people to support other farmers in neighbouring areas.

Considerations for Farmer-oriented NRM Strategies

It is a well-established observation that the management of natural resources is best done by its users and that such farmer-oriented strategies of natural resource management (NRM) are viable, productive, and sustainable. The current work on the PTD process discussed in this chapter is an example of farmer-oriented NRM strategies which further reiterates this position. It has, however, also identified a number of issues that need to be considered in designing effective and sustainable farmer-oriented NRM strategies. Some of the important considerations are listed here.

- Farmer-oriented NRM should consider farmers' local knowledge and practices and incorporate them explicitly into a PTD process that gives farmers a leading role in all stages of decision-making. This, in turn, ensures a process of learning and empowerment.
- Building on farmers' knowledge and practices, sharing technical knowledge, and supporting farmers in their experimentation empowers farmers and the farming community and strengthens their social capital. This is particularly important in achieving sustainable NRM.
- Research and development endeavours in NRM should be process-oriented allowing changes to be made as they progress, to enable adaptation of management options to local environments and situations.
- This experience of PTD on soil and water management strongly suggests that farmers are interested in NRM practices and interventions that start generating economic benefit very quickly. Therefore, ecosystem services should be tied with productivity enhancement. Farmers' priorities, or highly productive areas with income maximisation potential, should be used as entry points for promoting NRM interventions. In the current case, farmers were interested in grasses and forage species not only because these were effective against soil and nutrient losses, but largely because they increased access to and provided quality fodder for their animals.
- Consideration of equity issues in NRM is important but should not be imposed from outside. It should be internalised through the involvement of the community. It has been seen that resource–poor farmers do not generally participate in the beginning of a new initiative to minimise their risk, but they will often join later when they see the benefits.
- Interventions for NRM should be system compatible and harness niche opportunities. In the current work on soil and water management, hedgerows on the outer boundary of the bench terrace were not preferred by some farmers as they replaced soybean and beans. Similarly, farmers at Nayatola research site preferred to integrate orange and coffee along the hedgerow as the site had a good niche for production as well as marketing for these crops.

- Consideration of the scales of operation is equally important. Management of natural resources, initiated at farm or farmer level, often requires consideration at watershed and/or community level. In the current work on soil and water management, farmers were found to be aware of the benefit of diverting runoff from the cultivated land but most of them were not practising it. This required constructing a network of diversion channels at watershed level, and community action to initiate and complete the construction.
- The management of natural resources often requires long-term decision-making and investments by farmers and by the farming community and therefore, a long-term commitment from research and development institutions involved in the process.

Conclusions

Understanding farmers' knowledge and farming practices lays a firm foundation for the initiation of PTD in soil and water management. The experiences of incorporating farmers' local knowledge into the PTD process for developing soil and water management interventions in the middle hills of Nepal suggest that the process is powerful in understanding farmers' knowledge and the rationale behind their practices; in identifying locally suitable soil and water management interventions; and in motivating and empowering farmers to experiment with new interventions by themselves.

Sharing of scientific knowledge and understanding of the ecological processes with farmers and the farming community and exposing farmers to research and demonstration sites helps them to visualise the positive and negative aspects of their practices and conceptualise the new interventions and motivates them to undertake their own research. Such motivation is even higher when they are provided with technical and material support from outside. The partnership and collaboration between farmers and scientists appears to better target research and produce more useful outputs than research done by farmers or by scientists in isolation.
Involving farming communities, including 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 imparts the notion that these farmers represent the community and so should be committed to their experiment and share information and findings with other farmers in the community.

The PTD approach used here appears to have been more effective in disseminating information and new interventions from research farmers to non-research farmers in the community than the conventional research method. Extending adoption and/or adaptation and scaling up of the new interventions within and outside the research communities, however, needs long-term support and collaboration between research farmers, scientists, and development agencies.

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, Volume 2: Main Findings.* Kathmandu: Central Bureau of Statistics

CBS (1999) *Statistical Year Book Nepal.* Kathmandu: Central Bureau of Statistics

Chambers, R.; Pacey, A.; Thrupp, L.A. (1989) *Farmer First: Farmer Innovation and Agricultural Research.* London: Intermediate Technology Publications

de Boef, W.; Amanor, K.; Wellard, K.; Bebbington, A. (1993) *Cultivating Knowledge: Genetic Diversity, Farmer Experimentation and Crop Research.* London: Intermediate Technology Publications

Dixon, H.J.; Doores, J.W.; Joshi, L.; 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).* Kathmandu: NARC, LARC and London: Queen Mary and Westfield College, University of London

Gill, G.J. (1991) 'Indigenous Erosion Control Techniques in the Jhikhu Khola Watershed'. In Shah P.B., Schreier, H, Brown, S.J. and Riley, K.W. (eds) *Soil Fertility and Erosion issues in the Middle Mountains of Nepal,* pp152-164. Kathmandu: ICIMOD

Hagmann, J.; Chuma, E.; Gundani, O. (1997) 'From Teaching to Learning - Tools for Learning about Soil and Water Conservation.' In *Information on Low External Input and Sustainable Agriculture (ILEIA) Newsletter*, 13(3):26-27

Haverkort, B.; van der Kamp, J.; Waters-Bayer, A. (1991) *Joining Farmers' Experiments: Experiences in Participatory Technology Development*. London: Intermediate Technology Publications

Joshi, K.D.; Tuladhar, J.K.; Sthapit, B.R. (1995) 'Indigenous Soil Classification Systems and Their Practical Utility: A Review'. 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, Proceedings of Workshop held at Lumle Agricultural Research Centre, Nepal,* 17-18 August, pp. 36-42. Lumle (Nepal): LARC

Joshy, D. (1997) 'Indigenous Technical Knowledge in Nepal'. In *Indigenous Technical Knowledge for Land Management in Asia,* Papers Presented at the Assembly for the Management of Soil Erosion Consortium, 28 January - 2 February 1997. Bangkok: IBSRAM

Kendon, G.; Walker, D.H.; Robertson, D.; Haggith, M.; Sinclair, F.L.; Muetzelfeldt, R.I. (1995) 'Supporting Customised Reasoning in the Agroforestry Domain'. In *New Review of Applied Expert Systems,* 1:179-192

Nakarmi, G. (1995) 'Indigenous Water Management Systems in the Andheri Khola Sub-watershed'. In Schreier, H.; Shah, P.B.; Brown, S. (eds) *Challenges to Mountain Resource Management in Nepal: Processes, Trends and Dynamics in Middle Mountain Watersheds,* pp. 211-225. Kathmandu: ICIMOD

Partap, T.; Watson, H. R. (1994) *Sloping Agricultural Land Technology (SALT): A Regenerative Option for Sustainable Mountain Farming,* ICIMOD Occasional Paper 23. Kathmandu: ICIMOD

Rhoades, R.; Bebbington, A. (1995) 'Farmers Who Experiment: An Untapped Resource for Agricultural Research and Development'. In Warren, D.M., Slikkerveer, L.J., Brokensha, D. (eds) *The Cultural Dimension of Development: Indigenous Knowledge Systems,* pp 296-307. London: Intermediate Technology Publications

Richards, P. (1985) *Indigenous Agricultural Revolution.* London: Hutchinson

Shah, P.B. (1995) 'Indigenous Agricultural and Soil Classification'. In Schreier, H.; Shah, P.B.; Brown, S. (eds) *Challenges to Mountain Resource Management in Nepal: Processes, Trends and Dynamics in Middle Mountain Watersheds,* pp. 203-210. Kathmandu: ICIMOD

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, Bhopal, India, August 24-27, 1992

Shrestha, P.; McDonald, M.; Sinclair, F.L. (2003) 'Application of Knowledge-based Systems Approach in Participatory Technology Development: Developing Soil and Water Management Interventions for Reducing Nutrient Losses in the Middle Hills of Nepal'. In Tang Ya; Tulachan, P.M. (eds) *Mountain Agriculture in the Hindu Kush-Himalayan Region,* pp 61-68. Kathmandu: ICIMOD

Sinclair, F.L.; Walker D.H. (1998) 'Qualitative Knowledge about Complex Agroecosystems. Part 1: A Natural Language Approach to Representation'. In *Agricultural Systems,* 56: 341-363

Subedi, P.P.; Lohar, D.P. (1995) 'Methods of Soil Fertility Maintenance for Perennial Fruit Crops'. 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. 30-35. Lumle (Nepal): LARC

Tamang, D. (1991) 'Indigenous Soil Fertility Management Systems in the Jhikhu Khola Watershed'. In Shah P.B., Schreier, H; Brown, S.J.; Riley, K.W. (eds) *Soil Fertility and Erosion issues in the Middle Mountains of Nepal,* pp.135-151. Kathmandu: ICIMOD

Tamang, D. (1992) *Indigenous Soil Management Practice in the Hills of Nepal: Lessons from East-West Transect,* Research Report Series No. 19. Kathmandu: HMGN/Ministry of Agriculture and Winrock International

Tang Ya. (1999) 'Factors Influencing Farmers' Adoption of Soil Conservation Programmes in the Hindu Kush-Himalayan Region'. In McDonald, M; Brown, K. (eds) *Issues and Options in the Design of Soil and Water Conservation Projects,* School of Agricultural and Forest Sciences Publication Number 17, pp. 91-102. Bangor: University of Wales

Thapa, B.; Sinclair F. L.; Walker, D. H. (1995) 'Incorporation of Indigenous Knowledge and Perspectives in Agroforestry Development. Part Two: Case Study on the Impact of Explicit Representation of Farmers' Knowledge'. In *Agroforestry Systems,* 30: 249-261

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 (Nepal): LARC

Turton, C.; Gurung, G.B.; Sherchan, D.P. (1995) *Traditional Farming Systems of Red Soil Areas: The Eastern Hills of Nepal,* PAC Technical Paper No. 164. Dhankuta (Nepal): Pakhribas Agricultural Centre

Turton, C.; Vaidya A.; Joshi K.D.; Tuladhar, J.K. (1996) *Towards Sustainable Fertility Management in the Hills of Nepal.* Lumle (Nepal): LARC, and Chatham (UK): Natural Resources Institute

Turton, C.; Sherchan, D.P. (1996) *The Use of Rural Peoples' Knowledge as a Research Tool for Soil Survey in the Eastern Hills of Nepal,* PAC Occasional Paper No. 21. Dhankuta (Nepal): Pakhribas Agricultural Centre

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): LARC

Walker, D.H.; Sinclair, F.L.; Kendon, G. (1995) 'A Knowledge- Based Systems Approach to Agroforestry Research and Extension'. In *AI Applications*, 9(3): 61-72

Walker, D.H.; Sinclair, F.L.; Joshi, L.; Ambrose, B. (1997) 'Prospects for the Use of Corporate Knowledge Bases in the Generation, Management and Communication of Knowledge at a Frontline Agricultural Research Centre'. In *Agricultural Systems,* 54: 291-312

Walker, D.H. and Sinclair, F.L. (1998) 'Qualitative Knowledge about Complex Agroecosystems. Part 2: Formal Representation'. In *Agricultural Systems,* 56:365-386