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THE ADOPTION AND ASSOCIATED IMPACT OF TECHNOLOGIES IN THE WESTERN HILLS OF NEPAL

C.N. Floyd, A.H. Harding, K.C. Paddle, D.P. Rasali, K.D. Subedi and P.P. Subedi

Abstract

This paper summarises the results of an adoption study conducted in 1994/95 in the western hills of Nepal, to determine the level and extent of adoption of 15 selected field crop, horticulture, livestock and forestry technologies. The study formed part of an evaluation of the research impact of Lumle Agriculture Research Centre (LARC) and aimed to identify lessons for the future conduct of research and research-extension linkages. A sample of 424 households were stratified by agro-ecological zone (low hills, middle hills and high hills) and by level of LARC extension input (high, medium, low and no input). To determine the distribution of adoption of the technologies, a set of key factors was developed from the stratification and by classifying households according to ethnicity, food self-sufficiency, accessibility, sex of household-head and sex of questionnaire respondent. Survey questions were used to identify the reasons for household adoption and the reasons for the distribution of adoption.

The level of awareness of technologies was generally good: more than 80 per cent of households were classified as aware of the new technologies. Households were most frequently classified as having not tried a technology (25 to 70 per cent across the technologies). The dominant reasons for not trying a technology were related to constraints internal to the farming system (typically lack of labour or land). Lack of information/inputs needed to try the technology, or technical problems—typically difficulty of managing the technology or its incompatibility with the farming system—were less important. Once technologies had been tried, the majority (more than 60 per cent) of households adopted them.

Adoption was highest for the cases of improved maize, wheat and grain legume varieties, improved tree fruit crops and planting of fodder trees. Intermediate levels of adoption were found for the technologies of improved rice, finger millet, potato and barley varieties, crossbreeding of cattle and buffalo, parasitic drenching of livestock and improved forage species. Adoption levels of improved vegetable crops, vegetable seed production and rabbit farming were low.

The level and distribution of adoption was significantly influenced by LARC extension input and by ethnicity and household food self-sufficiency. Greater extension input increased awareness of the technologies, and also increased the rate of trying and thus adoption rates. Adoption rates were significantly lower amongst some ethnic groups and overall, decreased with decreasing household food self-sufficiency status. The influence of agro-ecological zone, access and gender on adoption were much smaller and more variable among the different technologies.

Multivariate analysis identified five groups of households characterised by their adoption profiles. The smallest group (10 per cent of the sample) were high adopters—adopting or undecided on up to five technologies. The largest group (27 per cent of the sample) were non-adopters—had not adopted and were not undecided about any technology.

The results of the adoption study were compared to those of an extension impact study conducted for the same sample of households in the previous year. There was a significant positive association between households who had adopted new technologies and those that had reported an increase in total food grain production, fodder supply and increased workload in the extension impact study.

The authors of this paper were all staff of Lumle Agricultural Research Centre at the time of the study.
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Tables, boxes and figures

Acronyms

AEZ	agro-ecological zone
CV	canonical variates
CVA	canonical variate analysis
DFID	Department for International Development (UK)
ECA	extension command area
EIS	extension impact study
HMGN	His Majesty's Government of Nepal
LARC	Lumle Agricultural Research Centre
masl	metres above sea level
ODA	Overseas Development Administration
PAC	Pakhribas Agricultural Centre
RCA	research command area
RIMS	research impact and management study

Acknowledgements

This study was part of a wider assessment of the extension and research programmes at LARC conducted by consultants whose findings have been recorded elsewhere and which includes their record of the adoption study data. While the interpretation of the adoption study given here is those of the authors, we wish to acknowledge the role of the consultants, notably that of Drake Hocking, but also of Bhishma Subedi and Anna Hocking, for providing much of the framework within which these results were obtained.

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1 INTRODUCTION

Lumle Agricultural Research Centre (LARC) is located in the middle hills of Nepal. From 1975 to 1995, LARC was responsible for agricultural research, extension and training within an Extension Command Area (ECA) in parts of three districts adjacent to the centre comprising around 1,100 km² and 15,000 farming households. Since 1989, LARC has also been responsible for agricultural research in a Research Command Area (RCA) covering 11 hill districts surrounding the centre, but where agricultural extension is the responsibility of the respective government line agency. The objectives of LARCs work in both areas has been to improve the livelihoods of hill farmers through the development and extension of appropriate agricultural—crop, horticulture, livestock and forestry—technologies.

The RCA covers a range of agro-ecological zones; there is wide variation in altitude (400-3,500 metres above sea level—masl), rainfall (1,500-5,000 mm p.a.) and aspect. As a result, rapid changes in climate—from sub-tropical to alpine—occur within tens of kilometres. The range of crops grown and the diversity of farm enterprises reflects this variability. The farming systems of the area are complex and farming households, if not risk prone, are risk averse.

Farming systems are characterised by the interdependence of crop and livestock production and forest use. These components are closely linked, with the forest acting as the resource base by which crop and livestock production are sustained. Individual farm holdings are small (less than one hectare). Although households are large (typically five to seven members), seasonal or permanent migration (particularly of adult males) and increased school attendance means that labour is a constraint. Agricultural production is predominantly for household consumption, although only around 20 per cent of households in the area are self-sufficient in staple grains for 12 months a year. Households depend on a number of on- and off-farm sources for their livelihoods. Commercial agricultural production, mainly of fruit and vegetables, is increasingly important in localised, more accessible areas.

Groups of Indo-Aryan origin (Brahmin/Chhetris) predominate in the low and middle hills, whereas groups of Tibeto-Burman origin (Gurung/Magars) are more common in the high hills. Occupational castes are found throughout. Brahmin/Chhetri and Gurung/Magar groups are more oriented towards agricultural production for their livelihoods than Occupational castes. Seasonal or permanent migration occurs in all groups, but is most marked in Gurung/Magar villages.

The adoption study

Since 1975, LARC had been funded predominantly by the Overseas Development Administration (now the Department for International Development—DFID) of the British Government through a bilateral aid programme. In 1993, an Extension Impact Study (EIS) was commissioned in LARCs ECA to determine the value of DFIDs investment since 1975 and to learn lessons for the conduct of extension in similar environments. The EIS was conducted by LARC staff, assisted by consultants in the winter of 1993/94 (for details see LARC, 1994). It reported a favourable impact—one that was beneficial for farmers and cost effective for DFID—although the distribution of benefits had been positively skewed to relatively resource-rich farmers.

Following the EIS, a further complementary impact study of LARCs research component was commissioned. This second study, the research impact and management study (RIMS) covered both LARC and its sister centre—Pakhribas Agricultural Centre (PAC)—in the eastern hills. The RIMS was conducted in the winter of 1994/95 (MASDAR, 1995a; 1995b).

The objectives of the RIMS were: (i) to assess the economic and social impact of the LARC research activities; and (ii) to identify lessons for improving the effectiveness of research in the hills of Nepal. One component of the RIMS at each centre was an adoption study[1] (Box 1).

Box 1 Objectives of LARC adoption study

- To determine the level and extent of adoption of selected agricultural technologies, which LARC had a substantial involvement in developing and/or disseminating within its research and extension command areas;
- To identify the reasons and factors influencing the adoption of these technologies;
- To determine the distribution of adoption by examining factors related to access, household resources, ethnicity and gender and if possible, determine the reasons for this distribution;
- To identify lessons for the future conduct of research at LARC;
- To identify lessons for research and extension linkages and for research/extension coordination, to help ensure a wider impact of LARC research outputs.

2 METHODS

Technologies studied

The adoption study was conducted to determine the level of adoption of selected technologies from among those recommended by LARC. These technologies were selected by LARC staff in a workshop which reviewed and assessed the technologies involved. The criteria for selecting the technologies were that they 'should have a current impact, that they should be widely adopted and have significant social, economic or environmental returns'. For the purpose of the study, an impact was defined as 'an enduring change with an attributable cause' (MASDAR, 1995a). The technologies selected for study are given in Box 2.

Survey design

The adoption study comprised a household survey in LARCs ECA and an adjacent area of the RCA within the same districts. The procedure was the same as that used for the EIS (LARC, 1994), to allow direct comparison of the impacts detected in the EIS and the adoption and benefits detected in the adoption study.

The sample population was stratified for three dimensions; agro-ecological zone (AEZ), LARC extension impact and gender of survey respondent. The AEZs were defined as low hills (300-950 masl), middle hills (950-1,500 masl) and high hills (above 1,500 masl).

For LARC extension impact, the population sample was stratified into LARC ECA villages and non-LARC ECA (i.e. RCA) villages. This enabled the relative effect of LARCs extension to be compared with that of extension provided by the government extension services. Villages receiving LARC extension input were further stratified into high, medium or low LARC input. The villages with government extension input—defined as non-LARC extension input villages—were selected from those identified by government staff as receiving a medium level of extension input.

The survey also purposively selected male and female respondents from the sampled households, approximately alternately. The resulting gender balance was 60:40 male:female respondents.

Box 2 Technologies selected for the adoption study

Technology/code

Improved rice varieties (Rc)
Improved maize varieties (Mz)
Improved finger millet varieties (FM)
Improved potato varieties (Po)
Improved wheat varieties (Wh)
Improved barley varieties* (Ba)
Improved grain legume varieties (GL)
Improved vegetables (Ve)
Vegetable seed production (VS)
Improved tree fruit crops (Fr)
Crossbred cattle and buffalo (CB)
Parasitic drenching of livestock (PD)
Rabbit farming (Ra)
Fodder tree planting in private land (FT)
Improved forage species (FS)

* high hills only

The final sample comprised 432 respondents, 12 households from 36 sample villages. These 12 households were made up of four households each from three resource status groups (rich, medium and poor). These groups were identified through wealth ranking by key informants. Landless households were not included in the sample, as they were not considered to be direct beneficiaries of agricultural research and extension.

To enable the identification of reasons influencing the adoption of technologies, a set of seven key factors—including the sample stratification dimensions—was developed (Table 1).

Data collection and interpretation

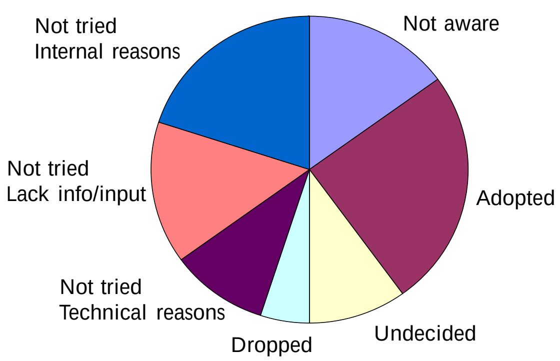
The level of household adoption was estimated using a questionnaire containing a series of questions for each technology. Household information was also collected to characterise the household with respect to the key factors (Table 1).

An adoption profile was generated for each respondent for each technology (Figure 1). Households who had tried a technology were divided into three categories according to their plans on whether to continue with the technology: (i) dropped; (ii) undecided; and (iii) adopted.

Respondents were asked to name the source from which they heard about the technology, if they had tried it and the source of the technology (the information and inputs required for the use of the technology). The reasons for not trying, dropping or continuing with the technology were also recorded.

Households classified as 'not tried' were further subdivided according to the reasons given for not trying the technology: (i) internal constraints to the farming household, for instance labour or land shortage; (ii) information/input constraints relating to the availability of information or inputs required to try the technology, such as lack of seed or technical know-how; and (iii) 'technical' constraints related to technical problems with the technology, for example late maturity, poor taste of crop varieties or lack of relevance to the circumstances

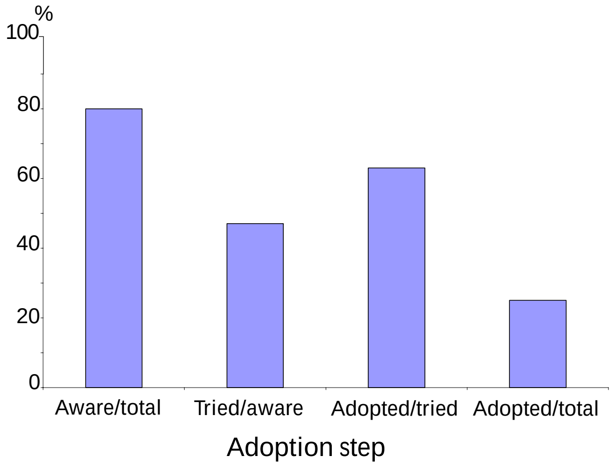
Figure 1 Technology adoption profile



of the farming household. Figure 1 illustrates the distribution of the responses between these categories for the 'not tried' population[2].

The level of adoption of a technology is a function of a step-wise process involving being aware of the technology, trying the technology and finally adopting the technology. Results were therefore also examined in terms of these adoption steps, in order to identify the relative importance of these steps in determining adoption (Figure 2).

Figure 2 Schematic technology adoption steps



Statistical analysis

Normal checking, editing and scrutiny of forms was carried out before entering data into the computer. Households with incomplete or suspect records (eight per cent of the sample) were revisited. Where it was not possible to correct or verify the value, the data was deleted and replaced with a missing value code. Missing values represented less than one per cent of the data.

Weighting

The sample—as stratified by AEZ and extension input level—was not proportional to the distribution of the target population for which the results were being extrapolated. To ensure that that the results were representative, a set of weights was applied to the sample[3].

Standard analyses and logistic regression

The data was analysed separately for each technology. Standard frequency tables were generated and categorical responses were cross-tabulated with each of the seven key factors (AEZ, extension input level, access, food self-sufficiency, ethnic group, sex of respondent and sex of household-head) and tested for association. Logistic regression was undertaken for the yes/no type responses to investigate any relationships with the key factors.

Multivariate analysis

Multivariate analysis was conducted to examine the adoption patterns of all technologies across all households. Cluster analysis was used to identify whether there were identifiable groups of households with similar adoption patterns. Canonical variate analysis (CVA) was used to investigate where cluster differences lay (Appendix 1 contains additional details of these analyses and the limitations of the sample).

3 ADOPTION OF INDIVIDUAL TECHNOLOGIES

Awareness

Figure 3 illustrates the mean levels of awareness for the 15 technologies. Values are given in Table 2. The mean proportion of the sample who were aware of individual technologies ranged from a minimum of 52 per cent in barley (for high hills only) to a maximum of 95 per cent in vegetables. For half the technologies, the level of awareness was greater then 80 per cent; only for barley was it less than 60 per cent. Mean awareness across the technologies was 81 per cent.

Table 1 Key factors and details of factor level characteristics in the population sample

Factors	Details
Agro-ecological zone	High hills (>1,500 masl), middle hills (950-1,500 masl) and low hills (<950 masl).
Extension input	LARC extension input, defined by the EIS as high, medium, low and none. Non-LARC is the RCA adjacent to the ECA in the same districts and equivalent to a medium level of government extension input. This was regarded as comparable to medium level of LARC input.
Access	Classified by mean number of hours walk (return journey) to the nearest roadhead or market/supply centre. Categories of <4 hours (0.5 day), 4-8 hours (1 day), 8-12 hours (i.e. overnight) and >12 hours were used.
Food self-sufficiency	Number of months for which a household is food self-sufficient. Categories of >12 months (surplus), 12-7 months (sufficient) and <7 months (deficit) were used.
Ethnicity	Ethnic groups of respondent households were classified into Brahmin/Chhetri, Gurung/Magar, Occupational caste and others.
Gender	1. By respondents (stratified sample). Respondents: 253 male respondents; 171 female respondents. 2. By household head (random).

Awareness of the technologies was most consistently and significantly affected by extension input levels (significant for all technologies except parasitic drenching). The pattern was one of decreasing awareness of technologies with decreasing extension input.

Access had the next greatest effect on awareness, but the pattern of results was less consistent than for the effect of extension input. This inconsistency reflects the fact that awareness of a technology is likely to be higher in areas to which that technology is better suited. For example, awareness of improved potato varieties and Jersey crossbreeds was highest in the high hills, the AEZ to which these technologies are most suited, but which are poor access areas. Parasitic drenching was the only technology for which awareness and access were consistently related; here awareness decreased consistently and significantly with decreasing access.

The only other key factor to have an appreciable and consistent effect on awareness was ethnicity. Gurung/Magar and Occupational caste groups were less aware than other groups, although this was only significant for five technologies—improved rice varieties, vegetable seeds, tree fruit crops, parasitic drenching and fodder tree planting.

Table 2 Incidence of adoption by adoption step for the fifteen technologies (% of previous step, except for aware and adoption which is % of whole sample)

Technology	Aware %	Tried (% of aware)	Adopted (% of tried)	Adoption %
Improved rice varieties	79.2	37.2	36.1	10.6
Improved maize varieties	92.9	72.1	78.8	52.7
Improved finger millet varieties	66.8	56.2	47.3	17.7
Improved potato varieties	88.3	40.9	71.6	25.9
Improved wheat varieties	90.9	62.8	86.0	49.0
Improved barley (high hills)	52.3	43.2	67.2	13.7
Improved grain legume varieties	84.1	70.9	81.5	48.7
Improved vegetable production	95.0	7.2	82.8	5.7
Vegetable seed production	69.6	12.9	60.5	5.4
Tree fruit crops	92.6	60.8	94.5	52.3
Crossbred cattle or buffalo	93.7	21.4	70.6	14.2
Parasitic drenching of livestock	79.4	32.9	65.8	17.2
Rabbit farming	82.5	17.4	24.6	3.5
Planting of fodder trees	86.6	57.2	96.6	47.9
Improved forage species	75.2	31.3	45.0	10.6

Trying the technology

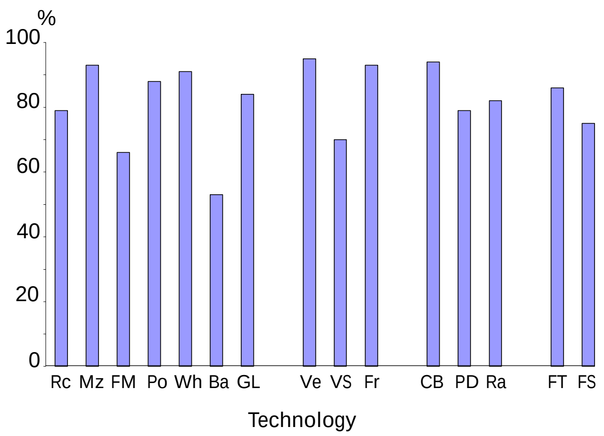
Figure 4 illustrates those within sample who had tried the technologies as a proportion of those aware of the technology (values are given in Table 2). For only six out of fifteen technologies was the percentage tried/aware greater than 50 per cent. For three technologies—improved vegetables, vegetable seed production and rabbit farming—it was below 20 per cent. The mean level of tried/aware was 42 per cent. The 'not tried' proportion ranged from a minimum of 26 per cent in maize to a maximum of 88 per cent in vegetables.

Of the adoption steps, the percentage was lowest for tried/aware in all technologies except improved rice and finger millet varieties (Table 2). Thus with the exception of these two technologies, the 'not tried' is the most constraining step in the adoption process.

Ethnicity and extension input levels had the most consistent effect on the level of trying technologies. Amongst ethnic groups, Occupational castes are less likely to try a technology. A decreasing level of extension input results in lower levels of trying, with some variation between technologies.

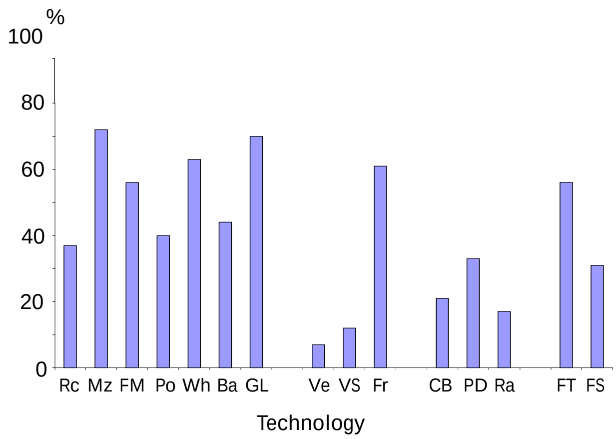
The effects of other factors on the level of trying were less consistent, less significant and often technology specific. However, food deficit households were less likely to try a technology than other households. There was also some evidence that levels of trying were, on average, lower in more remote areas and amongst female respondents and female-headed households. These effects occurred for only a few technologies and not

Figure 3 Awareness of the technologies (% of all households)



See Box 2 for codes

Figure 4 Proportion of those who tried the technologies out of those aware



See Box 2 for codes

with the same factor, or factor level for each technology. Thus it is not possible to provide a simple summary of effects related to these factors.

The distribution of reasons for not trying the technologies is illustrated in Figure 5. Reasons related to internal constraints are the most numerous, with those related to technical constraints the least numerous. Across the technologies, the proportion of technical reasons was greatest in the crop-based technologies and distinctly lower in horticulture, livestock and forestry based technologies. With the exception of parasitic drenching, the proportion of information/inputs related constraints varied less across technologies than for the internal and technical constraints.

The distribution of the reasons by constraint type amongst the levels of key factors was examined for each technology. Overall, the lower the rate of trying, the greater the proportion of reasons for not doing so that are classified as internal. Effects were most consistently significant for the food self-sufficiency and ethnic group factors but not for all the technologies. This pattern is illustrated in Figure 6, using the distribution of types of reasons for not trying improved potato varieties by food self-sufficiency level.

Sources of information

Results for the source of information leading to awareness and source of technologies when first tried, showed a consistent pattern. These are illustrated in Figure 7, for the example of improved maize varieties across extension input levels. As was expected, LARC was the dominant source of information in the ECA, with farmer-farmer sources making up the balance and little contribution from government line agencies. Conversely, government line agencies were the dominant source of information in non-LARC extension areas. Government was not as dominant in the non-LARC area as LARC was in the LARC input areas; respondents relied more on farmer-farmer sources.

Other information or technology sources—for instance other projects, LARCs extension bulletin, radio and the market—were not important (less than two per cent respondents for any technology).

Farmer-farmer sources were more important, relative to official sources, amongst groups disadvantaged by access, resource status, ethnicity and gender. This complements the trend of lower levels of awareness and trying the technology among such groups, and may reflect lower levels of extension contact.

Adoption

Adopted/Tried

The results for the third adoption step—adopted/tried—are illustrated in Figure 8 and Table 2. The net results of the three adoption steps—final adoption—are illustrated in Figure 9[4]. For most technologies—11 out of 15—adopted/tried was greater than 60 per cent. Adopted/tried was greatest for fodder tree planting (97 per cent) and was less than 60 per cent for improved forage species, improved finger millet and rice varieties and rabbit farming. Overall, once a technology was tried, the probability of it being adopted was good, with a mean adopted/tried of 67 per cent.

Adopted/Total

The mean level of adopted/total was 31 per cent, with five of the technologies having a markedly higher adoption level (Figure 9). The adoption profile of the technologies, ordered by decreasing levels of final adoption, illustrates the strong relationship between level of trying a technology and final adoption (Figure 10), confirming the earlier analysis that tried/aware is the most important adoption step.

Figure 5 Distribution of reasons for not trying technologies by type of constraint

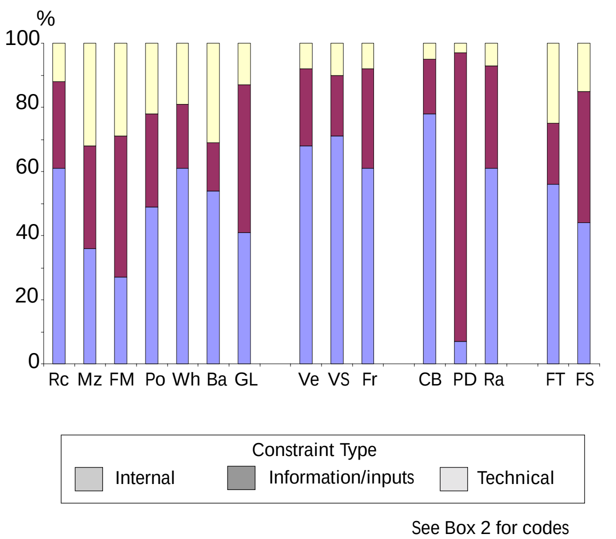
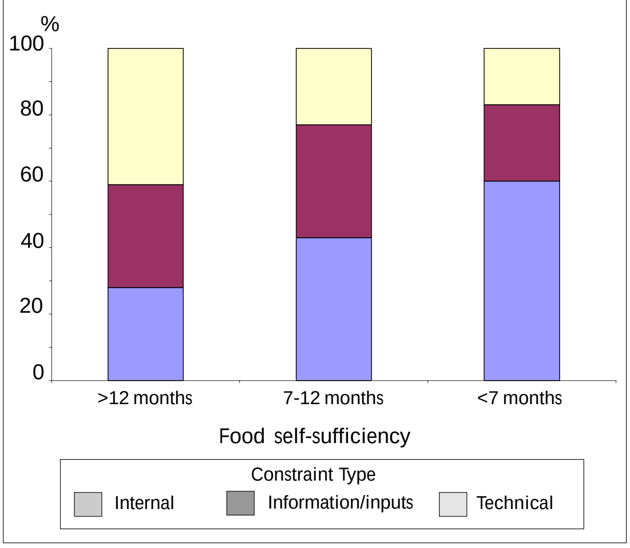


Figure 6 Reasons for not trying improved potato varieties by food self-sufficiency



Factors affecting adoption

Access

Adoption levels for the majority of technologies were significantly affected by access. However, for only a few technologies was this relationship a simple and consistently significant one. This is because many technologies are adapted to specific AEZs and strongly associated with access levels. Thus the adoption of potatoes, Jersey crossbreeds and rabbit will be higher in the high hills to which these technologies are adapted; but which are typically poor access areas. Conversely, the adoption of vegetable seed production will be higher in medium access middle and low hill areas. Thus while strong associations may exist between access and adoption, it is not a simple relationship where increased access is associated with increased adoption.

The technology showing the most significant and consistent trend of decreasing adoption with decreasing access was parasitic drenching. Here decreased adoption with decreased access resulted from a comparable decline in awareness and rate of trying with decreasing access. It is likely that this reflects the reduced availability of inputs—medicines—required for the technology.

Overall, the lack of a significant reduction in adoption levels with decreasing access is taken to indicate that in the study area, and for the improved agricultural technologies studied, there was no systematic disadvantage or inequity of adoption with reduced accessibility. Except where the availability of inputs is critical for adoption, the suitability of a technology to an area was a more important determinant of adoption.

Food self-sufficiency

There was a consistent pattern across all technologies (except improved barley varieties and tree fruit crops) of decreasing adoption levels with decreasing food self-sufficiency. However, this was significant only for improved rice, maize and wheat varieties, improved vegetables and crossbreeds. For all technologies except improved wheat varieties, whenever the effect of food self-sufficiency on adoption was significant, there was a significant complementary effect of food self-sufficiency on the tried/aware adoption step (the most important step determining final adoption).

The most frequently reported reasons for not trying a technology were related to constraints internal to the household (typically lack of land or labour). The relative importance of internal constraints did not however differ markedly between food self-sufficiency classes. The relative importance of each reason for the household was not determined by the questionnaire. However, the association between the frequency of internal reasons for not trying a technology, the low rate of trying and the low adoption by food deficit households suggests that technology adoption by these households is primarily constrained by factors related to household resources.

The consistent, and often significant pattern of reduced adoption with reduced food self-sufficiency, is taken to indicate that low food self-sufficient households are consistently at a disadvantage with respect to the adoption of improved agricultural technologies.

Ethnicity

There was a consistent and significant effect of ethnic group on adoption for all technologies except barley, grain legumes, vegetables and crossbreeds. The dominant pattern was for the Occupational caste group to have significantly lower levels of adoption (in nine of the fifteen technologies). Differences between Brahmin/Chhetri and the Gurung/Magar and 'other' ethnic groups were more variable. The earlier results for awareness and trying suggest that low adoption amongst Occupational caste households results from low rates of trying (i.e. the tried/aware adoption step).

Figure 7 Improved maize varieties: First source of information by LARC input level

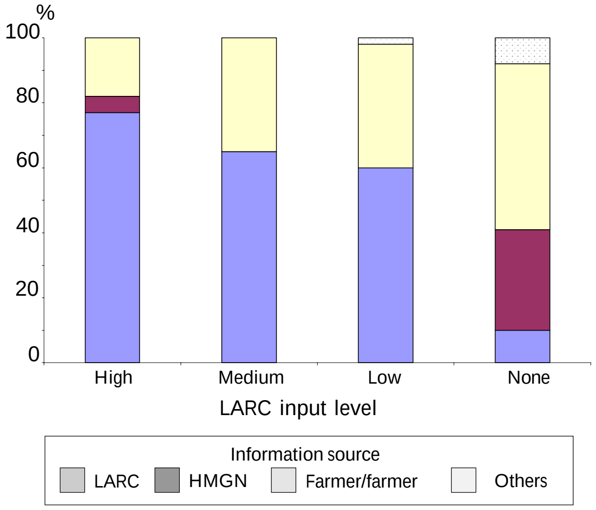
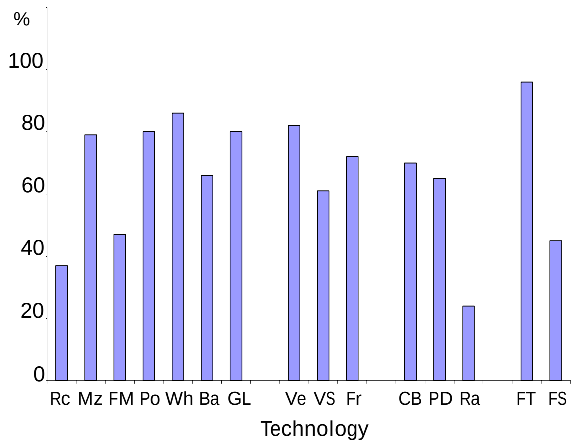


Figure 8 Adoption of the technologies out of those who tried



See Box 2 for codes

For most technologies, adoption amongst Gurung/Magar households was not significantly different to those for Brahmin/Chhetri households. The exceptions were the significantly lower adoption by the Gurung/Magar of improved rice and wheat varieties, vegetable seed production and parasitic drenching, and higher adoption of improved finger millet varieties and fodder tree planting. These relatively small differences may simply reflect the altitudinal stratification of these ethnic groups and technologies; Gurung/Magar and maize/finger millet production systems predominate in the high hills and Brahmin/Chhetri and rice-wheat systems predominate in the middle and low hills.

These results provide evidence of a systematic disadvantage for Occupational caste households with respect to adoption of new technologies. Occupational caste households are, however, traditionally less dependent than other groups on agricultural production for their livelihoods.

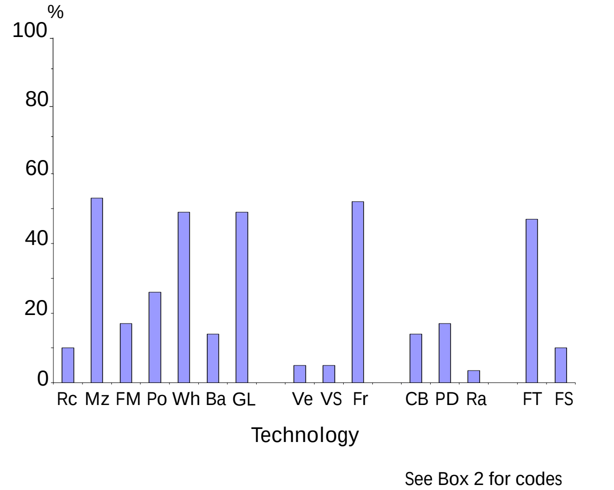
Gender

Sex of respondent, or of household head, had a relatively small effect on reported adoption. As the questionnaire was designed to assess household, rather than individual respondent adoption, it was anticipated that differences in household adoption reported by sex of respondent, were unlikely. For most technologies, adoption reported by female respondents was slightly, but not significantly, lower than for male respondents. These results may reflect a tendency for respondents to reply from an individual rather than a household perspective.

Results for sex of household head are considered to provide a more reliable indicator of the gender dimension of technology adoption by households. This is because results are more likely to reflect differences in household resources. Sex of household head was significant for only two technologies (improved varieties of finger millet and wheat). For a further nine technologies, female-headed households reported lower adoption rates. Higher adoption of finger millet varieties amongst female-headed households probably reflects the importance of finger millet to Gurung/Magar households, which have a higher rate of male absenteeism due to male out-migration[5].

Overall, there is little conclusive evidence of a systematic disadvantage based on gender with respect to adoption of new technologies.

Figure 9 Final adoption of the technologies % of all households

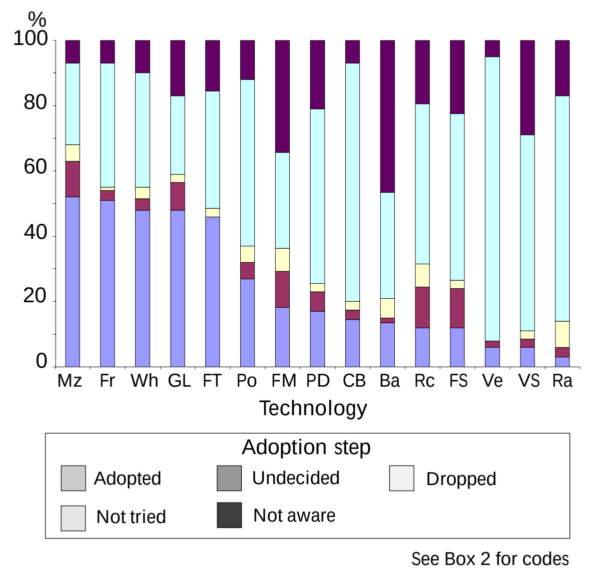


4 HOUSEHOLD ADOPTION AND EXTENSION IMPACT

In the previous sections, the adoption profiles of each technology were examined individually. In reality, however, each household is a potential adopter of any number and combination of new technologies. The goal of LARC has been to promote improved livelihoods at the household level, through the adoption of new technologies. The adoption profiles for each household were therefore examined simultaneously across all the technologies to achieve a better understanding of the extent to which this goal has been achieved. The multi-technology adoption profiles were then linked to perceived impacts on key indicators.

The following sections summarise the findings. Firstly, household adoption patterns across the technologies are examined using the multivariate technique of cluster analysis (see Appendix 1). The multi-technology household adoption clusters identified are then related to those impacts detected in the earlier EIS (LARC, 1994), to determine whether there is a relationship between technology adoption and perceived impact.

Figure 10 Adoption profile for all technologies



Multi-technology adoption

Household clusters

In order to classify households according to their adoption of all the technologies studied, a cluster analysis was performed using the five step adoption profile developed for the sample households, for each of the 15 technologies (see Appendix 1). Preliminary hierarchical cluster analysis suggested that between four and eight clusters might be appropriate. Canonical variate analysis found that well-differentiated clusters were obtained with a five cluster solution. This was therefore used for further analysis.

Table 3 Number of technologies in adoption profile classes for each cluster of households

Adoption profile	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
Adopted	4	2	2	1	0
Undecided	9	6	3	1	0
Dropped	2	6	6	4	4
Not tried	1	6	7	13	10
Not aware	0	0	0	1	1
Cluster size	10%	19%	26%	18%	27%

The five adoption profile steps were given values from one to five, with the class 'Not aware' given the value 1, Not tried – 2, Dropped – 3, Undecided – 4 and Adopted – 5. For each cluster of households, the cluster mean value for each technology was calculated and each technology was then assigned to one of the adoption profile steps (Table 3).

For Cluster One, the mean value for four technologies exceeded 4.5 and these technologies were therefore classified as adopted. Nine technologies had a mean value between 3.5 and 4.4 and were classified as undecided. No technology in Cluster One had a mean value of less than 1.5, i.e. there were no technologies which Cluster One households were unaware of. Comparing Cluster One with other clusters shows a

Table 4 The technologies in the adoption profiles for each cluster

Adoption Profile	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
Adopted	Maize Wheat Vegetables Tree fruits	Finger millet Maize	Fodder trees Tree fruits	Wheat	
Undecided	Rice Grain legumes Potatoes Vegetable Seeds Fodder trees Crossbreeds Parasitic drenching Rabbit farming	Wheat Grain Legumes Potatoes Fodder trees Tree fruits	Maize Wheat Potatoes	Maize	
Dropped	Finger millet Forage species	Rice Forage Species Crossbreeds Parasitic Drenching	Rice Grain legumes Forage species Crossbreeds Parasitic Drenching	Grain Legumes Potatoes Fruit Trees	Maize Grain legumes Fodder trees Tree fruits
Not tried	Barley	Barley Vegetables Vegetable Seeds Rabbit Farming	Barley Finger millet Vegetables Vegetable Seeds Rabbit Farming	Finger millet Rice Vegetables Vegetable Seeds Fodder trees Forage Species Crossbreeds Parasitic Drenching Rabbit Farming	Finger millet Rice Wheat Potatoes Vegetables Vegetable seeds Forage species Crossbreeds Parasitic drenching Rabbit farming
Not aware				Barley	Barley

progressive decline in the number of technologies adopted or undecided on, and an increase in the number of technologies not tried. Cluster One therefore represents adopting households. It is the smallest cluster and comprises only 10 per cent of the sample. Clusters Two, Three and Four form a gradual progression to Cluster Five (the largest cluster with 27 per cent of households), who are essentially non-adopters.

A detailed adoption profile for each cluster is given in Table 4, where individual technologies contributing to the adoption profile distribution in Table 3 are listed. It indicates that there are certain common technologies adopted or undecided upon, across several clusters. These include improved maize and wheat varieties (apparent in four clusters), followed by tree fruit crops, planting of fodder trees and improved potato varieties (three clusters). There are two technologies, namely improved vegetables and improved finger millet varieties, which have been adopted by only one cluster.

Another group of technologies falls consistently into the dropped, not tried or not aware category. These include improved barley and forage species. If Cluster One is excluded, then the list of technologies which have generally low adoption (i.e. dropped, not tried or not aware) across clusters can be expanded to include improved rice varieties, improved vegetables, vegetable seed production, parasitic drenching, crossbreeds and rabbit farming.

Relationship between clusters and key factors

Loglinear modelling was used to investigate the relationship between the clusters of households and the key factors. Interactions which are not important (for instance, the interaction between access and ethnicity) were not included in the model, nor were three or more factor interactions. This considerably simplified the model by keeping the number of cells with zero count to a minimum.

Sex of household head showed little association with cluster membership and sex of respondent was only marginally associated. All other key factors were strongly associated with cluster membership. The distribution of households is not even across the five clusters but is affected by key factors. For example, AEZ is strongly associated with cluster membership; relatively larger numbers of low hill households occur in Clusters One and Three than would be expected. Similarly, relatively larger numbers of middle hill households occur in Cluster Four and high hill households in Clusters Two and Five. These associations were used to characterise the clusters in terms of the key factors (Table 5). Each is characterised by the key factor level which had the largest positive residual. The result therefore gives a typical household in each cluster, although households with these characteristics can also belong to other clusters.

To determine the relative importance of the key factors on household adoption patterns across technologies (i.e. multi-technology adoption), the mean deviances for the loglinear models were examined. The resulting order of importance was ethnicity, LARC extension input, food self-sufficiency, AEZ, access and sex of respondent. Brahmin/Chhetri households with more than twelve months food self-sufficiency, located in the low hills, with good access and in a high LARC extension input village are likely to be high adopting households. At the other end of the multi-technology adoption spectrum, non-adopting households are likely to belong to Occupational castes, be less than seven months food self-sufficient, located in the high hills, with poor access and in non-LARC input areas.

It is possible that the significant and positive association between extension input and multi-technology adoption clusters could be unintentional. For example, high extension input areas might contain more Brahmin/Chhetri, food self-sufficient households in the more accessible low hills, which tend also to be high adopting households. In order to test this possibility,

Table 5 Cluster profiles derived using associations between key factors and clusters

Key Factor	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
Agro-ecological zone $p<0.001$	Low hills	High hills	Low hills	Middle hills	High hills
Extension input $p<0.001$	High LARC	High LARC	Low LARC	Low LARC	Non-LARC
Access $p<0.001$	<4 hours	4-8 hours	<4 hours	<4 hours	>12 hours
Food self-sufficiency $p<0.001$	>12 months	>12 months	7-12 months	7-12 months	<7 months
Ethnicity $p<0.001$	Brahmin/ Chhetri	Gurung/ Magar	Brahmin/ Chhetri	Brahmin/ Chhetri	Occupational
Sex of respondent $p=0.043$	Male	Female	Male	No association	Female

Table 6 Cluster profiles derived using associations between EIS impacts and clusters

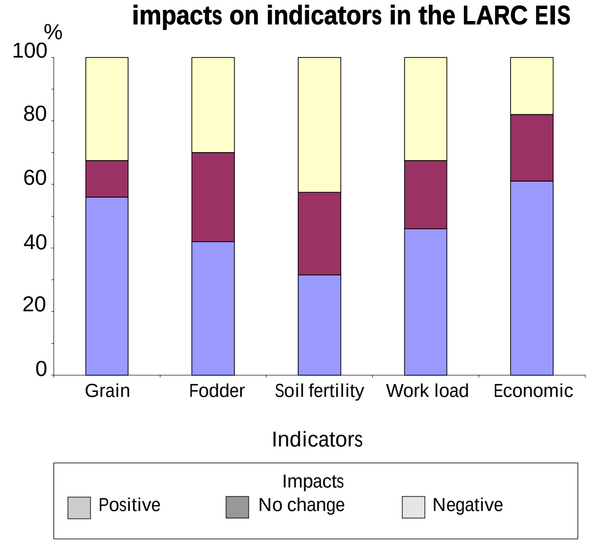
EIS impact	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
Total food grain production	Increase	Increase	Increase	Decrease	Decrease
Fodder supply	Increase	Increase	Increase	No change	Decrease
Soil fertility	Increase	No change	Increase	Decrease	No change
Work load	Increase	Decrease	Decrease	Increase	No change
Economic status	Increase	Increase	Decrease	No change	No change

the loglinear model was re-run with the extension input factor by cluster membership term fitted last. By doing this, the extension input influence on cluster membership was tested after all other influences had been accounted for; and was found to be still significant. This is taken as strong evidence of a causal relationship between extension input and multi-technology adoption cluster membership. LARC extension input to a household increased the multi-technology adoption rate.

Multi-technology adoption and household impact

Loglinear modelling was also used to investigate the relationship between household adoption cluster membership and impacts (either positive/increased, no change or negative/decreased) perceived by the respondent households on the indicators used in the EIS (LARC, 1994). The distribution of the perceived impacts in the population for the indicators where effects were statistically significant (namely total food grain production, fodder supply, soil fertility, workload and economic status) are summarised in Figure 11.

Figure 11 Percent of households reporting impacts on indicators in the LARC EIS



Source: Redrawn from LARC (1994) data

The results revealed strong relationships between multi-technology adoption cluster membership and the perceived impacts on total food grain production, fodder supply, soil fertility and economic status. There was a small association between cluster membership and workload. The cluster characteristics developed from these associations are shown in Table 6.

Table 6 shows that for Cluster One, all the impacts have been positive. Clusters Two, Three and Four have combinations of positive, no change and negative impacts. For Cluster Five households, the five indicators show either no change or a negative impact. This shows that Cluster One households—who have adopted most technologies—have benefited most, with increases in total food grain production, fodder supply, soil fertility and economic status, although at the cost of increased work load. On the other hand, Cluster Five households have benefited little, if at all.

Loglinear modelling also showed significant associations between the key factors and the perceived impacts (a reflection of the associations between the multi-technology adoption clusters and the key factors described in the previous section). Thus, positive impacts were more likely to be perceived by Brahmin/Chhetri, food self-sufficient households living in good access, low hill areas. As for the earlier examination of the association between extension input and multi-technology adoption cluster membership, the extent to which the association between extension input and positive impacts could have occurred unintentionally was tested by re-running the loglinear model with the extension input by impacts term fitted last. A significant association remained between extension input and the perceived impacts on total food grain production, fodder supply and workload.

Implications

The analysis shows that sample households can be reliably clustered according to their multi-technology adoption profiles. The five clusters are graded from high adopting households with high multi-technology adoption profiles (10 per cent of the sample), through to those with intermediate adoption patterns, to those who are essentially non-adopters (27 per cent of the sample). The distribution of the sample amongst the clusters indicates that about a quarter of households had adopted no technologies, about half had adopted one or no technologies, and most households (90 per cent) two or less technologies. Most technologies are therefore adopted by only a small and common proportion of households.

The combination of technologies most likely to be adopted by high adopting households (improved maize, wheat and potato varieties, tree fruit crops and the planting of fodder trees) and the socio-economic characteristics of adopting households (Brahmin/Chhetri, food self-sufficient households in low hill areas with good access) reinforce the associations demonstrated in the earlier single-technology analyses. There were also significant differences in perceived impacts between households grouped according to their multi-technology adoption profile. Adopting households reported increased total food grain production and fodder supply, but at the cost of increased workload in comparison to non-adopting households.

The significant positive association leads to the main conclusion of this analysis: there is a positive, significant and causal relationship between enhanced extension input to farming households and the wider beneficial impacts perceived by these households, as a result of the adoption of the improved agricultural technologies. This relationship occurred firstly between LARC extension input and the multi-technology adoption cluster membership; secondly between this membership and positive impacts on total food grain production and fodder supply; and thirdly between LARC extension input and these impacts.

5 DISCUSSION

Level and extent of adoption

The primary objective of this study was to determine the level and distribution of adoption of technologies, to determine the economic value and impact of research. The examination of the relative effects within studies, for example between adoption steps and across farmer categories and of the causal mechanisms and reasons involved, are also an important means to improve research and extension strategies and processes.

The adoption studies conducted under the LARC/PAC RIMS are the most comprehensive to have been conducted in the hills of Nepal. Although some earlier adoption studies in Nepal have covered hill farming systems (KHDP, 1993; Clinch and Vaidya, 1993; Belbase, 1992; Pachico and Ashby, 1983; Rokaya, 1983 and Sharma, 1981), most have been concerned with the plains (Upadhyaya *et al*, 1993; Thapa *et al*, 1992; Morris *et al*, 1994; Shakya and Flinn, 1985; and Karki, 1981). These studies have also had a commodity and variety technology focus, concentrating on rice (Malla, 1983) but also covering wheat, fertiliser use, seeds and cross-breeding.

Comparisons between adoption studies need to be made cautiously. Studies have different objectives and methods and different issues are examined. Furthermore as the results of this study demonstrate, the level and extent of adoption depends on a range of factors that are likely to vary between study populations. The more similar studies are in terms of technologies, farming systems, factors and study methods, the more reliable will be the comparisons. This is reinforced by comparing the LARC and PAC RIMS adoption studies which were carried out in comparable environments using comparable methods. A positive rank correlation (r_s=0.75; $p<0.10$) and similar levels of adoption amongst the seven common technologies was evident.

Comparisons with other Nepali adoption studies also provide evidence of consistent effects between studies and confirm some factors influencing adoption as generally applicable. Factors—common to the LARC study—identified as positively associated with increased adoption, were increased access (Belbase, 1992) and increased extension activity (Malla, 1983). Other factors associated with increased adoption in the other studies, namely increased farm size (Belbase, 1992; Malla, 1983), lower input (fertiliser) prices (Shakya and Flinn, 1985; Upadhyaya, 1993), irrigation availability (Belbase, 1992; Malla, 1983), risk-bearing capacity (Pachico and Ashby, 1983), tenure status (Shakya and Flinn, 1985) and credit (Shakya and Flinn, 1985), were not specifically examined in the LARC adoption study. In the LARC study, households were classified on the basis of food self-sufficiency which previous experience has shown to be a surrogate factor for assessing resource status. For example, food self-sufficient households are likely to be larger farmers who consequently have less need to enter share-cropping arrangements, which are themselves negatively associated with the adoption of modern varieties (Shakya and Flinn, 1985). Also, they can also more easily absorb the risk inherent in the evaluation of a new technology and so tend to be early adopters (Pachico and Ashby, 1983). Thus the findings of the LARC study, on the basis of using household food self-sufficiency as a surrogate factor, appear consistent with the earlier studies.

An important feature to bear in mind is that research and extension programmes have been well-resourced and institutionally integrated within LARCs ECA. Programmes have also been assessed as well oriented and managed (LARC, 1994; MASDAR, 1995b). These are conditions expected to lead to favourable adoption rates. The rates of adoption estimated here may therefore be a reliable guide to the maximum that may be realistically achieved from a well-functioning research and extension system, servicing primarily subsistence-oriented, hill farming systems.

Reasons for, and factors influencing adoption

Comparisons of the adoption steps across technologies (See Figures 3, 4, 8 and 9) help identify the important adoption gaps for the different technologies. Associated survey questions identify the constraints to and incentives for adoption. The major barriers to adoption were low rates of trying technologies, and the importance of internal constraints of the farm household (typically lack of land or labour) as reasons for not trying new technologies. The considerable variation in adoption between technologies once tried, and the logical and technology specific reasons given for non-adoption, have important implications for the future conduct of research at LARC. Extension emerged as a dominant factor.

Distribution of adoption

Adoption levels were lower amongst households with low food self-sufficiency and from Occupational castes—results that were not unexpected. Low adoption occurred principally because of low rates of trying. However, awareness and adoption once tried, was only marginally influenced by ethnicity and food self-sufficiency. Distribution of adoption therefore appears to be related mainly to the distribution and intensity of constraints to trying (largely internal) amongst the farm households, rather than to different types of constraints affecting different categories of households. Improved understanding of the internal constraints, together with initiatives in the research process that reduce the internal constraints to trying technologies are therefore likely to be beneficial in creating a more equitable distribution of adoption and the resulting benefits.

The finding that most technologies are adopted by only a small and common number of households and that adoption was skewed in favour of the better resourced households, has important implications for the targeting of research and extension. LARCs institutional objectives include those of equity and requires that LARC takes specific steps to avoid this skew. Undoubtedly this is a difficult task. One step that can be taken is for socio-economists to provide a set of guidelines that can be applied by the researchers at each step of the research process to ensure that the requirements of less well-resourced households are always considered in setting research agenda and methods. Another step is to conduct research into the reasons for not trying technologies; such research would self-select these disadvantaged households for attention.

Future conduct of research in the hills of Nepal

The fourth objective of the study was to identify lessons for improving the effectiveness of research in the hills of Nepal. Implications and research needs for each technology were presented in the original report (Floyd, 1997) and are not further discussed. Amongst these, however, a number are common across technologies.

The first implication is the need to address the most important adoption gap—that of not trying a technology—which appears to occur due to internal constraints of the farm household. Across technologies, the ‘not trying’ households form the largest group of households, and a reduction in these households will have the greatest impact on the level of final adoption. The extent to which these households are able to try technologies and what needs to be done to achieve this needs to be identified. This should be followed by an assessment of whether this can be achieved by changes in research strategies and methods, or whether more substantial changes beyond the remit of research will be required. These findings will determine the extent to which research priorities and/or methods need to be adjusted.

A second implication, particularly for crop based technologies, is the need to consider non-yield variables (e.g. cooking quality and taste of varieties) when assessing technologies for their adoptability. Incorporation of such assessments into the research process is, on the evidence provided here, likely to lead to improved adoption.

A third feature of the results was the interaction between the not trying adoption gap and technology development. The emphasis should be on enhancing the participation of farmers and other stakeholders in the technology development process. The benefit of their participation would range from the greater and more relevant use of other, non-yield, assessment criteria in screening crop varieties, through to product development or identification of market opportunities for new technologies.

A fourth feature of the results is that adoption is skewed away from resource-poor households. The need for explicit targeting of resource-poor farming households, who have not benefited through the adoption of the technologies studied was discussed above and is reiterated here. Such an approach in the conduct of research and extension is not only in the interest of the farm households, but is also in the interests of research and extension systems. Explicit targeting will increase the impact of research and extension and so the justification for their funding.

Research-extension linkages

Of the factors examined, the level of extension input had the largest and most consistent effect on adoption. In this study, a strong association between extension input and adoption was expected because LARC has been able to provide a high level of support in its ECA. The discussion should therefore focus on how extension can be more effective.

One implication that can be drawn from these results is that a balanced investment in research and extension is needed to ensure adoption at the household level, and research has a role in ensuring that this occurs.

This implies complementary research and outreach research programmes, together with pro-active attention to research-extension linkages to support extensionists in their task of disseminating technologies to farmers, and to ensure that farmers and extensionists are actively involved in technology development.

A result of the study that has particular implications for the future conduct of research-extension linkages is the consistent importance of information and input-related constraints as reasons for not trying a technology. Typically, the reasons given were either the lack of technical know-how or the supply of inputs. The frequent mention of the lack of seed as a constraint reinforces the importance of research contributing to the availability of foundation and certified seed, especially for those crops where private sector supply is unavailable.

With respect to the sources of information or the inputs needed for technology adoption, results demonstrated that farmer-to-farmer mechanisms are important, especially where official sources are scarce, or amongst disadvantaged households. Farmer-to-farmer information flows can be built on by extending the involvement of farmers in technology development, and by developing methods to enhance their current roles in technology dissemination. These developments are likely to be more appropriate for technologies which do not depend heavily on external inputs. However, where substantial improvements in the official extension and input delivery systems are unlikely, as in comparable hill areas and/or when technologies are dependent on inputs (parasitic drenching in this study) alternate systems and networks will need to be tested.

Technology adoption and household benefit

The integrated nature of household farming systems in the hills of Nepal meant that in order to assess research impact at the household level, adoption patterns needed to be determined for a range of technologies. Multivariate analytical techniques were used to provide an integrated analysis of adoption across the fifteen technologies and is a distinguishing feature of this study, shared only with a few other adoption studies (Karim *et al*, 1995; Bapat *et al*, 1992; Daramola, 1989). The advantage of the approach lies in its ability to integrate, at the household level, the adoption profile for all technologies. Once this is done, it is possible to link households' reactions to a large number of technologies with their perceptions of the technologies impacts.

The statistically significant association between technology adoption and perceived positive impact at the household level is an important finding of the EIS and RIMS studies. It provides empirical evidence in support of continued funding for agricultural research and extension in the hills of Nepal.

6 CONCLUSIONS

Adoption was highest for the technologies of improved maize, wheat and grain legume varieties, improved tree fruit crops, and the planting of fodder trees. Intermediate levels of adoption were found for the technologies of improved rice, finger millet, potato and barley varieties, crossbreeding of cattle and buffalo, parasitic drenching of livestock and improved forage species. Adoption levels were low for improved vegetables, vegetable seed production and rabbit farming. The highest rates of adoption are associated with technologies based on existing production systems (e.g. production of staples and fodder) and are lowest with technologies based on exotic production systems (e.g. introduced vegetables and seeds).

The level of awareness of the technologies was generally good, ranging from a minimum of 52 per cent awareness of improved barley varieties, to a maximum of 95 per cent for improved vegetables. For half the technologies, the level of awareness was greater than 80 per cent. Awareness was most strongly influenced by extension input levels, and decreased consistently and significantly with decreasing extension input.

The most important gap in the adoption process was in trying the technologies. Households who had not tried the technologies ranged from 25 to 70 per cent of the sample across all technologies. The most frequent reasons given were related to the internal constraints of the household (lack of labour or land), followed by those related to the availability of information/inputs concerning the technology (lack of technical know-how and unavailability of seed). Technical reasons for not trying the technologies (typically, difficulty of managing the technology and the incompatibility of the improved technology with the farming system) were the least important.

Levels of not trying the technologies were significantly and consistently influenced by factors related to extension input and the socio-economic and ethnic characteristics of households. Increased levels of not trying were significantly associated with lower levels of extension input and amongst Occupational castes. Food deficit households were less likely to try a technology.

Once technologies were tried, the majority (greater than 60 per cent) of households adopted them. Extension input or socio-economic characteristics of households had little influence on adoption at this point. This indicates a generally high level of internal acceptability of the technologies, although for a few technologies—improved rice and finger millet varieties, rabbit farming and improved forage species—more than 50 per cent of households that had tried the technology had either dropped it, or were still undecided on whether to adopt.

The level of adoption of the technologies was consistently and significantly effected by the level of extension input. Increased levels of extension input were associated with increased levels of technology awareness, with increased rates of trying once aware and with a lower frequency of information/input related constraints. This underlines the importance of maintaining adequate extension input and effective research/extension linkages, in order to ensure research impact.

Adoption rates were lower amongst resource-poor households and amongst Occupational castes, although there were no consistent significant differences related to gender or access. From the available data, the reasons for lower adoption among these households appear to be primarily related to the higher level of internal constraints of the households. About a quarter of the households had adopted no technologies, about half of the households had adopted one or less technologies, and most households (90 per cent) two or less technologies. Most technologies are therefore adopted by only a small and common proportion of the sample households, who are better resourced or live in more favourable (lower hill and better access) areas.

There was a positive association between the household adoption patterns of the technologies and the household perceptions of positive impacts, as measured in the earlier EIS for the same population sample. Adoption was associated with increased total food production, fodder supply, soil fertility and economic status, but at the cost of increased work load.

There was a positive association between household adoption of technology and increased extension input into the household on one hand, and household perceptions of positive impacts on the other. This strongly implies that improved agricultural technologies, generated as outputs from research and effectively disseminated, lead to perceived socio-economic benefits at the household level.

This suggests that the value of any adoption study lies as much in the improved (qualitative) understanding of both the adoption process and the impact on the farming system as in the (quantitative) determination of absolute levels and extent of adoption.

Lessons for the future

The following conclusions form the basis of recommendations for the future conduct of agricultural research in the hills of Nepal.

The most important adoption gap—that of not trying a technology—which occurs due to internal household constraints, requires more attention. A more thorough explanation of the causal relationship between not trying a technology and the internal constraints of households is needed, and the association between these reasons with socio-economic factors.

Research should address ways to make more effective use of the resource—typically land or labour—that is the most limiting constraint to adoption. For other constraints, research may be unable to make a significant contribution: in these cases the problem or the technology would be a low research priority.

The skewed patterns of adoption of the technologies in favour of better-resourced farmers indicate a need for more explicit targeting of resource-poor farmers. These are the households that must be reached if wider adoption and impacts of research programmes are to be achieved.

The underlying research and extension programmes examined in this study have been well-resourced, managed and institutionally integrated within the area studied. These are conditions likely to lead to favourable rates of adoption. Thus the levels and distribution of adoption achieved are a reliable guide to the maximum that may be realistically achieved from a well-functioning research and extension system servicing comparable hill farming systems.

APPENDIX 1 STATISTICAL METHODS

A multivariate analysis was conducted to examine the adoption patterns of all technologies across all households using the software package Genstat (Release 5.3 [2]).

Cluster analysis was used to identify whether there were identifiable groups of households with similar adoption patterns across all technologies.

Canonical variate analysis (CVA) was used to investigate where cluster differences lay. A solution from a preliminary hierarchical analysis was taken as the starting point for a non-hierarchical iterative partitioning analysis (Hair *et al*, 1992). The method chosen for the non-hierarchical clustering maximised the Euclidean distance between classes. The cluster membership from the non-hierarchical analysis was used as the group membership in a CVA.

The number of clusters in the solution was selected to ensure that clusters were obtained which were well-differentiated with respect to the inter-cluster distances, and in the two-dimensional space represented by the first two canonical variates (CV). CVA was then used on the chosen solution from the non-hierarchical cluster analysis to identify those technologies which were important in differentiating between clusters.

The clusters were profiled in two ways. First, the cluster mean values describing each of the clusters, were used to draw an adoption profile showing the number of technologies adopted, dropped, etc., for each cluster. Second, the clusters were then profiled for the external variables, i.e. the key factors which were not used in generating the cluster solution. Loglinear modelling was used to investigate relationships between these key factors and the household clusters obtained. The second method of profiling also served as a check on the external validity of the cluster solution.

Limitations of the sample and reliability of interpretation

Data analysis and interpretation was conducted cautiously. For example, only the main effects of the key factors were tested in logistic regression and care was taken to ensure that assumptions underlying analyses were not violated. Additionally the stability of the multivariate results was established by comparing the degree of similarity of the solutions from cluster analyses and canonical variate analyses on each of ten random (sub)samples of 210 households from the data, and between the sub-samples and the whole sample cluster solution. An adoption profile was drawn up, and the relationships between clusters and the key factors were examined for each of the ten sub-sample cluster solutions to test the stability of the cluster analysis. Details of the methods and the precautions taken are given in Floyd (1997).

This approach was taken in recognition of the constraint imposed by the limited size of the final sample (424 of a total 432 households) and the degree of association between the number of respondents per cell within cross-tabulations of key factors in two-way tables. These associations occur naturally in the population. Within the sample, and without a more deliberate sampling strategy, such associations are difficult to avoid. Additionally, the low level of adoption for some technologies meant that estimates were based on very few cases.

ENDNOTES

1 The other components of the RIMS were a farming systems study to determine the economic benefit of the technologies studied (MASDAR, 1995a) and a research management study (MASDAR, 1995b). The findings of the consultants with respect to all three components are recorded elsewhere (*op cit.*). The interpretation of the adoption study results presented here is that of LARC staff who were responsible for the adoption study. For full details see Floyd (1997).

2 Characterisation by respondent was not possible as each respondent could have cited reasons from more than one category. Although the subdivision of 'not tried' should be interpreted with caution, it is useful for understanding the results of the survey, particularly with respect to constraints to adoption.

3 The population distribution used to calculate the weights (high hills 39.5 per cent, middle hills 57.1 per cent and low hills 3.3 per cent) were the best estimates available for the ECA (LARC, 1994).

4 In the full report (Floyd, 1997), the results for each of the technologies are considered in greater detail by examining the reasons reported for adoption and non-adoption once the technologies were tried by the households. This was done in order to identify lessons for the future conduct of research and for research and extension linkages with respect to the individual technologies. Here it is only possible to provide a summary of the effects for the individual technologies.

5 Results for female headed households need to be interpreted with caution as they accounted for only seven per cent of the sample.

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