NATURAL RESOURCES SYSTEMS PROGRAMME

FINAL TECHNICAL REPORT[1]

DFID Project Number

R7412

Project title

Incorporation of local knowledge into soil and water management interventions which minimise nutrient losses in the Middle Hills of Nepal

Project Leader

Dr. Morag A. McDonald

Organisation

School of Agricultural and Forest Sciences,
University of Wales, Bangor
Gwynedd, UK, LL57 2UW

NRSP Production System	*Date*
Hillsides	31/03/03

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Annex 2. Tripathi, B.P., Shrestha, S. P., Acharya,G. P., Gardner, R., Mawdesley, K., Gaskin, S. and Adams, S. 2001. Assessment of soil and nutrient losses from rainfed upland (*bari*land) terraces in the western hills of Nepal. Paper presented at the International Symposium on Mountain Agriculture in the Hindu Kush-Himalayan Region, 21-25 May 2001. ICIMOD, Kathmandu, Nepal.

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ABBREVIATIONS AND ACRONYMS

ARSL	Agriculture Research Station, Lumle
CEH	Centre for Ecology and Hydrology
DFID	Department for International Development
FPR	Farming Participatory Research
FSR	Farming Systems Research
HKH	Hindu Kush Himalaya
ICIMOD	International Centre for Integrated Mountain Development
LIBIRD	Local Initiatives for Biodiversity, Research and Development
NAF	Nepal Agroforestry Foundation
NARC	Nepal Agricultural Research Council
NARS	National Agricultural Research System
NGO	Non-Governmental Organization
NR	Natural Resource
NRSP	Natural Resources Systems Programme
PEA	Participatory Extension Approach
PLAR	Participatory Learning and Action Research
PME	Participatory Monitoring and Evaluation
PRA	Participatory Rural Appraisal
PTD	Participatory Technology Development
RRA	Rapid Rural Appraisal
RGS	Royal Geographical Society (with the Institute of British Geographers)
SALT	Sloping Agricultural Land Technology
UWB	University of Wales, Bangor

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1. EXECUTIVE SUMMARY

Between the elevations of 1000 and 2000 m in the Mid-Hills of Nepal, over 12 million people subsist on land-holdings of less than 0.5 hectare. These farmers are have very limited access to commercial inputs such as fertilisers and are reliant on rainfall and organic manures for soil fertility maintenance. In particular, b*ari* lands (upper slope rain-fed crop terraces) in Nepal are increasingly becoming a focus of concern in terms of soil fertility decline and management. Previous work has shown that erosion is important during heavy rainfall events pre- monsoon in April/May and, later in the season; nutrient losses through leaching are significant. There is a need for soil and water management interventions which utilise locally available resources that control erosion without resulting in high leaching and so are effective in minimising total nutrient losses. Farming alternatives that conserve water and soil are urgently needed in these marginal and fragile hillside environments to sustain soil fertility and hence rural livelihoods.

The objective of the project ‘Incorporation of local knowledge into soil and water management interventions which minimise nutrient losses in the Middle Hills of Nepal’, was to ensure that nutrient losses due to leaching and erosion are minimised by devising economically and culturally viable land, soil and water management techniques, building upon the sophisticated local knowledge of the movement of water across soil and existing scientific data, and promoting them through participatory approaches to the design of technologies.

To meet this objective, the project worked towards developing a process and methodology by which technology options addressing a common constraint across arrange of livelihood and biophysical circumstances could be identified and evaluated. Participatory field work was conducted in three communities: Landruk, a high altitude (c. 5,500m), high rainfall site. Typical terraces are narrow with 0 to 5^{o} outward slope angles and sited on steep slopes; Bandipur, a mid-altitude (c. 3000m), low to moderate rainfall (c. 1500 mm pa) site where the terraces tend to be about 3 to 5 metres in width and slightly outwardly sloping, 0 to 4^{o} being typical; and Nayatola, a mid altitude (c. 1600m) site with low to moderate rainfall. The site is in Palpa district where large, steeply sloping terraces are predominant. These terraces are so constructed because size of terrace is perceived as reflecting wealth and status in this area. They contrast sharply with the flat to moderately sloped narrow terraces characteristic of most Middle Hill areas. In Nayatola terraces are likely to be 20 to 50 metres wide, and characterised by slope angles of 20 to 35^{o}.

The project approach lay in combining farmers' local knowledge and practices with that of scientists' knowledge and findings, and supporting farmers' experimentation in developing soil and water management interventions. The process included four stages: problem identification; knowledge analysis and sharing; farmers' experimentation; and participatory monitoring and evaluation. The results obtained suggest that incorporation of farmers' knowledge and perspectives in the technology development process, and giving farmers and farming community a lead role in experimentation and decision-making not only ensures development of appropriate technologies but also increase farmers' empowerment and participation in the process.

The objectively verifiable indicator of the project purpose was that; by 2003, professionals in NGOs and NARC would incorporate local knowledge and perceptions of soil erosion in their assessments of conservation needs, and adopt PTD processes in their interventions with farmers to design conservation technologies, which has been achieved in on-going projects conducted by the target institutions. The contribution to the NRSP purpose was in delivering new knowledge to enable poor people that are largely dependent on the natural resource base to improve their livelihoods. This contribution was both direct, by facilitating improving technologies, and indirect, by transferring new knowledge to the institutions supplying services to poor people.

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2. BACKGROUND

The hills of Nepal occupy about 51 % of the total agricultural land of the country, and provide shelter to about 52 % of the total population with an average agricultural land holding of less than 1 ha (CBS, 1996; CBS, 1999). The Middle Hills, that stretch between 1,000 to 2,000 metres asl, occupy about 30% of the land area of Nepal (Carson, 1992). The agricultural land holding in the hills is very small - about 46% of the population owning 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 as *bari* land. *Bari* land constitutes 64 % (1,717,000 ha) of the cultivated land in Nepal, of which 61 % lies in the Middle Hills alone (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/year to as high as 105 t/ha/year (Gardner *et.al*, 2000). A recent study has revealed that nutrient losses, especially N and P, through leaching exceed those in runoff and soil erosion (Gardner *et.al*, 2000), in contradiction to the widely held belief that erosive losses are the major reason for the declining soil fertility and crop productivity in the Middle Hills of Nepal (Carson, 1992; Turton, *et.al.*, 1995; Vaidya, *et.al.*, 1995).

Previous work by the Royal Geographical Society (with the Institute of British Geographers), Queen Mary and Westfield College and Agricultural Research Station Lumle sought to understand the reasons for variability in soil and nutrient loss on rainfed agricultural terraces on *bari* land in different farming systems and agro-ecological zones in Nepal. The variables measured include surface runoff, erosion, volumes and chemistry of leachate in 25 plots at three contrasting locations; Nayatola (20-25° slopes, annual rainfall 1000-1500mm); Landruk (terraces 0 - 5° slope, 3000-3500mm annual rainfall); Bandipur (terraces 0-5° slope, 1100-1500mm annual rainfall). The results show that erosion is important during heavy rainfall events pre-monsoon in April/May on steep cultivated slopes and even on low slopes because of high surface runoff and, later in the season, nutrient losses through leaching on moderate and lower slopes or where runoff is controlled are significant as infiltration throughout the monsoon is increased and high nutrient losses occur.

However, other than this, there has been remarkably very little work done to understand the dynamics of soil erosion and leaching losses of nutrients in the *bari* land in Nepal. As a result, the research and development efforts in generating management practices to control soil and nutrient losses from *bari* land so far have remained poor. At present, the availability and access to technological options that are effective in reducing such losses and that suit farmers' needs and environments are very limited. 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 the farmers although they are effective in reducing surface runoff and controlling soil erosion (Carson, 1992; Tang Ya, 1999). This is largely due to the fact that the research scientists, involved in the technology development process, have not been able to make adequate consideration of farmers' knowledge and practices about, and their needs on soil and water management.

A number of studies has now established that farmers, in the Middle Hills of Nepal, possess a good knowledge about the soil and water related ecological processes and they often make rational use of them to devise practices to combat with the problem of soil erosion and declining soil fertility (Gill, 1991; Tamang, 1991 and 1992; Carson, 1992; Joshi, *et.al.*, 1995; Nakarmi, 1995; Shah, 1995; Subedi and Lohar, 1995; and Joshy, 1997; Turton *et.al.* 1995; Turton and Sherchan, 1996). This has drawn the attention of the research scientists and development workers towards the value of farmers' knowledge and their potential use in technology development. These studies, however, have been

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limited to documenting farmers' knowledge and practices at a more general level. The methods used in these studies have not been able to make an in-depth and systematic acquisition and analysis of farmers' knowledge, and establish the underlying causal relationship. Similarly, there has been a general lack of willingness as well as of approach in incorporating farmers' knowledge into the research process aimed to design improved soil and water management interventions.

‘Participation’ has become a critical concept in development, and various methodologies have emerged over the last 20 years, originating in farming systems research (FSR) or farming participatory research (FPR), participatory technology development (PTD) and Participatory Learning and Action Research (PLAR), with all advocating agricultural research in the context of the whole farming system, and including some degree of farmer participation. Yet the word 'participation' is contested, and would be interpreted differently by practitioners of these methodologies. Multidisciplinary teams of natural and social scientists have developed FSR (Okali *et al*., (1995), Amanor (1990), Farrington and Martin (1998) and others), while PTD has been evolved largely through the efforts of NGOs to tailor technical solutions to rural reality. As they are absorbed into the broader field of farmer participatory research, experience shows that modes of 'participation' in research can range from 'consultative' (scientists ask farmers for their opinions, usually at the problem-identification stage) to 'collegiate' (farmers control the research process, supported by scientists) (Biggs, 1989; Martin and Sherington, 1997; van Veldhuizen *et al*., 1997). All involve a range of methodological tools, from rural rapid appraisal (RRA) and later participatory rural appraisal (PRA) drawing on the work of Chambers (1997) and others, built into participatory learning and action research (PLAR) (Pretty *et al*., 1995; Defoer & Budelmann, 2000; Defoer, 2002). Considerable developments have recently occurred in processes of participatory monitoring and evaluation (PM&E) (Estrella, 2000), now considered intrinsic to participation. Participatory technology development (PTD), as described in the current context is considered to draw eclectically from all these methodologies.

A widespread lesson from participatory research is the need to 'scale-up'. Much of the research has been small-scale and in communities interacting with an NGO; the need to involve state institutions, NARS, and develop complementary relationships, has been a focus of more recent developmental research (Farrington and Lobo, 1997; Farrington and Thiele, 1998; Hagmann *et al*., 1998; Lawrence *et al.,* 1999). Approaches are needed allowing researchers, development workers and farmers to interact on an action-research process (Defoer, 2002). Soil fertility management is particularly suited to this type of collaborative interaction and learning because it involves many issues that are complex and not directly observable (Defoer and Scoones, 2000). These particular challenges, through the complex nature of resource management, interact with both other components of the farming system, and with other members of the community.

The objective of this project was therefore to *develop a process and methodology* for the development of technology options which would ensure that nutrient losses due to leaching and erosion are minimised through economically and culturally viable land, soil and water management. The intention was to build upon the sophisticated local knowledge of the movement of water across soil and existing scientific data and incorporate both into the project design by the process of participatory technology development.

3. PROJECT PURPOSE

The project purpose, as originally defined, was to ensure that nutrient losses due to leaching and erosion are minimised by devising economically and culturally viable land, soil and water management techniques. The protocol would build upon the sophisticated local knowledge of the movement of water across soil and existing scientific data and would be incorporated into participatory technology development.

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The purpose was subsequently reconsidered to reflect revisions in the Hillsides logical framework introduced after preparation of the project documents. The project was expected to contribute to the development of improved methods of viable soil and water management techniques that reduce erosion and nutrient losses and provide greater benefits to farmers in the mid-Hills of Nepal, and promote them through participatory approaches to the design of technologies. The objectively verifiable indicator of this purpose was that; by 2003, professionals in NGOs and NARC would incorporate local knowledge and perceptions of soil erosion in their assessments of conservation needs, and adopt PTD processes in their interventions with farmers to design conservation technologies. This emphasis did not change the planned project activities.

4. OUTPUTS

4.1. Local knowledge and perceptions of soil and water conservation methods acquired and distribution with respect to spatial and cultural variation documented.

The in-depth documentation of farmers' local knowledge on soil and water management was conducted at the three project villages, namely Bandipur in Tanahun, Landruk in Kaski, and Nayatola in Palpa districts of western hills of Nepal. More than twenty farmers, both men and women, were selected purposively at each site for this purpose. These farmers were repeatedly interviewed in an informal manner by male and female project staff staying with the farmers in their village for periods of about three to four weeks.

The study of the distribution of farmers' local knowledge and perceptions about soil and water conservation methods was conducted with a separate set of 384 farmers sampled to represent a wide ecological and socio-economic variations existing in the middle hills of Nepal. A two-stage stratified random sampling technique was used to select these farmers. In the first stage, sixteen different villages representing different ecological factors namely, agro-ecological zones, rainfall domains and terrace environment were selected randomly from eight hill districts of Western Development Region of Nepal. In the second stage, 24 farming households - 50 per cent with food self-sufficiency less than six months and rest with more than six months - were selected randomly from each village sampled in the first stage. Similarly, during interview, 50 per cent of the sample households were marked randomly for interview with male elder members while the other 50 per cent with female elder member of the family. During data analysis, three more socio-economic factors namely, ethnicity, age and education status of respondents were also included (see Table 1 for details). Data analysis was done using SPSS computer software and Chi-square statistics was used to test any significant differences in the distribution of farmers' knowledge due to spatial and cultural variation.

Table 1. Number of households by factors and categories used in selecting sample households.

Factors	Categories	Households	
		Number	%
1. Agro-ecological	1. Lower mid hill (LMH): 1000-1500 m asl	288	75.0
	2. Upper mid hill (UMH): 1500-2000 m asl	96	25.0
2. Rainfall	1. Medium rainfall (MR): 1200-2000 mm	288	75.0
	2. High rainfall (HR): 3000-3500 mm	96	25.0
3. Terrace type	1. Bench terrace	288	75.0
	2. Sloping terrace	96	25.0
4. Food Sufficiency	1. High food deficit (0-3 months)	61	15.9
	2. Medium food deficit (4-6 months)	130	33.9
	3. Low food deficit (7-11 months)	113	29.4

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	4. Food sufficient (12+ months)	80	20.8
5. Ethnicity	1. BCJ (Brahmin/Chhetri/Jogi)	189	49.2
	2. MGNS (Magar/Gurung/Newar/Sunuwar)	150	39.1
	3. KDS (Kami/Damai/Sarki)	45	11.7
6. Gender difference	1. Male	192	50.0
	2. Female	192	50.0
7. Age of respondents	1. Young (< 30 years)	81	21.1
	2. Early mid-aged (30-45 years)	129	33.6
	2. Late mid-aged (45-60 years)	114	29.7
	3. Old aged (> 60 years)	60	15.6
8. Education status	1. Illiterate	174	45.3
	2. Primary education	116	30.2
	3. Secondary education	57	14.8
	4. University education	37	9.6

The results of the in-depth acquisition of farmers' knowledge carried out at three representative villages in the middle hills of western Nepal shows that farmers possess a wide range of knowledge about soil and water conservation methods on their farm as well as in the community. Farmers' knowledge on soil and water conservation methods is largely explanatory and experiential as well as passed on from the elder farmers in the community. The knowledge elicited has been represented into an electronic knowledge base called "SoilWater", using the WinAKT computer software. Farmers' local knowledge and perceptions on soil and water conservation methods are summarised below (see Shrestha, 2000 for details).

Local soil classification and associated soil properties

Farmers had good knowledge about variation in soil types found around the village, both on cultivated and uncultivated land. They were using a number of criteria to classify the *bari* soils into different soil classes. These included soil colour, soil stone content, soil texture, soil consistency, soil structure, soil workability, soil fertility and even sound produced by soil on tillage. Among these, soil colour was the most frequently and widely used basis for local soil classification followed by soil texture and soil stone content often resulting into similar soil classes. *Kalo mato* (black soil), *rato mato* (red soil), *phusro mato* (light gray soil) and *pahelo mato* (yellow soil) was reported at all the three villages. However, farmers were found to use different names for any variation from these distinct soil classes and, because of this, variation in names for some of the same soils between the farmers of different village as well as of the same village were found. Farmers, however, had good knowledge about the associated soil properties such as soil fertility, water infiltration and retention capacity, erosivity and their management requirements (tillage and manure application) and were able to recognise variation in these soil properties among different soil types (Table 2).

Table 2. Farmers' classification of *bari* soils and their properties.

Soil types	Composition features	Colour	Fertility	Erosivity	Drainage	Moisture retention	Water requirement (wetting rate)
Kalo mato	Light, loose and may contain small amount of stones	Black	High	High	High	Medium	Low
Rato mato	Heavy, hard and very little or no stones	Red	Medium	Low	Low	Medium to high	High
Phusro mato	Light, loose and may contain small amount of stones	Light grey	Medium	Medium to High	Medium to High	Low	Low
Khahare mato	Light, loose and contain high amount of round stones	Light brown	Medium	High	High	High/low	Low

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Chiure mato	Light, loose and contain high amount of flat stones	Light brown	Medium	High	High	High/low	Low
Pahenlo mato	Heavy, hard and very little or no stones	Yellow	Very low	Low	Low	High	Low
Kamere mato	Heavy and contains mica and calcareous stones	White to light gray	Low	Low	Low	High	Low
Dhainse mato	Heavy, hard and very little or no stones	Light yellow	Very low	Low	Low	High	High
Jogi mato	Heavy, hard and mixed soil and mottling	Dark red	Very low	Low	Low	Medium	High

Source: Synthesised from Shrestha, 2000.

The results, therefore, show that despite some variation in the names or terminology used to denote different soil classes, farmers' bases for local soil classification are quite consistent and that these could be used not only in communicating with them but also understanding the rationale behind local soil and water conservation methods.

The study on the distribution of knowledge about local soil classification showed a similar pattern as discussed above. Despite 40 different types of soil, more than 10 per cent of farmers reported only five type of soil indicating that a majority of them were using similar criteria and nomenclature for classifying *bari* soils. The most frequently reported soils were *rato mato* (72 per cent farmers)*, kalo mato* (67 per cent farmers)*, phusro mato* (20 per cent farmers)*, pahenlo mato* (13 per cent farmers) and *kamero mato* (12 per cent farmers). A large number of other soil types showed that farmers give a variety of names to soils that vary from the distinct soil types based on local terms commonly used in day-to-day communication but often combining with more generic elements associated with soil colour, texture and structure. As a result, the same soil was termed differently by different farmers in different localities. However, farmers were quite knowledgeable about the characteristic properties of these soils and based on this it was possible to amalgamate some of the soil types bringing down the total number of soil types from 40 to 17. The result suggests that the generic concepts underlying local soil classification were similar across location and culture, and, with the use of a systematic method, the local soil classification can compliment the scientific study on the variation in local soils.

Soil and nutrient losses

Farmers were quite aware about the soil erosion occurring from their *bari* land. They perceived soil erosion as a continuous natural process which cannot be stopped completely. Farmers were consistently knowledgeable about the mechanism of soil erosion and its effects on crop production. They articulated that an increased intensity of rainfall causes an increased rate of surface soil erosion through the formation of *bhal* (water runoff) that flows down the hill. *Bhal* washes down surface soil of the fertile top layer along with it and is evident from the turbidity of the *bhal*. Similarly, soil erosion causes a decrease in soil fertility and subsequently low availability of soil nutrients to crops resulting into low crop production. Farmers had a good knowledge about the intra-seasonal variation (variation within different months of rainy season) in the amount of soil erosion. According to them, the amount of soil erosion is highest in pre-monsoon months of *Baishakha* and *Jestha* (mid-April to mid-June) though it receives low rainfall than in early monsoon months of *Asadha* and *Shrawan* (mid-June and mid-August) and late monsoon months of *Bhadra* and *Asoj* (mid-August to mid-October). They explained that soil is loose after fresh ploughing, dry and dusty and without vegetative cover, and with sudden storms of rain heavy soil erosion takes place. The seasonal soil erosion pattern mentioned by farmers was quite similar to the pattern obtained with scientific measurements at these villages (Figure 1).

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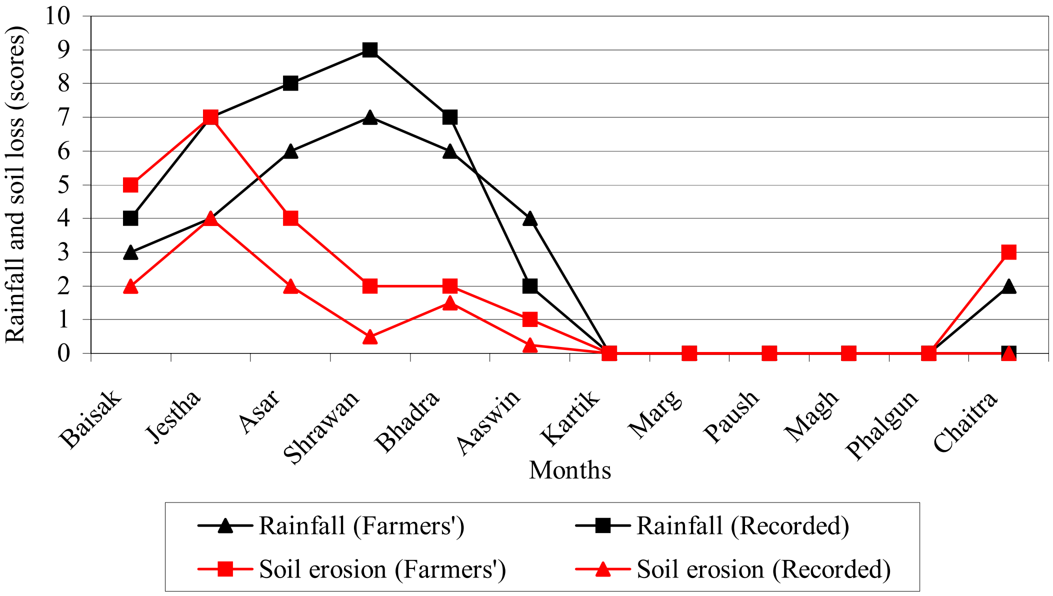

Figure 1 Comparison between farmers' perception and recorded data on rainfall and soil erosion at Landruk.

Farmers also had good knowledge about the effect of soil types, especially soil texture, terrace shape (slope angle and concaveness) and size (width of terrace), vegetative cover, cropping density (and therefore cropping pattern), and inter-cultural operation applied to the crops (tillage and weeding) on the rate and amount of soil erosion. Farmers reported to use a number of practices to minimise soil erosion from the *bari* land, some of which were implemented with primary objective of reducing soil erosion and with full knowledge about the working mechanism (direct practices) while others were in use for other objective and farmers did not know the actual mechanism through which it was reducing soil erosion (indirect practices). These are listed below.

Farmers' practices directly minimizing soil loss:

- Construction and maintenance of bench terrace
- Manipulation of terrace slope – inward or outward depending on the amount of *bhal* and whether the terrace was vulnerable to collapse or not
- Diversion of *bhal* (runon) from *bari* land by channelling through hillside ditch

Farmers' practices indirectly minimizing soil loss:

- Keeping/planting forage and weed vegetation on the terrace risres
- Retaining/planting trees on bari terrace risers
- Retaining forage-weeds in the crop field
- Mixed cropping practices

Farmers' knowledge about losses of soil nutrients was linked largely to soil erosion. The other means or ways of nutrient loss from the *bari* land were not widely articulated by the farmers. Very few farmers mentioned about loss of manure in the dissolved form in *bhal* water. The number of farmers mentioning about the leaching loss of nutrients was even smaller. Farmers, however, commonly perceived at all three villages that late incorporation of animal manure into the soil causes loss of

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manure-nutrients through volatilization due to air and sun exposure. Following are some of the direct and indirect practices farmers were adopting to minimize the nutrient loss from their *bari* land.

Farmers' practices directly minimizing soil loss:

- Early incorporation of animal manure if resources permit
- Planting legume crops in poor fertility soil
- Construction/maintenance of bench terrace
- Diversion of *bhal* (runon) from bari land

Farmers' practices indirectly minimizing soil loss:

- Keeping/planting forage and weed vegetation on the terrace risers
- Retaining/planting trees on bari terrace risers
- Retaining forage-weeds in the crop field
- Mixed cropping practices
- Symptom-based use of chemical fertiliser

The results of the knowledge distribution study showed that knowledge about the pattern and mechanism of water induced soil loss was widely held by farmers across different ecological domains and socio-cultural contexts. About 98 per cent of the farmers surveyed for the study reported that soil erosion takes place from the *bari* land during the rainy season. Similarly, knowledge about intra-seasonal variation in the amount of soil erosion was also widely held by the farmers. About 98 per cent of the farmers mentioned that amount of soil erosion from the *bari* land varied in different months of the rainy season, and that the soil erosion was higher in the pre-monsoon months of *Baishakha* and *Jestha* despite relatively lower amount of rainfall than in other months. More than 50 per cent of the farmers mentioned loose, friable and dusty state of soil to be the main reason for this. The distribution of the knowledge about this reason was influenced by altitude domain, gender, food sufficiency status and ethnicity of the farmers. A significantly high proportion of men farmers (p=0.013) in upper mid-hill (p=0.002), with low food deficit (food sufficient for 6-11 months) (p=0.008), and Brahmin/Chhetri/Gharti ethnic group (p=0.008) had more knowledge about it than farmers of other categories. The effect of terrace type, and age and education status of the farmers was not found on the distribution of this knowledge.

The knowledge that the rate and amount of soil erosion is affected by soil types, land features (shape and size of terrace), cropping density (and therefore cropping pattern), and inter-cultural operation applied to the crops (tillage and weeding) was also widely held by farmers irrespective of variation in their ecological domains and socio-cultural contexts. A high proportion (87.8 per cent) of farmers reported that the extent of soil erosion vary, among other things, according to soil types. Farmers mentioned a number of attributes associated with various soil types that influence the extent of soil erosion in a particular soil type (Table 3) and these were very similar to those found during knowledge documentation study at three representative sites. Of these, soil texture and structure was most common attribute reported by about 79 per cent of the farmers, and the knowledge about this was widely held at all ecological domains and by all categories of farmers. They mentioned that sandy and light soils erode most followed by medium texture loamy soil while heavy clay soil eroded least. Almost all farmers (97.4 per cent) in the study areas reported that different features of *bari* terraces affect rate and amount of soil erosion occurring from these land. Similarly, about 82 per cent of farmers mentioned that intensity of soil erosion in *bari* land was influenced by different cropping patterns, i.e. density of vegetative cover. Of these farmers, about 89 per cent reported that maize grown as sole crop has the highest amount of soil erosion than grown as mixed crop.

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Table 3. Farmers' knowledge about soil attributes influencing soil erosion.

Soil attributes	% hhs (n=384)	Differences between levels within ecological and socioeconomic categories for specified soil attributes (χ^2 test of significance)						
		Ecological factors (n=192)			Socioeconomic factors (n=384)			
		Altitude	Rainfall	Terrace	Rex	Food sufficiency	Ethnicity	Education
Soil texture and structure	78.6							
Soil melting/dissolving in water	21.9						**	
Water infiltration capacity	15.9			*B	**W			
Soil stone content	11.5		*L				*	
Soil depth	6.8							
Soil fertility	6.3				**W			
Rainfall and runoff	3.9							
Water absorption/ retention capacity	3.4							
Soil water content	1.6							
Soil cover	1.6							
Rat infested soil	0.3							
Sub-soil soil hardness	0.3							

* indicates a significant difference at $p \leq 0.05$ and ** indicates a significance difference at $p \leq 0.01$ within a category, and letter after it indicates the level with the higher response for dichotomous categories (U=upper mid-hill; L=lower mid-hill; H=high rainfall; L=low rainfall; B=bench terrace; S=sloping terrace; M=men; and W=women).

Soil fertility

Farmers perceive soil fertility as the ability of soil to produce a crop and is often used interchangeably with soil productivity. However, they know that soil fertility alone is not sufficient for good crop yield and it depends on other factors such as insolation and water availability. Farmers were found to use a number of soil fertility management practices, again some of these were practised with the primary objectives of maintaining soil fertility while others produced this as an indirect result.

Farmers' practices for directly maintaining soil fertility in *bari* land:

- Application of animal manure or farmyard manure
- In-situ manuring with animals
- Use of chemical fertilisers
- Scraping off of terrace risers and mixing the scrapped materials into the terrace soil
- Burning of crop residues and weeds trashes
- Planting legumes on infertile soil
- Use of forest soil
- Burying of dead animals, especially in orchards
- Use of oilseed cakes

Farmers' practices for indirectly maintaining soil fertility in *bari* land:

- Inclusion of grain legumes in mixed cropping
- Mulching of rhizome crops with forest leaf litters
- Use of forest leaf litters and crop residues as animal bedding materials

The results of the knowledge documentation study at Landruk, Bandipur and Nayatola showed that farmers had good knowledge about variation in the fertility of *bari* soils and the underlying causes of such variation, especially land types and location, soil types and soil attributes and fertility management practices. The flat and wide *bari* terraces have higher productivity than steep and narrow terraces as soil erosion and shading effect is low on the former than the later type of terrace. Similarly,

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the terrace with north or northeast aspect, locally called *rip* land (wet land) is less fertile/ productive than the terrace facing south or southwest, locally called *poshilo* land (nutritive land). Regarding productivity of different soil types, farmers have an old Nepali saying, "*rato raja, kalo kaji and phusro paji*". This translates as, "*rato mato* (red soil) is king, *kalo mato* (black soil) is minister and *phusro mato* (light grey soil) is bad guy". Farmers, however, mentioned that this was true when there was good rainfall. In a low rainfall situation the fertility of these soils was reported to be in the order of *kalo mato>rato mato>phusro mato*. This was related to farmers' perception about the influence of soil texture and colour on soil fertility. Farmers perceive that the productivity of heavy textured soil is higher than the productivity of light textured soil if the rate of rainfall and manure application is high, and vice versa. Similarly, black colour of the soil indicates its higher fertility due to a high content of organic matter.

Farmers strongly perceived that the use of animal manure to maintain soil fertility of *bari* land is more beneficial to soil than the use of chemical fertilizers. The application of animal manure increases both quantity and quality of soil, and the effects last longer than chemical fertilizers. It makes soil loose, friable, increase water-holding capacity and heats up soil. On the other hand, farmers perceived that application of chemical fertilisers makes soil dry and hard, forms a large amount of clods on ploughing, demands more water, exhausts soil nutrients and makes soil ‘dead’. Farmers, however, were aware that the detrimental effects of chemical fertilizers could be reduced if applied in combination with animal manure. Similarly, farmers had good knowledge about the nutritive value of dung/ manure from different animals and, therefore, their differential effects on soil fertility. They perceived that the sharpness (nutritive value) of manure of different animals was in the order of chicken> goat/sheep> cattle> pig> buffalo.

Farmers had very detailed knowledge about the effect of late and early incorporation of animal manure into the soil. They perceived that early incorporation of animal manure conserves manure-nutrients while late incorporation causes loss through volatilisation of nutrients due to air and sun exposure. Despite this knowledge, many farmers were found to incorporate manure into soil late than desired due to shortage of labour and oxen. This clearly indicated that non-use of a desired practice is not necessarily due to lack of knowledge but is also due to farmers' constraints. Similarly, farmers also knew about the green manure plant species and their use in increasing soil fertility. However, green manuring was used only on *khet* land due to their limited availability and slow decomposition on *bari* land. Farmers also knew that legume crops increase soil fertility but they were not aware about root nodulation and fixation of atmospheric nitrogen by *Rhizobium* bacteria.

The study on the distribution of knowledge shows that the knowledge about the variation in fertility of *bari* soils and their underlying causes, and about fertility management practices are widely held across ecological domains and socio-cultural contexts. Almost all farmers (98 per cent of the surveyed farmers) perceived that *bari* soils differ in their fertility and that the soil fertility was influenced by a number of soil attributes. The distribution of the detailed knowledge about the soil attributes influencing soil fertility was affected more by gender difference and ethnicity of the farmers and by terrace domain than by other factors (Table 4).

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Table 4. Farmers' knowledge about soil attributes influencing soil fertility.

Soil attributes	% hhs (n=384)	Differences between levels within ecological and socioeconomic categories for specified soil attributes (χ^2 test of significance)						
		Ecological factors (n=192)			Socioeconomic factors (n=384)			
		Altitude	Rainfall	Terrace	Gender	Food sufficiency	Ethnicity	Educat-ion
Soil texture, structure and workability	54.9			**B				
Inherent soil fertility	34.6							
Manure content	30.5			*B	*M		**	
Soil stone content	26.6							**
Manure retention and release capacity	22.1				*M			
Soil water requirement	15.6					*	*	
Soil water absorption/ retention capacity	23.2	**L			**W		*	
Water infiltration capacity	8.1				**W			
Crop vigour and production	7.3							
Leaf litter content	4.9							
Soil depth	4.9							
Soil erodibility	3.9							
Parilo mato (soil receiving high sunshine)	3.6							
Soil colour	1.3							
Seed germination and root growth	1.0							
Manure leaching	0.5							
Insect infestation	0.3							

* indicates a significant difference at $p \leq 0.05$ and ** indicates a significance difference at $p \leq 0.01$ within a category, and letter after it indicates the level with the higher response for dichotomous categories (U=upper mid-hill; L=lower mid-hill; H=high rainfall; L=low rainfall; B=bench terrace; S=sloping terrace; M=men; and W=women).

Regarding the use of chemical fertilizers, about 92 per cent of the surveyed farmers perceived that its use had negative impact on soil. Farmers mentioned about 12 such negative effects of which deterioration of soil physical quality and exhaustion of soil fertility were articulated widely (reported by about 52 and 18 per cent of farmers respectively). Similarly, about 96 per cent of the farmers perceived that early incorporation of animal manure into the soil increases soil fertility than late incorporation. Farmers had extensive knowledge about the effects of early or late incorporation of manure into the soil and mentioned about 19 such effects. Of these, the distribution of knowledge about the most frequently mentioned effects, such as loss of manure due to air and sun exposure (reported by 83 per cent) and mixing of manure into the soil (reported by 43 per cent), was widely held and affected only by gender roles of the farmers. The distribution of knowledge about function of animal manure, i.e. organic matters other than contribution to crop growth and production was quite limited. Similarly, very limited number of farmers knew about the nitrogen fixing ability of legumes while none knew about the actual biological mechanism of nitrogen fixation.

Soil and plant interaction and its implication on soil and water conservation

The incorporation of trees, especially fodder trees on the *bari* land is common practice in the middle hills of Nepal. The documentation of farmers' knowledge in the three villages showed that farmers knew about the effects of trees on the soil and crops underneath. Because of that knowledge farmers were found to keep different numbers of fodder trees on the terrace risers and/or edge of the terrace depending on how they perceived the trade-off between fodder and crop production. Farmers perceived that trees on *bari* land generally affected soil, and crop growth and production but the intensity of such effects was low for some trees - locally called *malilo* (fertile) trees and more for others - locally called *rukho* (infertile) trees. Farmers also apply a similar classification to crops.

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Wheat and mustard were perceived as *rukho* crops while legume crops were perceived as *malilo* crops. Farmers also knew about a number of tree and crop attributes that affected *malilo* or *rukho* properties of these trees and crops. The major attributes mentioned by the farmers were decomposition of fallen leaves and plant parts, amount of nutrient and water uptake, intensity of *tapkan* (water drip from leaves), intensity of shading, amount of roots, and horizontal root spread.

The distribution of knowledge about *malilo* and *rukho* attributes of different types of trees and crops was widely held by farmers across ecological domain and socio-cultural contexts. Farmers mentioned more than 18 attributes that influenced *rukho-malilopan* (fertile-infertileness) of trees and crops, and the most frequently mentioned attributes were quite similar to those mentioned during the knowledge documentation survey at the three representative villages discussed above. Though gender had more influence on the distribution of knowledge about tree and crop attributes, the effects of other ecological and socio-economic factors were generally low.

To summarise, farmers generally had a good knowledge about *bari* soil types and their properties, soil erosion processes and practices to minimise soil losses, soil fertility and fertility management, and soil and plant interaction and its effect on crop production. Farmers had more knowledge about the soil and water conservation practices and activities they were more involved in. Similarly, farmers held more knowledge about above ground soil and water related ecological processes than below ground processes. A majority of the knowledge was widely held by the farmers despite variation in their ecological and socio-cultural environments. The distribution of knowledge about the underlying details of soil and water conservation practices was affected by ecological and socio-economic factors to a different extent. Among ecological factors, the effect due to difference in terrace types was highest followed by difference in altitude domain and least by rainfall domains. Similarly, among socio-economic factors, the effect of gender was most wide spread followed by ethnicity and food sufficiency (proxy of wealth), least by education status and age of the farmers. The knowledge about some of the below ground processes such as leaching loss of nutrients; role of organic matter in conserving nutrients and water, heating soil and enhancing microbial activities; and mechanisms of nitrogen fixation by legumes was limited to very few farmers. This provided the basis for sharing scientific knowledge with farmers.

4.2. Locally adoptable interventions which minimise nutrient losses by erosion and leaching designed by combining local knowledge (from 1) and scientific knowledge through PTD in three different farming systems in the Lumle command area.

The following interventions were designed and experimented by the farmers to minimise nutrient losses by erosion and leaching at the three representative research sites in the middle hills of Nepal. Full details of the technical effectiveness of these interventions are given in annexes 1,4,5 and 6.

Landruk research site

Agro-ecologically Landruk represents an upper mid-hill and high rainfall environment with an altitude range of 1500-1800m asl and mean annual rainfall of about 3524 mm. The crops are cultivated on *bari* land. Maize is the principle crop and is intercropped with finger millet, or bean, cowpeas or soybeans, and followed by wheat or barley in winter in alternate years. The Landruk farmers designed and experimented with the following three interventions.

Intervention 1: Included a grass barrier on the terrace riser and hedge of legume forage on the top of terrace riser. Slips of *Setaria anceps* were planted on the upper portion and that of Napier and NB-21 (hybrid of Napier and Bajra), mixed together, were planted on the lower portion of terrace risers to act as barrier to the runoff water and recycle nutrients leaching down the terrace. This was combined with

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mixed hedge of *Flemingia congesta* and *Desmodium* spp planted on the top of terrace riser in order to trap nutrients leaching down the terrace.

Intervention 2: Included addition of a hillside ditch to intervention 1 to divert runon water from the terrace.

Intervention 3: Included addition of temperate fruit trees along the edge of the terrace to intervention 1. The fruits included were peach, plum, pear and guava. A shade tolerant grass (guinea grass) was also added to this intervention.

The majority of the farmers preferred intervention 1 and the grasses on the terrace risers were performing well. A considerable number of farmers were also attracted to intervention 3, especially in the *bari* land close to their house to secure the fruit production and generate cash income by selling the fruits. Farmers perceived that the hillside ditch included in intervention 2 is very effective in minimizing soil and nutrient losses but is not feasible to adopt in all the place as it requires community effort to establish the network of such hillside ditches in the whole watershed. Because of this the hillside ditch was taken out from intervention2 and amalgamated with intervention1. Another change made during the experiment was the removal of hedge of legume forage from the top of the terrace riser as the growth and establishment of the hedge species were very poor.

Bandipur research site

Bandipur represents a lower mid-hill and medium rainfall environment with an altitude range of 550-1000m asl and mean annual rainfall of about 1620 mm. The crops are cultivated on bench terraced *bari* land. Maize is the principle crop and is often intercropped with finger millet, or bean, cowpeas or soybeans, with the majority of the farmers keeping land fallow in the winter. Some farmers also grow *ghaiya* (upland rice) in place of or mixed with maize. This site also represents an orange growing area and has orange orchards of different size and age. The young or newly established orchard is intercropped with usually no intercropping done in old orchards. The Bandipur farmers designed and experimented with the following four interventions.

Intervention 1: This intervention was designed for young orange orchard inter-cropped with cereal crops. It included grass barrier on the terrace riser and hedge of legume forage on top of the terrace riser. Slips of *Setaria anceps* were planted on the upper portion and that of Napier, NB-21 (hybrid of Napier and Bajra) and guinea grass, mixed together, were planted on the lower portion of terrace risers to act as barrier to the runoff water and recycle nutrients leaching down the terrace. This was combined with mixed hedge of *Flemingia congesta* and *Desmodium* spp planted densely and *Leucaena leucocephala* (ipil-ipil) and *Bauhinia purpurea* (Tanki), planted at wider spacing on the top of terrace riser in order to trap nutrients leaching down the terrace.

Intervention 2: This intervention was designed for old orange orchards without inter-cropping. It included intervention 1 with the addition of coffee plants in between the orange trees and live-mulch of Mucuna bean (*Mucuna pruriens*) and seratro (*Macroptilium atropurpureum*) around the orange trees planted in circle outside the root-zone. The purpose of planting coffee was to trap the leached nutrients as well as to provide additional source of cash income while that of live-mulch was to conserve the moisture for orange trees as well as to recycle any leached nutrients.

Intervention 3: This intervention was designed for maize and *ghaiya*-based cropping system. It included grass barrier on the terrace riser and hedge of legume forage on the top of terrace riser. Slips of *Setaria anceps* were planted on the upper portion and that of Napier, NB-21 (hybrid of Napier and Bajra) and guinea grass, mixed together, were planted on the lower portion of terrace risers to act as

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barrier to the runoff water and recycle nutrients leaching down the terrace. This was combined with mixed hedge of *Flemingia congesta* and *Desmodium* spp planted densely and mulberry planted at wider spacing on the top of terrace riser in order to trap nutrients leaching down the terrace.

Intervention 4: This intervention was also designed for maize and *ghaiya*-based cropping systems. It included all features of intervention 3 but combined with water harvesting tank constructed at the top of the terrace to collect rainwater and reduce run-on on the terrace.

Farmers were positive about all four interventions. Water harvesting tank and live-mulch around orange trees with Mucuna bean, however, have attracted farmers most. Similarly to Landruk, the hedge of *Flemingia congesta* and *Desmodium* spp did not perform well. The widely spaced hedge of mulberry has performed well and farmers have increased its plant density.

Nayatola research site

Nayatola represents a lower mid-hill and medium rainfall environment with an altitude range of 1000-1500m asl and mean annual rainfall of about 1591 mm. The crops are cultivated on *bari* land. Maize is the principle crops and is often intercropped with finger millet, or bean, cowpeas or soybeans, followed by winter wheat, which is also intercropped with winter legumes and mustard. The Nayatola farmers designed and experimented with the following interventions.

Intervention 1: Double hedgerows of legume and non-legume forage species established inside sloping terraces. The upper hedgerow was planted with a mixture of *Flemingia congesta* and *Desmodium* spp while the lower hedgerow was planted with Ipil-ipil. Mulberry was planted in between the two rows at wide spacing (0.5 - 1.5 metre).

Intervention 2: Double hedgerows of legume and non-legume forage species with integration of orange trees established inside sloping terraces. The upper hedgerow was planted with a mixture of *Flemingia congesta* and *Desmodium spp* while the lower hedgerow was planted with Ipil-ipil. Orange saplings were planted along the upper hedge at plant-to-plant spacing of about 6 metres.

Intervention 3: Double hedgerows of legume and non-legume forage species with integration of orange trees and coffee plants established inside sloping terraces. The upper hedgerow was planted with a mixture of *Flemingia congesta* and *Desmodium* spp while the lower hedgerow was planted with Ipil-ipil. Orange and coffee saplings were planted along the upper hedge alternatively at plant-to-plant spacing of about 3 metres.

Intervention 4: Strip crops of maize (*Zea mays*) and ginger (*Zingiber officinale*) and maize and soybean (*Glycine max*).

The spacing between the hedgerows and strips varied from about 5 to 10 metres depending on farmers' needs and priority. The growth of *Flemingia* and *Desmodium* were very impressive and were producing a high amount of biomass. Hedgerow with integration of orange has become more popular because of cash generating opportunity from the sell of orange fruits.

4.3. Adoption and adaptation of interventions by farmers evaluated.

Soil and water management interventions usually have a long gestation period before showing effectiveness. By the end of the project period, the new interventions have just established and have started to show some initial results. Both research and non-research farmers are still observing and analysing these results and, therefore, it would be too early to do a full-scale evaluation of the

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adoption and/or adaptation of these interventions. Despite this, attempts 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/ adaptation of the interventions.

Observation of farmers' responses and actions to new interventions

Farmers at all three research sites showed keen interest in the new interventions and an interest to adopt/ adapt them if planting materials were made available to them. 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 the experimentation.

At Landruk research site, the 12 research farmers who started experiments in the first year also continued their experimentation in the second year. In addition to these, about 15 new farmers also started adopting/ adapting new interventions. On farmers request, 8,500 grass slips - 6,000 Setaria, 1,000 Nepier, 1,000 NB-21, and 500 Guinea grass were supplied to the interested farmers.

At Bandipur research site, total farmers planting grasses on the terrace risers increased from the initial 12 research farmers to 12 and 3 new ponds on farmers' own initiatives were constructed. Farmers planted an additional 9,000 grass slips - 7,000 setaria, 1,000 Nepier and 1,000 Moth Nepier.

At Nayatola, 9 new farmers started adopting the following interventions:

- Flemingia hedgrow with orange trees: 4 farmers
- Flemingia hedgrow with orange and coffee trees: 3 farmers
- Flemingia hedge and grasses: 2 farmers (teachers outside the research village)

Similarly, 5 of the first year research farmers extended the interventions to their new fields:

- Flemingia hedgerow with orange trees: 2 farmers
- Flemingia hedgerow with orange and coffee trees: 1 farmers
- Flemingia hedgerow with mulbery: 2 farmers

The farmers of the village were supplied with 6,000 slips of setaria grass, 1,200 sapling of mulberry, 200 saplings of orange and 121 saplings of coffee plants.

The above findings show that there has been a steady increase in the adoption/ adaptation of the new intervention largely within the research villages.

Tracer study for tracking flow of information and materials

The flow network analysis showed that the flow of information among farmers was higher than the flow of materials. This was obvious since the experiment was just in its second year and adequate planting materials were not produced on farm for farmer-to-farmer distribution. However, it showed that there was high potential for adoption/ adaptation of the new interventions. The flow of information and material was higher from farmer-managed experiments than scientist-managed ones, indicating that PTD approach to technology development is more effective in promoting flow of information and materials. An example of flow network diagrams from Landruk are shown in Figure 2 and 3.

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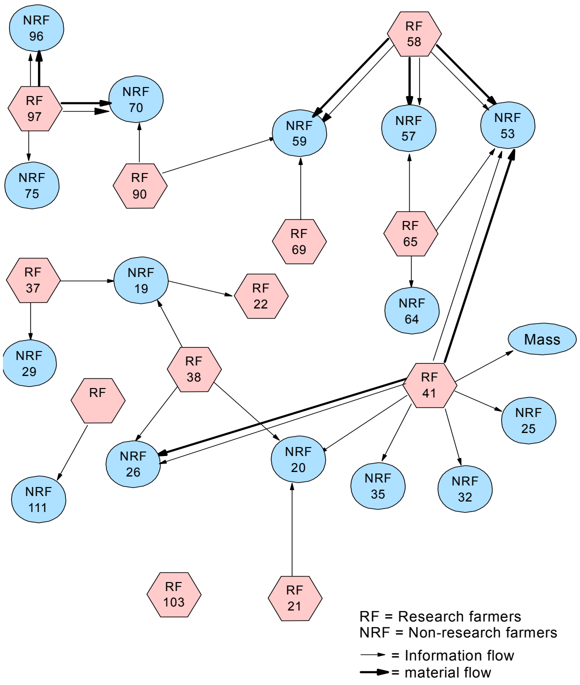

Figure 2. Flow of information and materials from farmer-managed experiments at Landruk, 2002.

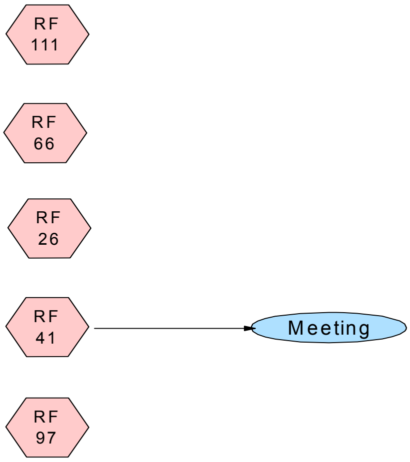

Figure 3. Flow of information and materials from scientist-managed experiments at Landruk, 2002.

Household sample survey

A large proportion (more than 70 per cent) of farmers were aware of the farmer-managed and scientist-managed experiments on soil and water management in the village (Figure 4). At Landruk, farmers' awareness about the scientist-managed experiment was even higher. This was mainly because of the high visibility of erosion plots and drums of the scientist-managed experiment plots. However, a higher proportion (57 per cent) of farmers reported to know about the details of the farmer-managed experiments than farmers (34 per cent) reported to know about the details of scientist-managed experiments (Figure 5). This showed that PTD approach of technology development enhances the flow of information.

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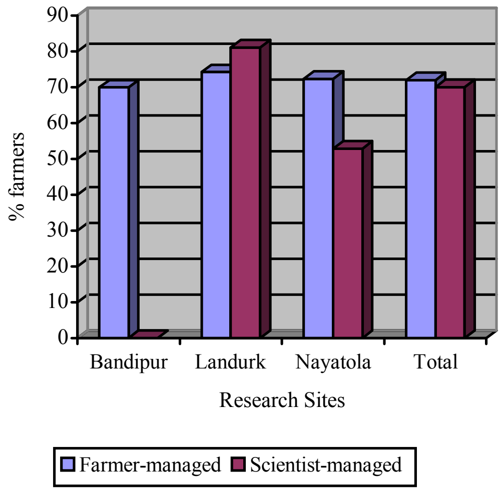

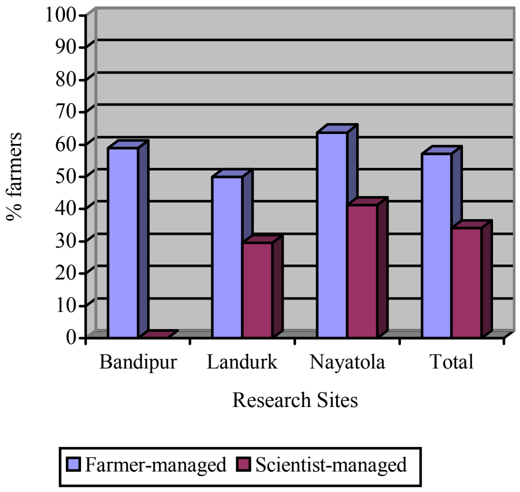

Figure 4. Farmers' awareness about experiment on new interventions, 2002.

Figure 5. Farmers' knowledge about details of experiment on new interventions, 2002.

Regarding differences in awareness, no significant difference was found among farmers due to difference in farmer types (field neighbour, house neighbour and other farmers), ethnicity and wealth categories. However, a high proportion of farmers from *Brahmin, Chhetri* and *Gharti* ethnic groups at Landruk and from poor and medium wealth categories at Nayatola reported to know more about the details of farmer-managed experiments. On the other hand, a high proportion of house and field neighbour farmers and farmers from *Brahmin, Chhetri* and *Gharti* ethnic groups reported more about the details of scientist-managed experiments.

The adoption/ adaptation of new interventions by non-research farmers was also high for farmer-managed interventions reported by about 25 per cent farmers as against about 7 per cent for scientist-managed interventions. It indicated that farmer-managed interventions were more readily adopted/adapted by the farmers. The difference in adoption was found significant for ethnicity at Landruk, where a significantly (p=0.000) higher proportion of farmers from *Brahmin, Chhetri* and *Gharti* ethnicity reported to adopt/ adapt new intervention than other. None of the farmers from *Kami, Damai* and *Sarki*, representing low caste and resource-poor ethnic groups, reported to have adopted/ adapted any new interventions. Regarding potential adoption/ adaptation, more than 30 per cent of the farmers were willing to adopt/ adapt new interventions in the future. The proportion of farmers willing to adopt/ adapt new interventions originating from farmer-managed experiment was lower at Landruk while higher at Nayatola.

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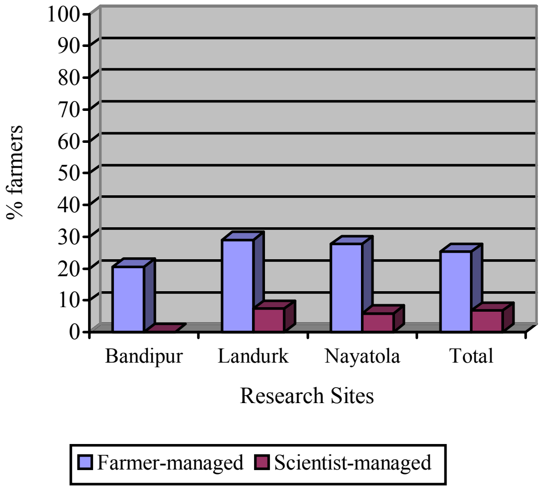

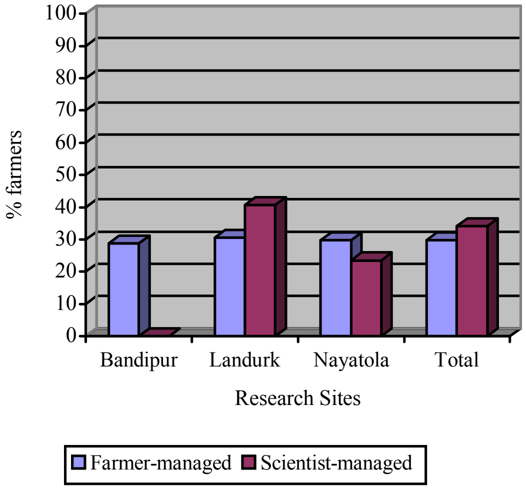

Figure 6. Non-research farmers adopting/ adapting new interventions, 2002.

Figure 7. Non-research farmers willing to adopt/ adapt new interventions, 2002.

Peer assessment by visiting farmers

Out of 18 farmers visiting Nayatola research site, 17 farmers liked and saw benefit from the new interventions under experimentation. While about 78 per cent farmers liked both the hedgerow and ginger strip cropping interventions, about 11 per cent liked only hedgerow interventions and about 6 per cent 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 per cent farmers (Table 5).

Table 5. Reasons for farmers' liking of soil and water management interventions under experiment at Nayatola.

Reasons	Responding farmers (multiple response)	
	Number (n=17)	%
1. Control soil erosion	15	88.2
2. Increase soil fertility	7	41.2
3. Increase crop yield	6	35.3
4. Production of forage on-farm	6	35.3
5. Increase farm income	3	17.6
6. Multiple crops and fruit production	2	11.8
7. Reduce terrace slope	2	11.8
8. Reduce terrace size	2	11.8
9. Possible to establish on small land area	1	5.9
10. Formation of bench terrace	1	5.9
11. Facilitate easy plowing of land	1	5.9
12. Perennial nature of forage species	1	5.9

Similarly, about 82 per cent of the farmers reported that both hedgerow and strip cropping interventions would be suitable to their village while about 12 reported only strip cropping and about 6 per cent only hedgerow intervention. A high proportion (about 94 per cent) of farmers expressed their willingness to try out these interventions in their farm. Of these, about 56 were interested on both hedgerow and strip cropping while about 33 only on hedgerow and about 11 only on strip cropping.

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

4.4. Methodology in PTD for HKH region developed and promoted.

The PTD process developed through the project was described (Figure 8) and recorded on video in both English and Nepali languages (Annex 7). The video will be completed April, 2003 and distributed to all stakeholders. Use of the methodology has been institutionalised by ARSL and LIBIRD and extended within on-going projects currently funded by HARP.

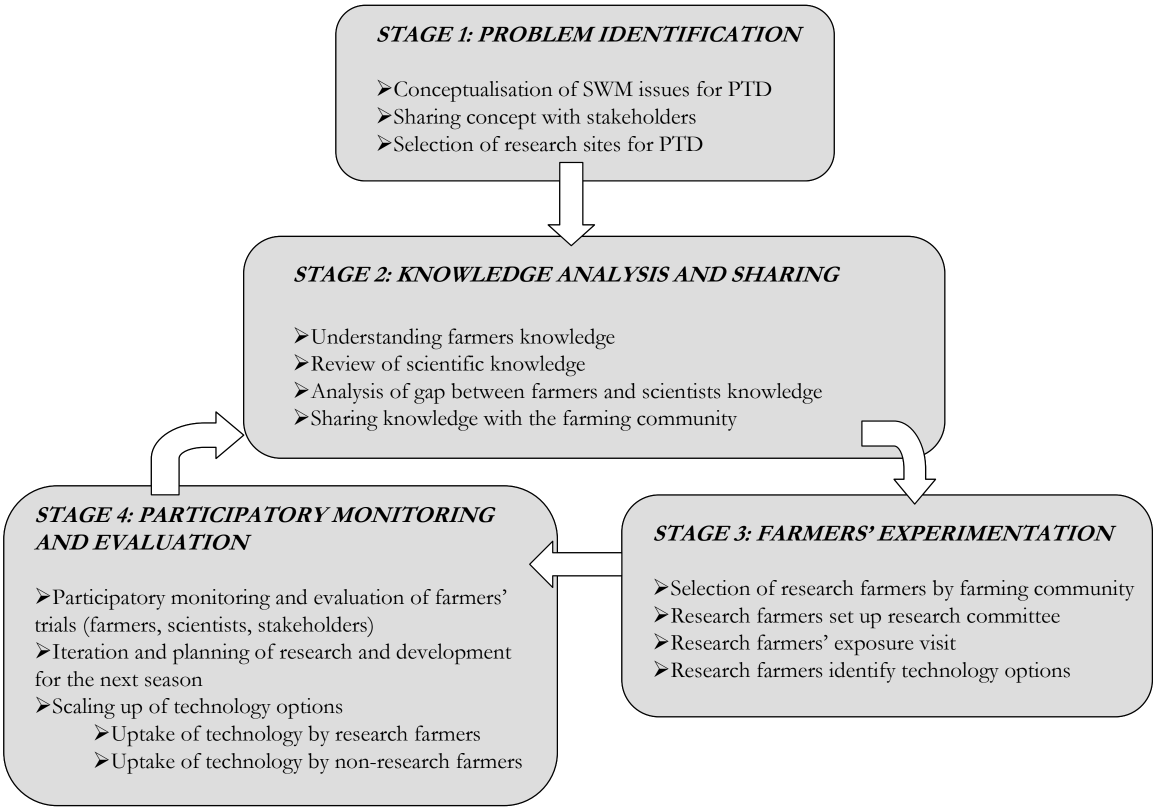

Figure 8. The Participatory Technology Development Process

5. RESEARCH ACTIVITIES

5.1 Problem identification

Stakeholder workshop

An inception workshop was conducted in November, 1999 with the following objectives:

1. To identify the roles and responsibilities of all collaborators
2. To plan the activities
3. To establish the contribution of the project activities to the project outputs

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4. To identify the communication network
5. To plan the dissemination activities

Full details are provided in McDonald (1999).

Selection of research sites

The research sites were selected on the basis of the previous work conducted by Gardner *et al*. (2000), Following the monitoring of qualitative data in seven Middle Hills sites in 1996, three were selected for more intensive quantitative monitoring of soil and nutrient losses in 1997 and 1998. These sites were Landruk, Bandipur and Nayatola.

Landruk is a high altitude (c. 5,500m), high rainfall site. Typical terraces are narrow with 0 to 5^o outward slope angles and sited on steep slopes (Landruk is situated on the mid slope of a steep sided, deeply incised river valley more than one mile deep). Terrace width can be less than a metre, few are greater than five metres. In some places, at the higher altitudes, farming is marginal on narrow, very stony terraces. The main crop is maize, occasionally with a sparse undercrop, usually bean, pumpkin or water melon. The growing seasons are longer than in other sites because of the altitude. In is normal for maize either to be relayed with millet, the millet being transplanted in late July/early August, or for barley to be grown in the spring before maize is planted.

Bandipur is a mid-altitude (c. 3000m), low to moderate rainfall (c. 1500 mm pa) site where the qualitative data in 1996 indicated uniform low response relative to other sites. The terraces tend to be about 3 to 5 metres in width and slightly outwardly sloping, 0 to 4^o being typical. Soil type does vary but differences to the predominant red/brown soil tend to exist only in pockets. Hillsides have less steep slopes than in Landruk and the topography precludes run-on on most sets of terraces. Bandipur is on a good road so has permanent access to market and it is possible to sell surplus crops easily and grow some cash crops. This facilitates greater crop variety and cropping patterns and the different farmer practice required to manage each crop was the main variation tested on the erosion plots sited here. Maize was again the main crop and bean, pumpkin and water melon again the main undercrops, though grown in greater densities than Landruk. Upland (rainfed) rice is an important secondary crop, as it is in many low to mid altitude sites in the Middle Hills, and there has been recent, large scale introduction of citrus trees into this area, some species of which will eventually shade out the maize undercrop.

Nayatola is a mid altitude (c. 1600m) site with low to moderate rainfall. The site is in Palpa district where large, steeply sloping terraces are predominant. These terraces are so constructed because size of terrace is perceived as reflecting wealth and status in this area. They contrast sharply with the flat to moderately sloped narrow terraces characteristic of most Middle Hill areas. In Nayatola terraces are likely to be 20 to 50 metres wide, and characterised by slope angles of 20 to 35^o (though are narrower and less steep where topography dictates). Whilst such terrace design might be thought to promote erosion the qualitative study showed that rainfall and runoff/soil loss response was often low, but that the terraces seemed highly vulnerable to the high magnitude events. Almost all individual terraces on steep slopes had developed an ‘S’ shape in profile. Terraces seemed more prone to rilling than elsewhere. Maize, often undercropped with moderately dense cowpea, soybean, bean and pumpkin, is the main crop during the monsoon period.

5.2 Knowledge analysis and sharing

The collection, storage and analysis of farmers' local knowledge and perceptions on soil and water management was done by using a methodology called Agro-forestry Knowledge Toolkit (AKT) developed by the University of Wales, Bangor in UK (see Dixon *et.al*., 2000 for details). It uses an ethnographic approach to knowledge acquisition and applies artificial intelligence and computer technology in storing, assessing and retrieving stored knowledge base (Thapa, 1994; Thapa *et.al*.,

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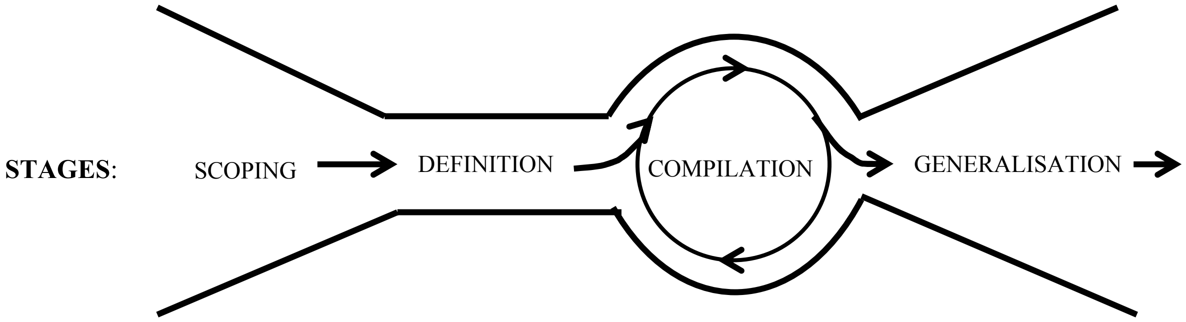
1995; Walker *et.al.*, 1995; Joshi, 1997; Walker et.al. 1997; Sinclair and Walker, 1998; and Walker and Sinclair, 1998). The AKT methodology uses different sets and combinations of methods, ranging from participatory rural appraisal (PRA) tools to interviews with the individual farmer, to suit available resources and local circumstances where the approach is to be applied. The framework of knowledge elicitation is divided into four inter-linked stages as shown in the Figure 9 (Walker and Sinclair, 1998).



Objective	To refine knowledge acquisition objectives	To generate a broad understanding of domain and define boundaries and terms	To create a coherent and comprehensive knowledge base	To validate the representativeness of the knowledge base and the distribution of knowledge
Informants and activities	A broad range of activities in order to familiarise with the source community and get a broader understanding of the knowledge held	One or two intensive interactions with a small number of purposively selected informants	Repeated interaction with stratified sample of key informants, knowledge representation and evaluation of emerging knowledge base	A variety of questionnaire-based survey approaches on a sufficiently large and randomly selected sample of informants from the community
Tools	A range of PRA techniques	Focus group discussions	Focus group discussion and repeated informal interviews	Sample household interviews

Figure 9. Overview of the four stages in the knowledge elicitation process.
(Source: Adapted from Walker and Sinclair, 1998).

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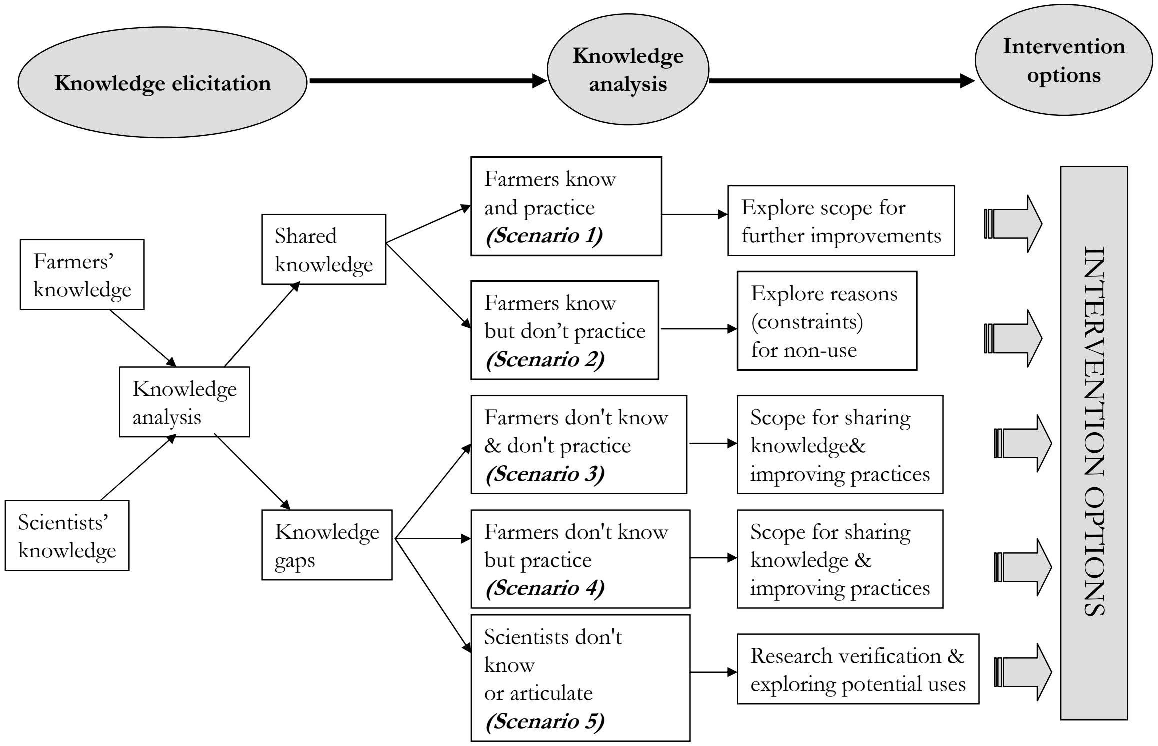

Figure 10. A framework for knowledge analysis and identifying intervention options for participatory technology development

The knowledge approach to technology development adopted a framework that allowed a systematic incorporation of farmers' and scientists' knowledge and practices (Figure 10) into a participatory technology development (PTD) process (Figure 8) for the development of technology options.

The elicitation of farmers' local knowledge on soil and water management was conducted with purposively selected farmers of the three project sites, Bandipur in Tanahun, Nayatola in Palpa and Landruk in Kaski districts of western hills of Nepal. More than twenty farmers, both men and women, at each site were repeatedly interviewed for this purpose. It showed that farmers possess a wide range of knowledge about soil and water management on their farm as well as in the community (Shrestha, 2000). This knowledge is largely explanatory, experiential and commonly held between the community. Similarly, farmers have more knowledge about above ground soil and water related ecological processes than below ground processes.

Knowledge sharing village workshop

Village workshops were organised at all the three research sites to share findings of the knowledge acquisition survey and scientists' generated information on soil and nutrient losses at these sites with the farming communities. Farmers (both men and women) were informed of and invited to the workshop through the 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 research scientist team (Plate 1). Additional emphasis was given on the areas of knowledge which were not well known or articulated by the farmers.

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Plate 1. Leaching demonstration by ARSL/LIBIRD staff at the knowledge sharing workshop in Landruk

5.3 Farmers' experimentation

Farmer selection and formation of research committees
The core of the conceptualised community intervention for innovation in natural resource management is the socio-organisational strengthening on one side and farmer experimentation and discovery on the other side within a negotiation process (Hagmann & Chuma, 2002). This is in keeping with the 'Participatory Extension Approach (PEA) described by these authors which includes 'social mobilisation' as an additional preliminary step in the technology development process (Figure 8). It has now been well established that farmers do their own research when they have access to new seeds, planting materials, animal breeds and information. Their research is largely explorative and adaptive in nature, and influenced by their needs and resource endowment. Based on these experiences, the project has adopted an approach that empowers research farmers to design and manage new soil and water management interventions by themselves, through village 'research committees'.

The sharing of knowledge and the realisation of nutrient loss through soil erosion and leaching motivated farmers to participate in the technology development process. Farmers and the village leaders, participating in the village workshop, were requested to identify and select farmers to undertake research on soil and water interventions suitable for these farmers and the community. They selected twelve farmers at each site for this purpose. To facilitate communication and support among each other as well as with farming community and with research scientists these farmers were called "research farmers" and their group as "research farmers' committee".

Exposure visits
The thirty-six research farmers from all three 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 Nepal Agricultural Research Council (NARC) and ICIMOD;
- Majhitar farming community in Dhading district supported by Nepal Agro-forestry Foundation (NAF);
- Godawari trial and demonstration site managed by ICIMOD; and
- Sankhu project site of Bagmati Integrated Watershed Management Programme.

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Farmers acquired new knowledge on and saw improved practices on soil and water management and were highly motivated to try a number of new soil and water management practices on their farm.

Farmer-managed trials

Meetings of research farmers were called and facilitated by the research scientists to discuss the design and installation mechanisms of new soil and water management interventions in their respective project sites. The meetings started with the review of the knowledge shared in the first village workshop and learning made 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 to be tested for few seasons to draw a meaningful conclusion;
- visualise that the intervention trials they would experiment with need to be compared with their current practice to see their effectiveness (the concept of control);
- think over the selection of land for putting 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 sites and based on their interest 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 laid out in a way that they envisaged would conserve nutrients and water on the farmed land. The next day of the meeting, the research scientists visited individual research farmers, made joint observations of the plot selected for trial placement and measured the trial plots to estimate the quantities of trial materials required.

Researcher-managed trials

Strategic trials were established building on the existing plots of Gardner *et al.,*2000 (which were retained as controls) in the Lumle command area. These plots were monitored by researchers although all farming activities were conducted by the farmer-owners. The plots were of a standard size 20m x 5m, and eroded sediments and runoff collected in a series of troughs with drums and splitters. Leachate was collected with lysimeters (which were redesigned to incorporate crops – the original weighted lysimeters used by Gardner *et al.* were isolated soil cores). The experimental protocol was developed in consultation with biometricians from the Statistical Services Unit of Reading University (McDonald *et al*., 2000). Eroded sediments were analysed for a range of physical and chemical properties, including total nitrogen, phosphorus, exchangeable cations, pH and particle size analysis. The soils within the plots were analysed for the above parameters plus bulk density and available nitrogen and phosphorus. Leachate and runoff were analysed for total nitrate, ammonium, phosphorus, cations, and pH. Bioassays of productivity were conducted by monitoring sub-plots of crop production within plots under the different interventions. All measurements were continuous over the project period. Interventions tested in comparison with the controls included; control of run-on and riser planting with improved fodder grasses at Landruk, and strip cropping of maize/legume and maize/ginger at Nayatola. No interventions were tested at Bandipur in the researcher-managed trials, but the existing plots were continuously monitored.

5.4 Participatory monitoring and evaluation

Observation of farmers' responses and actions to new interventions

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This simply involved observing and recording farmers' responses and actions to the new interventions experimented with at each research site. This was done throughout the season and analysis was done at the end of each year. The observations made were request of the farmers for planting and other research materials and distribution of such materials, and types of interventions adopted by the farmers.

Tracer study for tracking flow of information and materials

The flow of information about the interventions among the farmers shows their interest towards these interventions, and this can be used as an indicator of potential adoption/ adaptation the interventions. On the other hand, flow of materials indicates a current adoption/ adaptation of the intervention. An attempt was, therefore, made to trace flow of any information and/or 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 and/or material flow was traced and any flow of information and/or materials was recorded. This resulted in a flow network giving an indication of current as well as potential adoption of the interventions.

Household sample survey

At end the second year of the experimentation with new interventions, i.e. at the end of 2002 summer crop, a household sample 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 categories into three following three groups of farmers.

1. House neighbours of farmers involved in farmer-managed and scientist-managed interventions selected purposively
2. Field (with experiment) neighbours of farmers involved in farmer-managed and scientist-managed interventions selected purposively
3. Other farmers of the community selected through random sampling

Two sets of questionnaire were developed - one to get feedback about farmer-managed interventions and another to get feedback about scientist-managed interventions. The heads of the sample households were individually interviewed using a structured questionnaire and data analysis was done using SPSS computer software. Chi-square statistics was used to test the significant differences in farmers' response. The data obtained from interview with farmers sampled for survey about scientist-managed interventions was used as baseline data to evaluate the effectiveness of farmer-managed PTD approach of technology development. At Bandipur research site, however, there were no scientist-managed experiments and therefore no such comparison was possible.

Peer assessment by visiting farmers

A farmers visit programme to Nayatola was organised by ARS Lumle in September 2002. Eighteen farmers from Syangja, Palpa, Gulmi and Arghakhanchi districts visited the site to see the on-going research activities and to interact with the research farmers. These visiting farmers were requested to evaluate the performance and effectiveness of the new interventions independently. This also provided an indication of the potential wider dissemination of the new interventions.

Stakeholder evaluation

Stakeholder monitoring of the research trials was conducted as a part of regular research activities built into the programme. The purpose was to use diverse perspectives of the stakeholders to examine

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changes due to new interventions under trial and evaluate their effectiveness in reducing nutrient losses and due to leaching and erosion. It also provided opportunities for the scientist, development professionals and farmers to interact and make decisions regarding new interventions. A participatory monitoring and evaluation approach was adopted for the purpose. The scientists, development professionals and research-farmers made joint visits of trial plots, and made their own observations and evaluation of research trials based on their own monitoring criteria.

6. ENVIRONMENTAL ASSESSMENT

R7412 is an environmental project in the broad sense. Directly, it addresses land degradation. It seeks to minimise nutrient losses from *bari* land. If successful, fewer nutrients will be transported to water reservoirs, more will go towards better cover for the land, including woody species. Increased biomass on *bari* along with better use of organic manures in the soil are potentially positive for the environment in sequestering carbon. The increasing emphasis on fodder and stall-feeding of animals is environmentally beneficial. The project is also fostering the use of a greater number of species (and encouraging the more secure growth of local varieties) and the intensification of land use on productive units of land. Therefore it could be said that the project is contributing to biodiversity enhancement directly on-farm (agro-biodiversity) and in relieving pressure from adjacent forest and conservation areas (native species biodiversity).

Environmental threats may include the greater demand for organic materials and livestock forage, and an increased off-take from adjacent forests. Increased production from *bari* may also encourage a further swelling of the population and environmental impacts. There may also be a diversion of water and nutrients away from *khet* land because of their better utilisation on *bari*. Terrace collapse may also be a problem in some places if more water is conserved on *bari* land. Such effects are outside the project's influence and control. However, an objective assessment would probably conclude that the immediate environmental benefits probably outweigh any longer-term threats.

7. CONTRIBUTION OF OUTPUTS

The Goal of the Natural Resources Systems Programme is to generate benefits for poor people by the application of new knowledge to natural resource (NR) systems. This has been at least partially achieved through delivering new knowledge that can enable poor people who are largely dependent on the NR base to improve their livelihoods. The central focus of knowledge generation is on changes in the management of the NR base that can enhance the livelihood assets of the poor over a relatively long timeframe, thus providing greater livelihood security and opportunities for advancement of poor individuals, households or communities. Thus, there is a need for longer-term monitoring, which is being facilitated by the target institutions. Integrated management of natural resources is central to the research. The term 'integrated management' defines not only the adoption of a holistic view of the NR base (landforms, soil, water, vegetation and organic residues) but also appreciates the integrated and dynamic nature of people's livelihood strategies and how these affect their decision-making and capacity to use and manage the NR base. Studies of the livelihoods of the poor and their interaction with other (less poor) sections of society are an important part of NRSP's research, and this emphasis will be maintained in the continuing research led by LIBIRD and ARSL with multidisciplinary teams.

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8. Publications and other communication material

8.1 Books and book chapters

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8.2 Journal articles

8.2.1 Peer reviewed and published

8.2.2 Pending publication (in press)

8.2.3 Drafted

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8.3 Institutional Report Series

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8.4 Symposium, conference, workshop papers and posters

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8.5 Newsletter articles

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Local knowledge throws new light on agroforestry research in Asia. Asia-Pacific Agroforestry Newsletter (Spring, 2001).

8.6 Academic theses

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Acharya, G. P. 2003. Interventions to Minimise Nutrient Losses from *Bari* Land (Rainfed Upland) in the Middle Hills of the Western Development Region of Nepal. PhD thesis, University of Wales (in preparation).

Shrestha, P.K. 2003. Combining Local Knowledge in Developing Soil and Water Management Interventions to Minimise Soil and Nutrient Losses in the Middle Hills of Nepal: Using a Participatory Technology Development Approach. PhD thesis, University of Wales (in preparation).

8.7 Extension-oriented leaflets, brochures and posters

Acharya, G. P. 2002. Protecting fertile soil from erosion by strip cropping in sloping *bari* lands. Agriculture Research Station, Lumle, 22 pp (extension booklet in Nepali language).

8.8 Manuals and guidelines

8.9 Media presentations (videos, web sited papers, TV, radio, interviews etc)

Shrestha, P.K. 2003. Participatory Technology Development in Soil and Water Management: *A Case from Western Hill of Nepal* (Video production in English and Nepali)

8.10 Project reports and data records

8.10.1 Citation for the project Final Technical Report (FTR)

McDonald, M. A., Shrestha, P.K., Acharya, G. P., Tripathi, B. P., Lawrence, A. and Sinclair, F.L. 2003. Incorporation of local knowledge into soil and water management interventions which minimise nutrient losses in the Middle Hills of Nepal. University of Wales, Bangor. 37pp + appendices

8.10.2 Project technical reports including project internal workshop papers and proceedings

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Shrestha, P. K. 2001. Report on field monitoring of scientist and farmer managed research trials, LI-BIRD, 39 pp.

8.10.3 Literature reviews

8.10.4 Scoping studies

8.10.5 Datasets, software applications

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8.10.6 Project web site and/or other project related web addresses

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10. PROJECT LOGFRAME

NARRATIVE SUMMARY	OBJECTIVELY VERIFIABLE INDICATORS	MEANS OF VERIFICATION	ASSUMPTIONS
GOAL: Improved hillside farming strategies relevant to the needs of marginal farmers developed and promoted	**By 2002** new methods of cost effective soil and water conservation and tillage systems which explicitly benefit the poor validated in two targeted areas **By 2003**, this new knowledge incorporated into strategies to increase the local availability of food and/or fodder supplies and adopted by target institutions in two target countries	Reviews and data collected by Programme Manager Reports of research team and collaborating/target institutions Dissemination of products Local and international statistical data	Target beneficiaries promote systems and approaches Enabling environment exists Budgets and programmes of target institutions are sufficient and well managed
PURPOSE: Improved methods for the promotion of viable soil and water management techniques in the mid-Hills of Nepal promoted through participatory approaches to the design of technologies that reduce erosion and nutrient losses and provide greater benefits to farmers.	By 2003, professionals in NGOs and NARC - incorporate local knowledge and perceptions of soil erosion in their assessments of conservation needs - adopt PTD processes in their interventions with farmers to design conservation technologies	Project FTR For collaborating and target institutions, evidence of use and promotion of: - local knowledge of erosion and conservation needs - PTD processes	- Target institutions invest in the uptake and application of research results - Budgets and programmes of target institutions are sufficient and well managed
OUTPUTS: 1. Local knowledge and perceptions of soil and water conservation methods acquired and distribution with respect to spatial and cultural variation documented. 2. Locally adoptable interventions which minimise nutrient losses by erosion and leaching designed by combining local knowledge (from 1) and scientific knowledge through PTD in three different farming systems in the Lumle command area. 3. Adoption and adaptation of interventions by farmers evaluated. 4. Methodology in PTD for HKH region developed and promoted.	1. Village communities in Nepal surveyed for local knowledge on soil and water conservation and reports and knowledge base prepared by March, 2000. 2. Participatory research trials installed by March, 2000 (researcher-managed) and March, 2001 (farmer-managed). 3. Participatory monitoring and evaluation continued throughout the project period, and 5 years after the project termination. 4. Manuals and video produced and disseminated by March, 2003.	1.1Project reports 1.2 Journal papers 1.3 Popular articles 1.4 Web site linked to UWB and partner institution pages 2.1Project reports 2.2 Journal papers 2.3 Popular articles 2.4 Web site linked to UWB and partner institution pages 3.1Project reports 3.2 Journal papers 3.3 Popular articles 3.4 Web site linked to UWB and partner institution pages 3.5 Post-project evaluation of	Interventions proven to have beneficial effects on soil erosion accepted and adopted by farming communities

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		adaptation conducted in 2008 funded by NRSP 4.1 Video of PTD process 4.2 Manual of PTD process	
ACTIVITIES: **Initial participatory appraisal and knowledge acquisition** 1.1 Participatory rural appraisal principally involving researchers from ARSL and LI-BIRD interacting with the farmers. The communities will be from three areas representative of major farming systems from altitudes of 800m in Palpa District to those in excess of 2000m in Kaski District. The PRA will include prioritisation of problems and causal factors, identification of potential solutions and reactions to possible interventions, and the identification of farming groups willing to participate in the strategic trials (2.1), and their evaluation criteria. **1.2** Farmers' current knowledge and practice will be acquired using a combination of PRA tools and knowledge-based systems techniques. The PRA in 1.1 will be used to define the domain for knowledge collection and select a small purposive sample of farmers will be interviewed in depth. The distribution of knowledge will then be mapped by using the initial knowledge base to create a non-leading questionnaire which will be administered to a large, stratified, random sample of people across the western mid-hills. **Participatory technology development** 2.1 Strategic trials will be established building on e the existing plots of Gardner et al. in the Lumle command area. The existing plots will function as controls for comparison with adjacent plots incorporating interventions. The plots will be of a standard size 20m x 5m, and eroded sediments and runoff will be collected in a series of troughs with drums and splitters/ Leachate will be collected with lysimeters. The experimental protocol will follow a rigorous design developed in consultation with biometricians from the Statistical Services Unit of Reading University. Eroded sediments will be analysed for a range of physical and chemical properties, including total nitrogen, phosphorus, exchangeable cations, pH and particle size analysis. The soils within the plots will be analysed for the above parameters plus bulk density and available nitrogen and phosphorus. Leachate and runoff will be analysed for total nitrate, ammonium, phosphorus, cations, dissolved organic carbon and pH. The soil nutrient analysis will be conducted in the laboratories of ARSL, and the physical characterisations at UWB. Water analyses will be conducted in the laboratories of ARSL/LI-BIRD. Bioassays of productivity will be conducted by monitoring sub-plots of crop production within plots under the different interventions. The methodology for this will vary according to the different farming system, management regime and intervention, but will be continuous over the project period. 2.2 After separate reviews and baseline studies of indigenous soil conservation practices and institutional experiences in the area, farmers, NGOs and scientists will be brought together in a series of small rural workshops. Each group of stakeholders will make informal presentations about their soil conservation practices. This will create opportunities to discuss new ideas, and farmer groups can then plan their own trials building on new information acquired at the workshop	PROJECT MILESTONES: 1.1 PRA conducted by March, 2000. 1.2 Initial elicitation, collation and formalisation of knowledge completed by March, 2000. 2.1 Potential intervention incorporated into experimental design, and researcher-managed trials established by March, 2000. Samples of plot soils, eroded sediments, runoff and leachate collected and analysed over the period October, 1999 to September, 2002. 2.2 Interventions designed by farmers' groups and farmer-managed trials installed by March, 2001.		- Typical cross-section of farmers are willing to collaborate - Target institutions retain ability to collaborate - Weather conditions throughout experimental period are typical - Infrastructure continues to permit travel and communications between project sites

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Evaluation of adoption 3.1 The rate of adoption by farmers not directly involved in the trials of the tested interventions will be assessed from field observations. 3.2 The evaluation criteria of farmers who did adopt the interventions will be evaluated, and any subsequent adaptations documented. 3.3 Farmers' reactions to on-farm experiments (the farmers actually involved in the replicated experiments) will be evaluated. Their assessment of the efficacy of the interventions, and any constraints that they identify to further adoption will be evaluated. 3.4 Adoption, adaptation and diffusion of the technologies tested will be assessed by evaluation of all the study sites 5 years after the termination of the project. **Promotion** 4.1 A manual of the PTD process for the design of projects to develop improved interventions to facilitate soil and water management will be produced. The manual will be guided by ICIMOD and will contain procedures applicable throughout the HKH region. Dissemination will be discussed within the annual workshops but will be in cooperation with NGOs, government agencies, farmer groups and bilateral programmes. 4.2 An accompanying video will be prepared documenting the PTD process developed throughout the project period, and drawing on examples from other NRSP-funded projects in Nepal. 4.3 Annual workshops will be conducted locally to involve all institutional stakeholders, and a regional workshop will be organised and conducted by ICIMOD at the conclusion of the project. The final workshop will serve as a means to disseminate the project findings, and the PTD process developed throughout the project period, and will also disseminate findings form other DFID-funded projects. The synthesis will determine future demand-led research priorities.	3.1 Field observations over the period March, 2000 to September, November 2002 3.2 PM&E conducted over the period March, 2000 to November, 2002 3.3 As 3.2 3.4 PM&E conducted in March, 2008 4.1 Material generated for manual and video by November, 2002 4.2 Workshops completed by November, 2002. BUDGET: Staff £85,482 Overheads £48,374 Equipment £9,000 Overseas Travel £61,477 Miscellaneous £99,146 TOTALS £303,479		

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11. KEYWORDS

Leaching; Local knowledge; Participation; Soil erosion; Soil fertility; Nepal

12. ANNEXES

Annex 1. Acharya, G.P., Tripathi, B. P. and McDonald, M. A. 2001. Soil fertility status, soil and nutrient loss measurement and their conservation practices for improving the upland rainfed terraces (bariland) in the western hills of Nepal. Paper presented at the International Symposium on Mountain Agriculture in the Hindu Kush-Himalayan Region, 21-25 May 2001. ICIMOD, Kathmandu, Nepal.

Annex 2. Tripathi, B.P., Shrestha, S. P., Acharya,G. P., Gardner, R., Mawdesley, K., Gaskin, S. and Adams, S. 2001. Assessment of soil and nutrient losses from rainfed upland (*bari*land) terraces in the western hills of Nepal. Paper presented at the International Symposium on Mountain Agriculture in the Hindu Kush-Himalayan Region, 21-25 May 2001. ICIMOD, Kathmandu, Nepal.

Annex 3. Shrestha, P.K., McDonald, M. A. and Sinclair, F.L. 2001. Application of Knowledge Based Systems Approach in Participatory Technology Development: A Case of Developing Soil and Water Management Interventions for Reducing Nutrient Losses in the Middle Hills of Nepal. Paper presented at the International Symposium on Mountain Agriculture in the Hindu Kush-Himalayan Region, 21-25 May 2001. ICIMOD, Kathmandu, Nepal.

Annex 4. Acharya, G. P., Tripathi, B. P. and McDonald, M. A. 2002. Interventions to Minimise Nutrient Losses from *Bari* Land (Rainfed Upland) in the Middle Hills of the Western Development Region of Nepal. Paper presented at the 12th International Soil Conservation Organization Conference, Beijing, China, May 26-31, 2002

Annex 5. Acharya, G. P., Tripathi, B. P. and McDonald, M. A. 2003. Interventions to Minimise Nutrient Losses from *Bari* Land (Rainfed Upland) in the Middle Hills of the Western Development Region of Nepal. Paper presented in a symposium on "Renewable Natural Resource Management for Mountain Communities" organised by Natural Resources Systems Programme (NRSP) from 24-25 February 2003 in Kathmandu, Nepal.

Annex 6. Shrestha, P.K., McDonald, M. A., Lawrence, A. and Sinclair, F.L. 2003. Combining Local Knowledge in Developing Soil and Water Management Interventions to Minimise Soil and Nutrient Losses in the Middle Hills of Nepal: Using a Participatory Technology Development Approach. Paper presented in a symposium on "Renewable Natural Resource Management for Mountain Communities" organised by Natural Resources Systems Programme (NRSP) from 24-25 February 2003 in Kathmandu, Nepal.

Annex 7. Video script (English)

Annex 8. Project Inventory

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