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Environmental Change and Livelihood Diversification in Nepal: Where is the Problem?

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Abstract

This is a preliminary account of how farmers in the hills of Nepal perceive and adapt to environmental change (and particularly to declines in soil fertility) in the context of broad social-economic changes to their livelihoods. Sampling of farmers was precisely located within the Likhu Khola catchment, which has been the focus of detailed hydrological and geomorphological research. The type and severity of soil productivity decline and erosion is primarily determined by site specific geomorphological factors, but farmer response is highly dependent upon the particular circumstances of individual farmers who may be marginalised or favoured in various ways, both spatially and socio-economically. Local knowledge of conservation did not seem to be a factor determining effective response, although most had a rather sophisticated, albeit diverse, geomorphological sense of their local predicament. Rather than describe and celebrate their "local knowledge" in conservation, however, the paper concludes that it is more policy-relevant and empirically powerful to analyse farmers' responses to environmental change and productivity decline in terms of their broader socioeconomic circumstances - including labour shortages, cash availability to purchase chemical fertiliser and other changing opportunities for and constraints to livelihood diversification.

Introduction

The debates about the "Himalayan environmental crisis" have generated an enormous literature. Besides technical studies of land degradation deriving from predominately natural science, there is a whole genre from the social sciences which focuses upon agricultural practice and the structure of the household, the micro-region and wider regional economy. Many claim to be policy relevant, although the assumptions made about the political and administrative means of intervention are often optimistic in the extreme and almost always unexamined. Moreover, the earlier, more focused disagreements over "the problem" (e.g. the extent of natural versus anthropogenic causes of degradation, how forest cover and quality has changed through time, whether degradation is economically significant to hill farmers, and whether agricultural production can be increased through agronomic research), have become overtaken by more philosophical and epistemological debates over the construction of knowledge. Thompson and Warburton (1988) were among the first to offer a markedly social constructionist view ("the institutions are the facts"), and others have followed the more post-structural turn which social science has taken over the past decade or so to focus on the competing knowledge claims of science, the state and formal institutions, on the one hand, and of farmers, on the other (cf. the Mohonk Conference, 1987, Ives and Messerli, 1989; Biot et al. 1993, Forsyth 1995, and Guthman 1996). Development discourses in the Himalayan region and elsewhere have become markedly neo-populist in tone, and are situated in broader preoccupations with notions of knowledge and power, and the issue of "whose reality counts?" (Chambers 1997).

During 1993-96, a major research initiative was taken by the Royal Geographical Society (directed by Dr. Rita Gardner), in which the processes of erosion and conservation were studied in perhaps the greatest depth in one watershed that has hitherto been attempted in the Himalayan region by a team of hydrologists, geomorphologists and soil scientists. The project was situated in the Likhu Khola Watershed, about twenty miles due north of Kathmandu. It was almost entirely carried out by natural scientists, but towards the end of the project a small study was commissioned (and carried out by one of the authors of this paper) to begin to link the research findings to their practical application in agricultural extension and environmental management policy. The study had two objectives, firstly to understand how farmers in Likhu Khola perceived and managed their physical environment, and secondly to link some of the natural science findings of the project to socio-economic aspects of environmental management in the watershed. This paper reports its findings and reflects upon their significance in the context of wider debates about development in the Himalayan region.

Forest Fodder, Hill Farming Systems and the Impact of Environmental Scarcity

The important and complex role of forest resources in hill farming systems of Nepal has been widely recognised. Analysis of the multiple use of forestry in Nepal has largely focused on fuel wood, and to a lesser extent, canopy and fodder, considered together as the most important forest products in the middle hills. Fodder is a major component of nutrient management (and thus the maintenance of the rural economy) and is utilised to varying degrees depending on geographical-ecological, socio-economic and agronomical factors affecting the hill farm (Panday, 1982). Reliance on the combination of livestock, forestry and agriculture involves the transference of fertility from forest to arable land via livestock and farmyard manure (FYM) production. The value given by the farmer to the use of FYM and composts to maintain soil fertility, and the importance of sustaining the resources of materials for FYM and composts in the face of rising demand, are recognised in the literature (e.g. Panday 1982, Wyatt-Smith 1982, Hopkins 1983, Vaidya et al. 1995).

Indeed, processes of deforestation and the subsequent reduction in the availability of forest fodder and ground floor litter has generated concern on the part of outsiders and farmers alike regarding the ability of farmers to maintain adequate nutrient levels of agricultural land. The problems of fodder deficits resulting from forest clearance have been recognised, with numerous studies identifying compost and manure shortages, as well as the limited availability of chemical fertilisers. Both deficits of bio-mass from forests and pastures, and the inability of many farmers to purchase chemical fertilisers, have been seen to be a major cause of reduced soil fertility, deteriorating soil structure and subsequent declines in crop yields (Blaikie, Cameron and Seddon 1980, Panday 1982, Hopkins 1983, and Gardner and Jenkins 1995).

Both anthropological and formal economic investigations of the impact of increasing environmental scarcity on livelihoods in the mid-hills of Nepal conclude that deforestation results in falling agricultural output from existing cultivated land. This is a consequence of both the reduced application of forest-derived compost and the increased labour investment required to collect and process the forest products for conversion into compost, thus reducing labour available for other activities in agricultural production (Kumar 1988, Cooke 1998). Gender differences in intra-household labour allocation mean that this increased collection labour burden is met primarily from increases in women's collection time, which is greatest during the heavy monsoon season when their agricultural labour burden is also high. Thus, the consequences for production depend on women's ability to take on additional work, the degree of substitution between men and women's work, and the potential for alternative strategies. Not all households may be equally dependent on forest resources, which are located on common land (or state land, from which they are obtained illegally). Wealthier households may have access to resources from own private trees, whilst marginal landholdings have little land available to release for tree planting, and are thus more dependent on local communal forest resources.

Environmental resource-collecting households face complex decisions regarding the allocation of labour. The marginal product of labour can be relatively high in the hills when accessible resource stocks collected from both private and common property sources demand less collection time. However, this decreases as rising environmental scarcity of green fodder, forest litter, wild foods and game, etc. demands further investment in collection time. Recent studies suggest that households are responsive to the opportunity cost of their labour. Amacher et al. (1996), for example, report sensitivity to labour market opportunities of mid-hill households, and Cooke (1998) also notes that an increase in agricultural wages for women results in lower consumption of, and less labour time expended in, the collection of forest (and other) environmental products. Data collected from the Likhu Khola catchment suggests similar trends. Declining per capita environmental resources combined with labour market opportunities offering higher perceived rates of return are generating alternative livelihood and nutrient management strategies, influenced by the particular agronomic and socio-economic conditions which vary for each household. These involve the transfer of labour resources from the collection of environmental goods to wage labour and non-agricultural employment, and the investment of income thus obtained in the purchase of chemical fertilisers and other inputs to maintain soil fertility to substitute for a falling rate of application of FYM.

Method

The method used in this study comprised three inter-linking components. Firstly, a farmer survey using a structured questionnaire was designed, based on an extensively tested farmer production and consumption survey originally used in what was then west central Nepal (cf. Blaikie, Cameron and Seddon 1980) and since refined by the same researchers in other rural surveys (cf Bagchi et al. 1998, and Cameron et al. in this volume). It incorporates a high degree of cross checking, which is designed to be done soon after the interview so that follow-up may be made to clear up inconsistencies. The original questionnaire was considerably elaborated upon to incorporate more environment-related questions, and was pre-tested in the field.

Secondly, a stratified sample of households was designed in which a proportionate sample number of farmers was taken from three categories of farmers (big, medium and small) from three ecological/altitude zones (hill top, mid-slope and lower slope) within the Likhu Khola watershed. The categories were initially based on the knowledge of the field workers who had been involved in the larger scientific survey for over two years; but the first sample was found to be somewhat big-farmer biased, and a wealth-ranking exercise was then undertaken with local leaders and key informants in each village to estimate the proportion of farmers of each of these categories. A corrective additional sample was taken (mostly of small farmers). Sample size was originally 43 households (including one non-farmer, a shop keeper with no land, and thus removed from the analysis). The sampling method was rough and ready rather than rigorous, but probably not grossly unrepresentative, given the restrictions on time and the unavailability of base data. The data were coded and analysed using SPSS and Excel.

Thirdly, a sub-sample of 13 households was chosen for extensive interview by the first author and Krishna Thapa, who undertook the first survey and acted as co-researcher throughout the field phase of the research. These were chosen on the basis of representativeness and special interest. The underlying assumption which determined their selection, was that there is a great diversity of situations in which the farm household finds itself. This diversity derives from two components. The first is the resource position of the household itself, primarily concerning access to land of different qualities, labour availability, the availability of non-agricultural income and access to cash resources through savings or the amortisation of social capital, and the second is the precise location of the fields in terms of soil type, slope, and geomorphological processes. A semi-structured interview lasting about two hours or more was conducted with both men and women, and involved visiting a number of different fields of the farm household. Detailed field histories were recorded, including issues of physical field design, farming practice, changing soil fertility, use of chemical and farmyard manure, management strategies of soil instability, water disposal, aspects of land tenure and common and state-held land, local soil classification, reasons for degradation on the interviewee's own land and in the watershed as a whole, and the settlement history of the household. Most interviews involved a number of visits and on-site discussion of individual fields. These interviews generated a considerable amount of information, of which only the most general aspects are reported here.

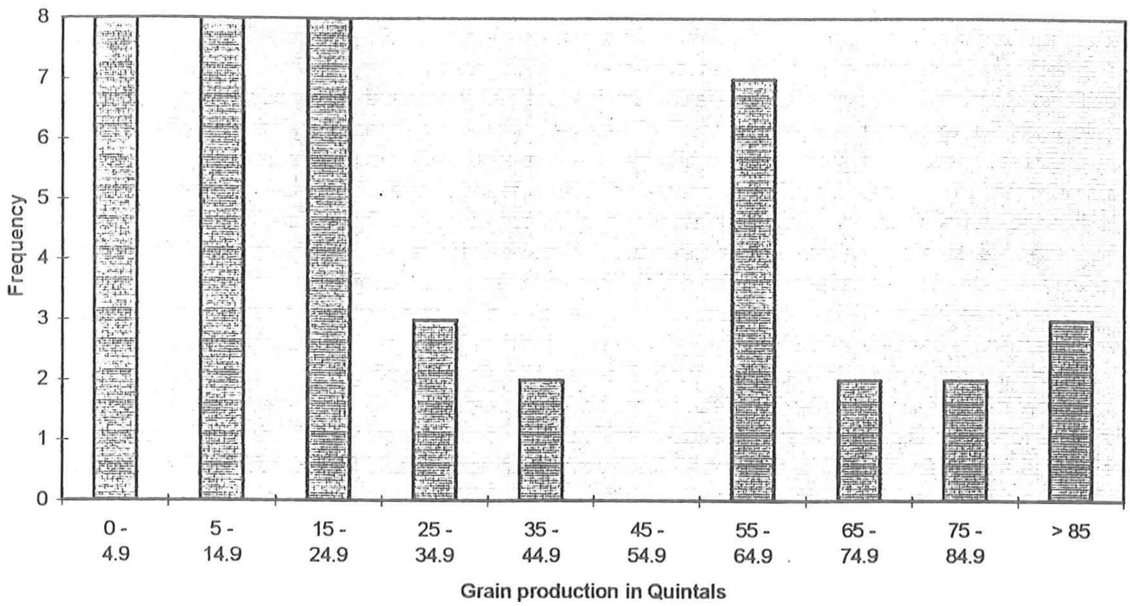
A Socio-Economic Introduction to the Likhu Khola Watershed

While it is a truism to say that impossible to describe a "typical" Middle Hill locality in Nepal, it is fair to say that the socio-economic conditions of the Likhu Khola catchment are not exceptional for that region of the country, although there are a number of surprising statistics which belie the stereotype Middle Hill farming system.

Significant cash flows are evident throughout the hill farm economy, with 98 per cent of farmers deriving cash income from agricultural sources, including sales of own produce, working on other people's land or renting out land and machinery, but only 2 per cent surviving purely by farming their own land without hiring out their labour. Thus the self-sufficient household in labour and land is almost absent. Almost half (45 per cent) of the farm households reported non-farm income from business, hotels, contracting, crafts and service occupations and employment elsewhere (this is not an area where a tradition of military service is well established). The implications for a diversified livelihood strategy by the majority of households are important, and discussed later. In earlier socioeconomic studies (eg. Blaikie, Cameron and Seddon 1980), the existence of non-farm income was acknowledged to have major implications upon total income and the ability to accumulate or disinvest, but the scale and significance of this aspect of rural livelihoods has undoubtedly increased (cf Seddon, Gurung and Adhikari in this issue).

The distribution of total grain produced by farm can be seen from Figure 1, with over half the sample producing less than 25 quintals, but with a third producing over 55 quintals. These latter farmers are overwhelmingly those with *khet* (irrigable, paddy producing) land at middle and lower altitudes.

Figure 1: Distribution of Farmers By Grain Production



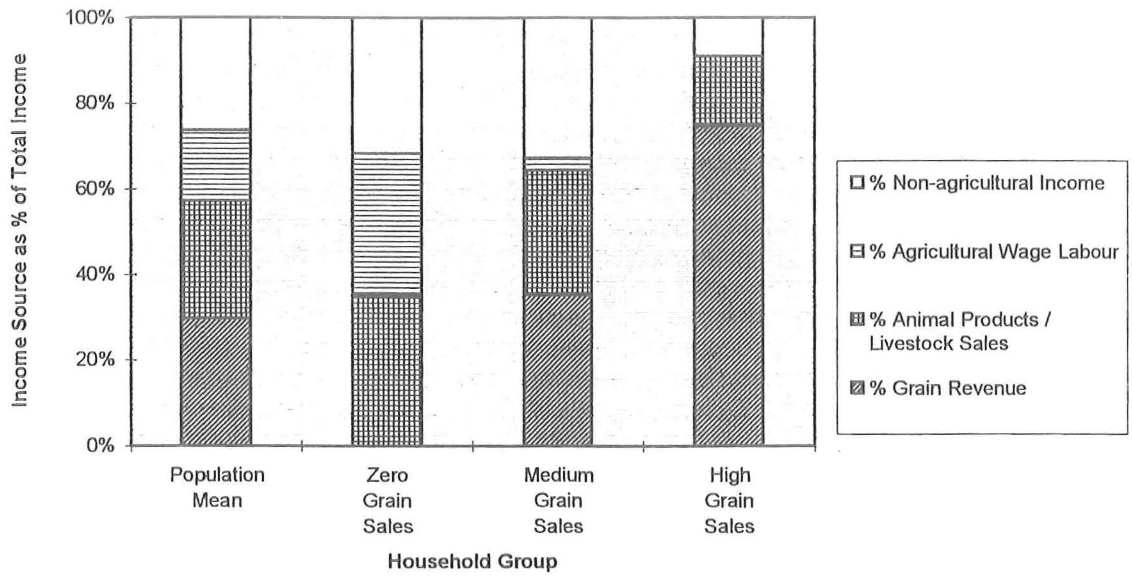
A significant aspect of the local rural economy is the strong surplus in paddy production, which is purchased by contractors who appear at the newly opened track to the west of the study area at harvest time. Fifty-seven per cent of farmers sell grain, of which 95 per cent is paddy, the remainder a combination of wheat, maize, mustard and millet. Despite being a paddy surplus area, 45 per cent of farmers did not produce sufficient grain for their own consumption for the year, and had to purchase grain for their household requirements. These statistics suggest a quite highly differentiated profile of households in the area. Considerable numbers of those small producers who are self-sufficient in total grain production for less than six months also sell paddy, and buy back cheaper grains for home consumption.

These sales by small and medium farmers contribute towards household cash requirements and the purchase of chemical fertilisers, in order that (a) increasing and unmet labour demands (predominantly on women) for the recovery of forest-derived nutrients can be replacedby less labour intensive chemical alternatives, and (b) declines in yields of dry land crops can be made good to some degree by application of those fertilisers. Animal produce and livestock sales also account for significant cash flows: 23 per cent of the sample sold produce from livestock (mostly ghee or milk), whilst 53 percent bought livestock during the year.

When crop revenue is examined further, grain producing households appear to form three clusters: 1) households without grain sales, 2) households with medium grain sales (less than Rs.10,000) and 3) households with high grain sales (greater than Rs18,000). Households without grain sales purchase significantly more grain than the others, and when recorded as a proportion of total cash income, the difference is significantly higher , this group also farms significantly less land than the others, the majority of it being dry land (*bari*), whilst grain-selling households cultivate much higher proportions of irrigable land (*khet*), renting *bari* out to others.

Proportions of different income sources are also significantly different between these three groups, as demonstrated by figure 2.

Figure 2: Sources of Income for Household Groups (Sorted by Grain Sales)



Households with no grain sales derive income from wage labour, non-agricultural income and animal products in roughly equal proportions. As grain sales increase, so does the proportion of income from grain revenue, whilst the proportions of animal sales, and more notably, wage labour, decrease. Standard deviations for non-agricultural incomes of the middle and higher groups are large, indicating that a range of strategies is employed.

This classification of households takes on added relevance when examining the uses of fertilisers and issues of labour, which will be discussed below.

Labour Markets and Labour Constraints

Fifty-two per cent of the sample employed labour, and 43 per cent hired family labour out for cash and/or grain and prepared food. This excludes reciprocal labour sharing relationships, which typically involved only two or three days for one or two household members a year.

The larger sample of 43 farmers was too small, and the data on labour allocations by each household member insufficiently disaggregated, to perform statistically credible quantitative analysis on the determinants and strategies of livelihood strategies. However, qualitative information from the smaller set of farming households interviewed in depth enabled a number of hypotheses to be examined, and, even if not rigorously and quantitatively tested, corroborated from the wider survey. The great majority of farms that produced under about 30 quintals of grains a year were dependent on cash income from labouring and other non-agricultural income and faced a particularly delicate trade-off in the allocation of labour between farming their own land and earning cash income from other sources.

Most admitted to decreasing returns to labour in obtaining a supply of naturally derived compost materials to maintain soil fertility, particularly on unirrigated land. One calculus is therefore to substitute, to some extent, chemical fertiliser for compost, and earn the cash to pay for it by other means, such as agricultural wage labour, petty commodity production, artisanal work, sale of livestock etc. This substitution is indicated by a simple cross-tabulation of grain production and labour hired in and out by the households (Tables 1 and 2). As expected, it is the larger producers who are responsible for a significant proportion of employment of labour. Conversely, smaller producers, with limited land and declining returns to fodder collection, invest a greater proportion of labour in wage labouring and sources of non-agricultural income.

Table 1: Grain production cross-tabulated by labour hired in by household

Grain production quintals / year	Household labour hired in (person-days / year)					
	0	1-49.9	50-99.9	100-199.9	200 +	Total
0-14.9	13	0	1	1	0	15
15-34.9	5	2	1	2	1	11
35-54.9	0	0	1	0	1	2
55-74.9	2	2	2	2	1	9
75 +	0	0	2	2	1	5
Total	21	4	7	7	4	40

I quintal = 100kg

Table 2: Grain production cross-tabulated by household labour hired out

Grain production Quintals / Year	Household labour hired out (person-days/year)					
	0	1-19.9	20-39.9	40-59.9	60 +	Total
0-14.9	2	4	6	0	3	15
15-34.9	8	1	1	1	0	11
35-54.9	1	1	0	0	0	2
55-74.9	8	1	0	0	0	9
75 +	5	0	0	0	0	5
Total	25	7	7	1	3	42

Purchases of Chemical Fertiliser and Natural Resource Constraints

The flow of cash in the local farm economy is thus very significant, and this general fact is supported by other recent surveys elsewhere in Nepal. Production expenditures are significantly affected by chemical fertiliser and the hire of labour. Ninety-five per cent of farmers use some form of chemical fertiliser. The mean total cost of fertiliser per user is Rs. 4,088, which represents a high cash input, particularly for poorer households. Further, purchases of fertiliser represented some 42 percent of the uses of credit. Table 3 describes the application rate for the four fertiliser types used and the mean cash expenditure. Application rates must be treated with caution since the calculation of area is notoriously unreliable.

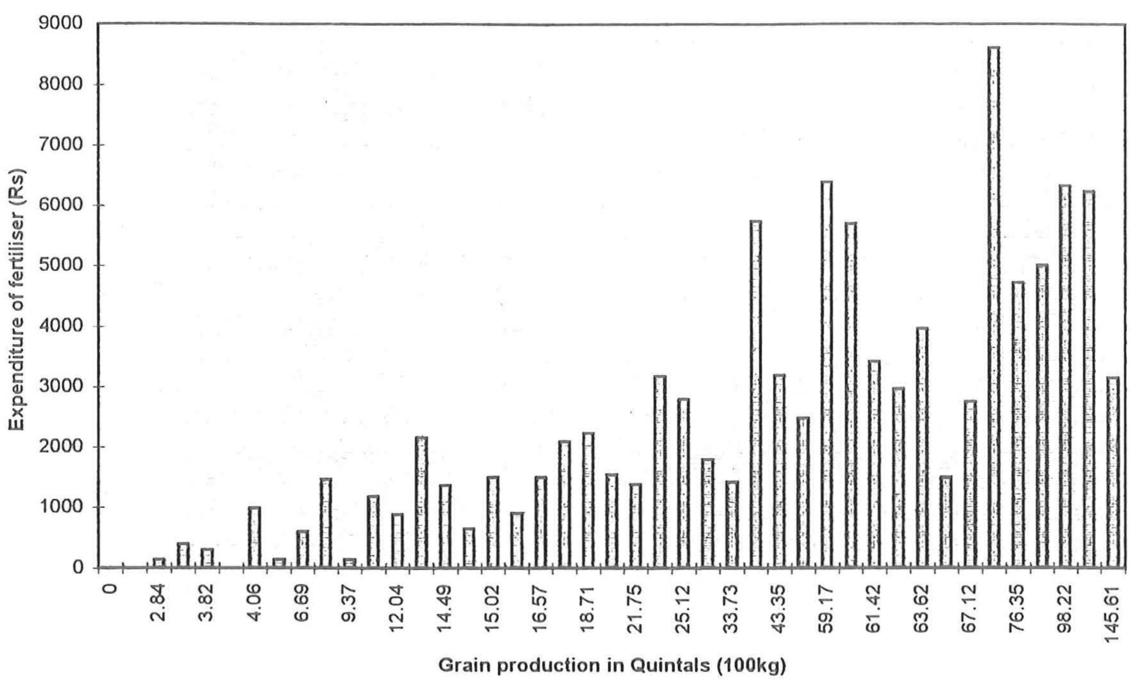
Table 3: Uses of fertiliser

Fertiliser	No. Farmers	Mean application rate Gk / ha	Mean annual expenditure by users
urea	40	94.4	1503
DAP	13	91.7	1670
ammonia	19	69.5	580
complexal	11	92.8	922
none	2	-	-

Urea is used universally on all crop types, whilst additional fertilisers are often reserved for *khet* crops (wheat, paddy and seedlings). Distribution of fertiliser usage is thus reflected in both size and type of land cultivated. Poorer households selling little excess grain are largely confined to *bari* land, applying urea and occasionally an additional fertiliser, whilst larger producers with lower-lying irrigated khet purchase a greater range of chemical inputs which are applied according to crop type.

As to be expected, Figure 3 demonstrates that it is the larger farmer, in terms of total grain production and sales, who dominates fertiliser purchases. However, of the 18 households which do not sell grain, 16 still purchase fertilisers, with expenditures reaching as much as Rs. 4000. Further, the cross-tabulation of fertiliser purchases by self-sufficiency in grain from farm production indicates many farms which grow less than half their annual grain consumption still make significant purchases of fertiliser. The implications of this for the maintenance of soil fertility are discussed below.

Figure 3: Expenditure on fertiliser by total grain production



Chemical fertiliser use is clearly a critical factor in the almost universally reported yield increases of both irrigated and unirrigated crops over the past ten years. This should be contrasted with the findings of Vaidya et al. (1995) which broadly confirm an overall decline in soil fertility for both khet and *bari*. This view however, may be masking the impact of soil degradation in terms of soil structure, especially on *bari* land, but which is offset for the time being by the application of chemical fertiliser. There were thirteen cases of fertiliser use (30 per cent) in which farmers stated that they had to use alternatives to the types of chemical fertiliser which they preferred because of unavailability. Subsequent consideration of this assertion through extended discussion indicated that unavailability implied a shortage of (predominately female) labour to travel increasing distances for fodder and mulch from grazing and forest land.

Quantitative data presented in Table 4 indicate that the smaller producing households with limited cultivable land have much fewer private supplies of tree fodder than the larger production oriented households, thus it is they who are more dependent on the diminishing resources of communal forests.

Table 4: Distribution of supply of tree fodder from private sources

Months supply from private fodder	Lower Group	Middle group	High Group
< 1	11	4	1
1 - 6	3	4	4
6 - 12	2	5	6

The shortage of labour for agricultural activities, exacerbated by the need to sell labour off-farm for a period of time, has been a crucial trade-off for small households facing declining soil fertility. The decreasing returns to labour invested in the transference of fertility from forest to arable land and the finite limits of women's labour time, have been addressed and partly solved by the application of chemical fertilisers to increase yields. Cash required for the purchase of chemical inputs is raised through the allocation of labour to other income-generating activities. The substitution of labour from on-farm to off-farm employment is, thus, a method of nutrient management, and serves as an investment to improve food security.

Agricultural Yields Through Time

As has been reported, yields are very low, although asking for verbal estimates from farmers is unreliable. However, every single farmer without exception in general terms for their farms as a whole, maintained that yields on both *bari* and khet land had increased over the last ten years, if the new epidemic of pest attacks (which figures prominently in many farmers' accounts) is discounted. Since the interviews were discursive and interactive, the researcher took the opportunity to challenge this unvarying reply, and in the course of taking a large number of field histories, with on-site visits, that view was sometimes qualified by the farmer. Yet the general picture is certainly counter-intuitive since all-Nepal temporal yield data show very considerable declines in almost all crops, particularly on *bari*, and a number of researchers have stated that fertility maintenance is a major degradation problem (cf. Vaidya et al. 1995). This was often linked with the increased application of chemical fertiliser. As has been discussed, virtually all farmers in the Likhu Khola catchment used chemical fertiliser (with a mean value of c. Rs.4,000, which is a very considerable sum and represents a major cost of production). Sale of crops, especially paddy, and of labour for those who do not have access to khet land, becomes crucial for the purchase of chemical fertiliser.

Whether the application of chemical fertiliser which, according to all interviewees has increased from a zero base over the past ten years, has served to replace natural fertility in the short term at least, cannot be reliably answered. However, there are qualitative indications cited above suggest that it may have. The method of application for both types of fertiliser on *bari* land is to plough it into the soil as little time before planting as possible with the express purpose of minimising its leaching or physical removal by water. This could be interpreted as a response to considerable overland flow and sheet wash at times of maximum rainfall and bare land surface (Gardner 1995, Gardner and Jenkins 1995). However, on the evidence of this survey it is not possible to suggest that chemical fertiliser has been used to compensate for soil loss and how successful this may be in the future if soil losses continue at the high rates that exist on some *bari* lands in the watershed.

Environmental Management and Livelihoods

Costs of Erosion Control

Erosion control and repair (including maintenance of soil fertility) is a major cost of production for practically all farmers, but varies considerably as between households. Eighty-three per cent of farm households who cultivate khet fields spent time repairing canals, with a mean number of person days of 13 days per year. Virtually all farm households spent time repairing fields. The average person days spent repairing or maintaining fields was 14. The distinction between repair and maintenance is difficult to make, but the former refers to remedial and reactive work which follows a definite event, while the latter refers to routine work of a preventative nature, such as cutting terrace backs and maintaining khet water-retaining rims. (Three other farmers currently involved in clearing up landslides incurring costs of Rs. 20,000 and 45,00 are excluded from these means). Sixteen per cent of farmers had experienced landslides on their land in the last twelve months, and 24 per cent had land which had been taken out of cultivation as a result of various types of degradation. Of course, there are many other reasons for taking land out of cultivation, but landslides, slumping and piping, and deteriorating soil fertility are some of the most important (see Johnson et al. 1982 for an early but key discussion; Joshi and Pant 1990; Sthapit and Tennyson 1991). In Likhu Khola, insufficient labour was the most stated reason, but subsequent discussion indicated that decisions to allocate labour for remedial action were based upon the opportunity cost of the labour required, and the expected returns from it. In the case of remedial action on already eroded *bari* land, scarce labour or insufficient funds to hire it in from outside were the major reasons for in-action.

It is possible that the existing literature on landslide management focuses largely on the technologies used, and amply demonstrates the richness and ingenuity which indigenous knowledge reveals (cf. Scott and Walter 1993, Domnesteanu et al. 1994, and a critical review by Forsyth 1995). This study adds nothing new to outsiders' knowledge of indigenous technologies of landslide management, and in any case, there is a strong argument for dissolving the divide between outsider and indigenous knowledge (Agrawal 1995). This study emphasises two other considerations. The first is the issue of trade-offs between alternative uses of labour, particularly when returns to labour in dry land agriculture are probably declining relative to incomes available outside the region and the sector altogether. The second is the ecology of local knowledge of landslide management—local here meaning the knowledge appropriate to very specific geomorphological conditions which may pertain to a few tens of square metres. Immigrant farmers (even if they have relocated from half a kilometre away) who find themselves on sensitive land, sometimes already eroded, do not have either appropriate knowledge or sufficient labour resources to manage such land in a sustainable manner. Indigenous knowledge is literally grounded and appropriate within farmers' own very particular socio-economic and locational circumstances.

Distribution of Slope Failures and Other Acute Erosion Sensitivity

Some locations in the watershed are particularly prone to serious erosion. These are on south-facing slopes, where tree growth and vegetative cover is sparser, and at the break of slope between old east-west geomorphological terraces (marking periods of tectonic stability) of the main Likhu valley and rejuvenated down-cutting by north-south tributaries to the Likhu Khola. These locations, which are close to the drainage divides, are typically at the headwaters of the ravines draining into the subcatchments and prone to gullying (see Gardner and Jenkins 1995). These north-south zones of sensitivity to human intervention, and of apparently high natural erosion are often, but not always, characterised by sandy (Nep. balua or balaute) soils. These sandy soils are likely already to be the remnants of soils from which the finer topsoils have already been eroded. Farmers who find themselves, as it were, at these locations may face very serious challenges, particularly from headward-encroaching gulleys, and probably also from the removal of soil from *bari* fields by overland flow.

It is not possible to draw any reliable conclusions from the very small sample of farmers in the Bore and Dee sub-catchments of the Likhu Khola study area, but it may be significant that four of the six farmers interviewed in these positions had a common settlement history. They had migrated from the high *lekh* under conditions of distress and food shortage. Two had purchased land in these sensitive locations at low cost (not surprisingly, since it is relatively infertile and already eroded), and the rest had hired the land from emigrants to Kathmandu at a peppercorn or very low rent in kind. It is just this type of incoming farmer, who has no experience of managing this sensitive land and is resource-poor, who is least able to cope with the formidable challenges of managing it. (The two other farmers not fitting this description had inherited their land but complained of acute shortages of resources to stave off what they considered to be disaster). A transcript of part of an interview is illustrative:

> Q. What will you do then, in this situation?
>
> A. Try to sell up and buy khet land further downslope, which is easier to manage.
>
> Q. But you will not get a good price for your *bari* land, will you?
>
> A. Well, it is like someone else's beautiful wife . . . you want, but what can you do? (Rueful laughter).

It is tempting to suggest a political ecological model which links spatial variations of sensitivity of land to erosion processes and management costs to spiralling poverty and degradation of already resource-poor farmers. A larger sample is required, though, to give it credibility.

The Design of Terraces

There is much more latitude in the design and quality of *bari* than khet fields. *Bari* fields are essentially comprised of a riser of between 70-90 degrees, either reinforced with a stone wall, grassed, or cut back each season, and the field itself which is usually outward sloping (Sthapit and Tennyson 1994). There is usually a small temporary ditch at the foot of the riser across the slope to drain off water. In larger fields this may be joined to other small channels leading to the next riser of the field below. In plan, the field is usually convex and sometimes undulating, and water tends to be drained both down the main direction of hill slope and also sideways across the main direction of slope by the convexity of the field. A minimum slope of about five degrees is preferred (when the low declivity of the hillside allows the farmer choice), to allow the dispersal of water and prevent it standing and damaging crop growth. Conscious improvement of *bari* terraces (e.g. smoothing, reduction of slope, combination of smaller fields into a bigger one) does not seem to be widespread nor considered worth the allocation of scarce labour, except where the conversion of *bari* into khet is concerned. But even here, this conversion, so often desired, (to provide higher value of crops and with much less variability of yield) is often precluded in practice by shortages of labour. Such conversion is a central aspiration of all farmers, and is carried out subject to a number of two sets of preconditions. The first set is physical and includes a supply of water by river course or canal. Since most all the irrigation possibilities for spring (*Chaiti*) paddy, which requires a perennial water source in the dry season, have already been taken up, remaining conversion opportunities are from *bari* to monsoon paddy. Also, the farmer has to make a judgement that the field will bear the weight of water and will not slump within several years. The second set concerns the allocation of labour. The remaining opportunities for conversion to khet on the least favoured sites, where the physical preconditions are barely met and which require large expenditures on labour. The only conversions currently taking place within the sample were by already wealthy farmers with strong paddy exports, who could afford the investment.

Property and Responsibility for Environmental Management

Property was found to be a major issue in land managment decisions. Basically, there are three property regimes to be found in the watershed: private, village and state (which *de facto* did not operate as a regime at all since it was treated as open access). Private land is almost exclusively arable land, although small patches of pasture and forest are also privately held. Share-cropped (*adhiyaa*, or half the crop each to the landlord and tenant) is not managed any differently from owner-cultivated land, and is almost always khet. Owners of *bari* land simply cannot find tenants, since yield/labour input ratios are insufficiently attractive to would-be tenants. The one exception is the poorer land (often sensitive and already eroded) onto which very poor farmers simply have little choice but to settle (as explained above). Also, badly eroded land tends to move from private to open access land, when owners can no longer cope with the erosion, and management responsibility lapsed. This is an important institutional issue to which the communities studied had no answer. It may also have serious environmental consequences for immediately adjacent land. State forests also are significantly worse managed than any other land. A casual glance at any hill slope in the study area could usually tell the viewer the exact boundary of the state forest. Lastly, village forest and pasture was sensitive to institutional responses to manage them. In some cases, management committees had been set up in the watershed.

Gender Issues of Management

It was found that conservation works (terrace construction and repair etc.) were almost completely done by men, although fodder collection, and much of the transportation and application of compost is carried out by women. Also, the decision to alter land use in response to a threat was likewise a male prerogative. A large proportion of field operations are done by women, and therefore agronomic methods of conservation would be expected to be under the control of women. However, active experimentation in agronomic methods of conservation, such as planting densities, ground cover, planting in lines orientated across or diagonally across the slope, again is a matter of male control. As with many agricultural decisions, the male decides and the woman works. However, from other cases in Nepal, this tends to be caste specific and the cross-caste sample in this study is too small to comment credibly. This study failed to explore decision making and land management technology with women farmers, the areas where it did enter into discussions concerned fodder collection, soil fertility, overall work loads and the impact of male absence from the farm and home.

Conclusions

The part of the Likhu Khola catchment is not an exceptional area in the Middle Hills of Nepal, characterised by the importance of non-agricultural income and cash in household budgets, livelihood diversification, and out-migration. While no area can be typical in a region of marked socio-economic and physical diversity, this one is not unusual. However, it is marked by very considerable export of paddy and therefore is a favoured area, although there are also many farmers who are poor and have no access to irrigated land.

There is strong scientific evidence from the natural science component of the research programme that considerable erosion and nutrient loss is occurring from specific sites, mostly from *bari* land and from degraded forest. With reference to land worked by the sample in this research, the most sensitive which is causing farmers the most serious problems of declining yields was that which is close to the drainage divide at the headwaters ravines draining into the sub-catchments of rivers flowing north-south. More widespread evidence of less spectacular but economically important land degradation exists in the form of significant rates of soil and nutrient loss from some *bari* land. It is clear that this has led to a medium-term potential reduction in yields of dry land crops (a finding substantiated by nation-wide statistics). However in this watershed, a greatly increased application rate in chemical fertiliser has taken place both in khet land with a view to increasing profits from sales via the newly opened up road to the Kathmandu market, and also in *bari* land brought about by smaller and even sub-marginal farmers to compensate for this decrease in potential yields in the context of replenishment of nutrients from forest sources, along with a radical re-alignment of the household budget to pay for this fertiliser. The implications of this situation, along with increasing labour opportunity costs of obtaining naturally derived compost from the forest and grazing lands has focused farmers' attention on what has become a crucial trade off. For smaller, mainly *bari*-only farmers, this involves the substitution of chemical fertiliser for naturally-derived compost and the seeking of income opportunities providing cash to pay for this fertiliser. Bearing in mind widespread labour shortages for environmental management and composting, the availability of chemical fertiliser through the provision of motorable roads becomes a major policy issue.

Moving now from fertility management to soil conservation works and the construction and maintenance of both khet and *bari* terraces, environmental management is a labour-intensive and costly necessity. Farmers manage a mobile landscape and respond to accidents in both a strategic and ad hoc manner (for more detail cf. Johnson, et al. 1982). Remedial work following slope failure or the opening up of a gully is particularly demanding in short term labour inputs. More wealthy farmers have to pay large sums to hire labour urgently, while resource poor farmers find it very difficult to meet the demand from within the household, and subsequent deterioration in the short term often results. The distribution of slope failures and gullying is largely determined by site-speicific geomorphological processes and topography, although human activity may trigger or exacerbate erosion. These are identifiable sensitive areas which are highly susceptible to erosion, and have been identified both by the project and by some (though not all) farmers. It is possible that it is resource poor and labour-scarce farming households which more frequently than others find themselves in these sensitive areas and then do not have the resources or perhaps the site-specific environmental knowledge to adopt adequate preventative or remedial measures. However, most farmers have a well-developed technical knowledge to control the erosion hazards in their domain, as long as they have had a settlement history which has allowed them to acquire it. Khet farmers are clearly well informed about the specific erosional hazards and their management which occur on irrigated terraces, while *bari* farmers are better informed about managing gullies and the design of *bari* terraces.

Implications for Research

1. While there is local evidence for anthropogenic accelerated erosion in limited and specific sites, it does not seem to be critical, although it may be important to some farmers some of the time. It does not directly threaten livelihoods of the majority but is important, particularly for poor farmers without access to irrigation. There are so many other adaptations to increasing land shortage (such as chemical fertiliser substitution, as mentioned here) that it is a gross overstatement to say that there is an erosion, or even a nutrient "crisis."

2. Livelihood diversification and the growth of non-agricultural income is a major feature of socio-economic change in the middle hills of Nepal over the last twenty years (cf. the 'rural livelihoods and long term change' project undertaken by the Overseas Development Group at the University of East Anglia, the Indian Statistical Institute and ActionAid, Nepal, discussed by Cameron et al., and by Seddon, Gurung and Adhikari, in this issue of the Bulletin and reported briefly in Bagchi et al. 1998). Decline in soil fertility is only one factor in the wider processes of environmental and socio-economic change, albeit an important one for resource-poor farmers at specific geographical sites. It is necessary, therefore, to link the findings of erosion research in the Himalayan region (and there is a great deal of it) with the changing economic and social circumstances of farmers, in order to evaluate the impact of any environmental degradation that is identified.

3. The current fashion of emphasising and celebrating the diversity and quality of local environmental knowledge which has much to do with political correctness and slaying the dragon of mindless technology transfer (see Biot et al. 1995 for a discussion of alternative approaches to land degradation) is producing decreasing returns. Of course most farmers know what they are doing, of course some farmers are more knowledgeable and competent than others, there are, too, bodies of environmental knowledge which are gender specific (and probably caste-specific too, although this was not confirmed by this study). However, the primitive and misguided advice regarding terrace improvements and other soil and water conserving measures of the 1970s in Nepal has now been so thoroughly discredited that it seems unnecessary to labour the point that farmers may know better than outsiders.

4. Studies of environmental change carried out by natural scientists in the Himalayan region can - if well executed - reduce the great degree of uncertainty which many post-structuralist commentators have assumed (if only critical social scientists could read widely enough— and understand it!). However, when using the information generated to consider the interactive relationship between environment and earning a livelihood, natural and social scientists have to work very closely together. Also, if they are together to provide policy-relevant findings, assumptions about delivery systems for new information must not be based upon overoptimistic assumptions. It may be worth while shifting the emphasis to helping farm households to develop appropriate livelihood strategies (including the diviersification of income opportunities), rather than to confine research to purely physical aspects of environmental change.

5. If environmental research is to contribute to increases in incomes and food security of farmers in the hills, the findings of scientific research in erosion hazards and conserving technologies need to be widely disseminated and converted into improved practices. In the absence, of an intensive and effective agricultural extension system, participatory evaluation of research projects by farmers themselves could be considered. Also there are foreign-financed agricultural programmes and NGOs that may be able to provide this service in limited areas and over limited periods of time.

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Spinner, Dolpo (photograph by Fr Francis Tiso)