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On-farm conservation of agricultural biodiversity in Nepal

Volume II. Managing diversity and promoting its benefits

Proceedings of the Second National Workshop 25–27 August 2004, Nagarkot, Nepal

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Understanding diversity

Influence of socioeconomic and cultural factors on management of rice varietal diversity in Nepal

Ram B. Rana, C. Garforth, Bhuwon R. Sthapit, Anil Subedi and Devra I. Jarvis

Abstract
The study reports findings from a questionnaire survey conducted on 408 sampled households to understand the role of socioeconomic, cultural and environmental factors in rice (*Oryza sativa* L.) varietal diversity management on-farm in two contrasting ecosites (mid-hill and plain) in Nepal. Multiple regression outputs suggest that parcels of land, livestock number, number of rice ecosystems, agroecology (altitude) and use of chemical fertilizer have significant positive influence on landraces diversity on-farm. Other factors like total land area and membership in farmers' groups have significant but negative influence on landrace diversity. Factors that had significant positive influence on diversity of modern varieties on-farm were parcels of land, number of rice ecosystems, access to irrigation, membership in farmers' groups, and use of insecticide. The study also concluded that resource-rich households maintain significantly higher varietal diversity on-farm than do resource-poor households. Resource-rich households also played a significant role in conserving 'vulnerable to erosion' landraces and those landraces with sociocultural and market-preferred traits. Gender role in agrobiodiversity conservation on-farm seemed to be contextual with higher contribution from females in hill communities than in plain communities. For an on-farm conservation programme to succeed in conserving agrobiodiversity, inclusion of resource-endowed households in the programme is essential because of to their crucial role in conserving diversity of landraces on-farm.
Key words: Agricultural biodiversity, on-farm conservation, varietal diversity, landraces, modern variety (MV), rice, Nepal

Introduction
Understanding the influence of sociocultural, economic and environmental factors on farmers' decision-making processes in management of agrobiodiversity on-farm is a prerequisite for devising a strategy for on-farm conservation (Jarvis and Hodgkin 1998). Brush (1995) identified socioeconomic factors such as land fragmentation, marginal growing environments, imperfect market conditions, cultural identity and preference for diversity as contributing positively towards on-farm diversity. Brush (1989) and Gurung and Vaidya (1998) found that economic status and food culture or culinary preferences of respondents influence diversity on-farm. Other studies have stressed the interconnectedness between cultural diversity and agrobiodiversity (Soleri and Cleveland 1993; Gonzales 2000; Negash and Niehof 2004).

Odero (1998) highlighted the significance of farm size, employing casual labour, fertilizer use and extension agent visits on maintenance of agrobiodiversity on-farm. Similarly, Cromwell and van Oosterhout (2000) identified economic, sociocultural and environmental factors which have a positive association with on-farm diversity of crops and crop varieties. Among economic variables they identified larger farm size to be positively associated with greater number of crops and crop varieties. The value of the crop to the farm family, the relative age of household head, and position of authority within the society were sociocultural factors that contributed positively to diversity on-farm. The main environmental factor with influence on crops and varietal diversity identified was the on-farm growing conditions.

The status of crop diversity in the field is mostly measured by counting farmer-named varieties. Bajracharya (2003) reported high consistency between farmers' naming of rice varieties and the results obtained from agromorphological and biochemical characterizations, which indicate that a farmer-named variety could be used as an independent unit for analysis. Above all, for farmers and practitioners in the field, genetic diversity means varietal diversity, which they can clearly distinguish on the basis of agromorphological traits, phonological attributes, postharvest characteristics and differential adaptive performance under abiotic and biotic stresses (Sthapit and Subedi 1997).

The purpose of this study is to identify different sociocultural, economic and environmental factors that influence farmers' decisions on management of rice varietal diversity on-farm. Specifically, the research attempts to test the following hypotheses:

- Different socioeconomic factors influence the numbers of landraces maintained on-farm at household level.
- Resource-rich farmers in any agroecological zone maintain significantly higher number of landraces on-farm than other categories of farmers.
- Women decision-makers maintain significantly higher landraces diversity on-farm than their male counterparts.
- Sociocultural preference of certain landraces contributes to their conservation on-farm.

Materials and methods

A socioeconomic and agroecological study was conducted in two contrasting ecosites in Nepal: Begnas represented mid-hill and Kachorwa represented plain conditions (Table 1). Household was taken as the sampling unit for the study. The study employed proportionate stratified random sampling design, and wealth category[1] was used for stratifying households (LARC 1995; Turton *et al*. 1997). Samples of 206 and 202 households out of 941 and 914 households in Begnas and Kachorwa study sites were selected, respectively. Information was collected on respondent profile, household features, farm characteristics, application of external inputs in agriculture, and access to market and information. Emphasis was laid on eliciting detailed information on the status of varieties: growing environment, area coverage, productivity, preferred and unpreferred traits, religious and cultural values, if any, of each variety.

Table 1. Characteristic features of study sites in Nepal.

Variables	Unit	Begnas	Kachorwa
Elevation (range)	Metres asl	668–1206	58–100
Annual rainfall	mm/year	3979	1515
Mean annual temperature	°C	20.9	24.6
Market access	Poor/Good	Poor	Good
Research and extension intervention	Low/High	Low	High
Total number of households	Number	941	914
Sampled households	Number	206	202
Mean family size	Person/HH	6.5±0.2	6.5±0.2
Agriculture as principal livelihood option	Percentage of HHs	70	97
Mean agricultural land area	Hectare/HH	0.7±0.1 (196)†	0.8±0.1 (188)

† Figures in parenthesis indicate number of responding households.

[1] Wealth category of households was derived through a wealth-ranking exercise conducted using mutually agreed criteria amongst the key informants (knowledgeable men and women numbering not more than 8–10) selected from within the village. A card-sorting method was used for the wealth-ranking exercise in both study sites to categorize all households into three different categories, namely 'resource rich', 'resource medium' and 'resource poor'. Food self-sufficiency (number of months) of household from owned land was the major criterion used in the exercise along with other criteria such as off-farm income, land in town area, etc.

The survey was carried out in January/February 1999. Local enumerators were hired to administer the questionnaires in both study sites. Orientation of the study objectives, discussion on survey questions and their role as enumerators were explained to them prior to the survey. A pre-test of 20 questionnaires was done in two villages adjacent to the study sites. The final questionnaire incorporated feedback from the pre-test. Data were collected in face-to-face interviews with farmers. The completed questionnaire passed through three steps of checking: first, by the interviewer; second, by a peer; and third, by the researcher, followed by numeric coding, conversion of measurements from local to standard metric units, and computer data entry of questionnaires.

For data analysis, SPSS and MINITAB software were used. Simple descriptive statistics such as mean, standard error of mean, maximum and minimum values were generated for comparison for different socioeconomic categories. One-way ANOVA was performed for 'interval variables' such as number of varieties and area coverage to compare across wealth categories, gender and study sites. Multiple regression analysis was performed to understand the relative contribution of different socioeconomic factors in maintaining household on-farm rice varietal diversity.

Results

Socioeconomic factors and varietal diversity at household level across study sites

Three sets of multiple regression analyses were performed taking number of varieties, number of landraces, and number of modern varieties (MVs) maintained per household as dependent variables against 26 independent variables pertaining to individual, household and farm characteristics. Only those independent variables which have a significant role in explaining the variation in dependent variables in the regression equations are presented for discussion.

The datasets for Begnas and Kachorwa ecosites were combined to run the analysis. The following codes were assigned for the responses for 'categorical' variables: chemical fertilizer, use 1 'yes' and 2 'no'; farmer group membership 1 'yes' and 2 'no'; gender of household head 1 'male' and 2 'female'; site 1 'Begnas' and 2 'Kachorwa'; access to irrigation 1 'yes' 2 'no', and use of insecticide 1 'yes' and 2 'no'. For continuous variables the values have been converted to standard metric units (e.g. land area in hectare) and used directly in the regression equations. The outputs from the regression analyses (t -value and significance of t -value) are presented in Table 2.

Table 2. Socioeconomic factors and varietal diversity at household level in study sites.

Independent variable	Total varieties		Total landraces		Total MVs	
	t-val.	Sig t	t-val.	Sig t	t-val.	Sig t
Area under landraces	12.59	0.000	–	–	–	–
Total parcel of land	6.82	0.000	6.52	0.000	4.55	0.000
HH food sufficiency	3.44	0.001	2.71	0.007	3.83	0.000
Total livestock number	4.28	0.000	6.16	0.000	0.57	0.571
Number of ecosystems	3.87	0.000	2.59	0.009	3.33	0.001
Chemical fertilizer use	–2.49	0.013	–3.31	0.001	–2.65	0.008
Total land area	–4.00	0.000	–3.17	0.002	–4.53	0.000
Total rice area	2.92	0.004	4.27	0.000	9.03	0.000
Membership of group	1.24	0.218	2.89	0.004	–5.44	0.000
Number of MVs	–	–	–5.50	0.000	–	–
Sex of HH head	–1.26	0.208	–2.59	0.010	–0.72	0.469
Agroecology of study	–1.17	0.241	–2.70	0.007	–0.48	0.629
Irrigation facility	–0.34	0.731	1.37	0.173	–2.56	0.011
Number of landraces	–	–	–	–	–5.13	0.000
Use of insecticide	–0.02	0.987	0.42	0.672	–2.65	0.008

Multiple regression outputs indicated that out of 26 different variables, 15 have statistically significant influence on the amount of varietal diversity maintained at household level. The multiple regression correlation coefficient, R^2, the measure of variability explained in dependent by independent variables, for varietal diversity, landraces diversity and MVs diversity were 0.668, 0.555 and 0.654 respectively. The results suggest that independent variables were better able to explain the variation in varietal diversity and MVs diversity than landraces diversity. Varietal diversity in the study sites was attributed to eight variables, of which seven had direct and positive relationships whereas one had an inverse relationship (Table 2). Variables with a direct relationship to total number of varieties at household level included: area under landraces, number of parcels of land, food sufficiency at household level, number of livestock, number of ecosystems, amount of rice land, and use of chemical fertilizer. The only variable having an inverse relationship with the number of varieties was the total land area.

Landraces diversity at household level was influenced by 11 different socioeconomic factors (Table 2). Of those, nine have direct and positive relationship whereas two have inverse effect. Seven variables from the previous equation also proved significant for explaining landrace diversity and the new ones included were: membership of farmers' group, number of MVs farmer maintained, gender of household head, and agroecology (site). The number of MVs had strong but negative relationship with number of landraces maintained at household level. Individuals with no affiliation to membership in farmers' groups maintained higher number of landrace diversity than otherwise. Male household heads maintained higher number of landraces per household than their female counterparts. Finally, the mid-hill ecosite (Begnas), with less intervention from formal research and development agencies and limited market integration harboured significantly higher landrace diversity than the plain ecosite (Kachorwa), which is characterized by high intervention from the formal research and extension system, and good market integration.

The third multiple regression model tested the relationship between number of MVs at household level and socioeconomic parameters. Out of ten different socioeconomic variables, six were common with the first model (varietal diversity). The other four variables with significant relationship were group membership, access to irrigation facility, number of landraces, and use of insect pest control measures. Farmers tend to cultivate MVs under assured irrigation hence access to irrigation and MVs were positively associated. Similarly, farmers in Kachorwa applied chemicals to control disease and insect pests predominantly in MVs as compared to landraces. Application of chemicals to control disease and insect pests in Begnas is not common at all. Understandably, the number of MVs maintained by households had an inverse relationship with the number of landraces maintained in addition to the total land area. Membership in farmers' groups means greater access to MVs as government research and extension systems invariably promote MVs only, which explains why membership was positively associated with higher number of MVs at household level.

Varietal diversity by gender and wealth category

We looked at on-farm diversity on the basis of varietal richness (measured by number of landraces and MVs) maintained at household and community levels. Of the 206 and 202 sampled households in Begnas and Kachorwa, respectively, 84.5% and 97.5% cultivated rice. Begnas and Kachorwa have 56 and 48 varieties under cultivation, respectively. Out of 56 varieties in Begnas, 91% are landraces and the rest are MVs, whereas in Kachorwa the figure is 60%. On average, farmers in Begnas maintained five varieties whereas at Kachorwa it was three. The difference in average number of landraces maintained at household level between study sites was statistically significant ($P<0.001$). Likewise, the difference in number of MVs farmers cultivated at Begnas and Kachorwa was statistically significant ($P<0.001$).

In Begnas, the mean number of varieties cultivated by resource-rich, medium and poor households were 5.7±0.5, 3.6±0.3 and 2.8±0.3 respectively (Table 3), and the difference was statistically significant (P<0.001). For landraces, the difference in number cultivated across wealth categories was statistically significant (P<0.01) with resource-rich maintaining more than resource-medium and resource-poor households. Similarly, the difference in number of MVs maintained across wealth strata was statistically significant (P<0.05). At Kachorwa, the number of varieties maintained by resource-rich and resource-medium households proved to be highly significantly (P<0.001) greater than the number maintained by resource-poor households. There was, however, no statistically significant (P=0.113) difference in the number of landraces cultivated amongst resource-rich, resource-medium and resource-poor households.

Analysis of gender role in management of varietal diversity revealed a general tendency for male decision-makers to maintain higher varietal diversity on-farm compared with female decision-makers in both study sites (Table 4). In Begnas, the larger number of landraces rather than MVs maintained explained the difference in gender role. However, in Kachorwa, female decision-makers generally maintained a lower number of both landraces and MVs than their male counterparts. In both the cases, the difference was statistically non-significant.

Table 3. Mean number of varieties across wealth categories for study sites.

Particulars	Begnas			Kachorwa		
	Rich	Medium	Poor	Rich	Medium	Poor
Average number of varieties/HH	5.7±0.5 (67)†	3.6±0.3 (67)	2.8±0.3 (39)	4.0±0.4 (21)	3.5±0.2 (73)	1.9±0.1 (103)
Average number of landraces/HH	4.7±0.4 (67)	3.2±0.2 (62)	2.9±0.3 (32)	2.0±0.4 (13)	1.8±0.3 (43)	1.2±0.2 (29)
Average number of MVs/HH	1.6±0.1 (42)	1.3±0.1 (33)	1.1±0.1 (15)	2.7±0.2 (21)	2.6±0.1 (69)	1.7±0.1 (94)

† Figures in parenthesis indicates number of responding households.

Table 4. Gender of respondent and varietal diversity on-farm across study sites

Particulars	Begnas		Kachorwa	
	Male	Female	Male	Female
Average number of varieties/HH	4.9±0.5 (74)†	3.8±0.2 (99)	2.8±0.1 (169)	2.0±0.2 (28)
Average number of landraces/HH	4.3±0.4 (70)	3.4±0.2 (91)	1.7±0.2 (74)	1.1±0.1 (11)
Average number of MVs/HH	1.4±0.1 (39)	1.4±0.1 (51)	2.2±0.1 (158)	1.7±0.2 (26)

† Figures in parenthesis indicates number of responding households.

Another aspect of diversity analysis at household level was to look at the number of households growing 1, 2, 3 or more varieties across wealth groups for the study sites. In Begnas, 3% of households in resource-rich category cultivated only one variety, whereas the figures for resource-medium and resource-poor households were 19% and 30% respectively (Figure 1). The highest number of varieties maintained at household level was 22 by a woman decision-maker belonging to resource-rich category. In Kachorwa, no household from the resource-rich category relied on a single variety, whereas 14% and 45% of households from resource-medium and resource-poor categories, respectively, depended on a single variety of rice. Conversely, the number of resource-rich households cultivating more than five varieties was 19%; the figure for resource-medium households was 14% and for resource-poor households only 2% (Figure 2).

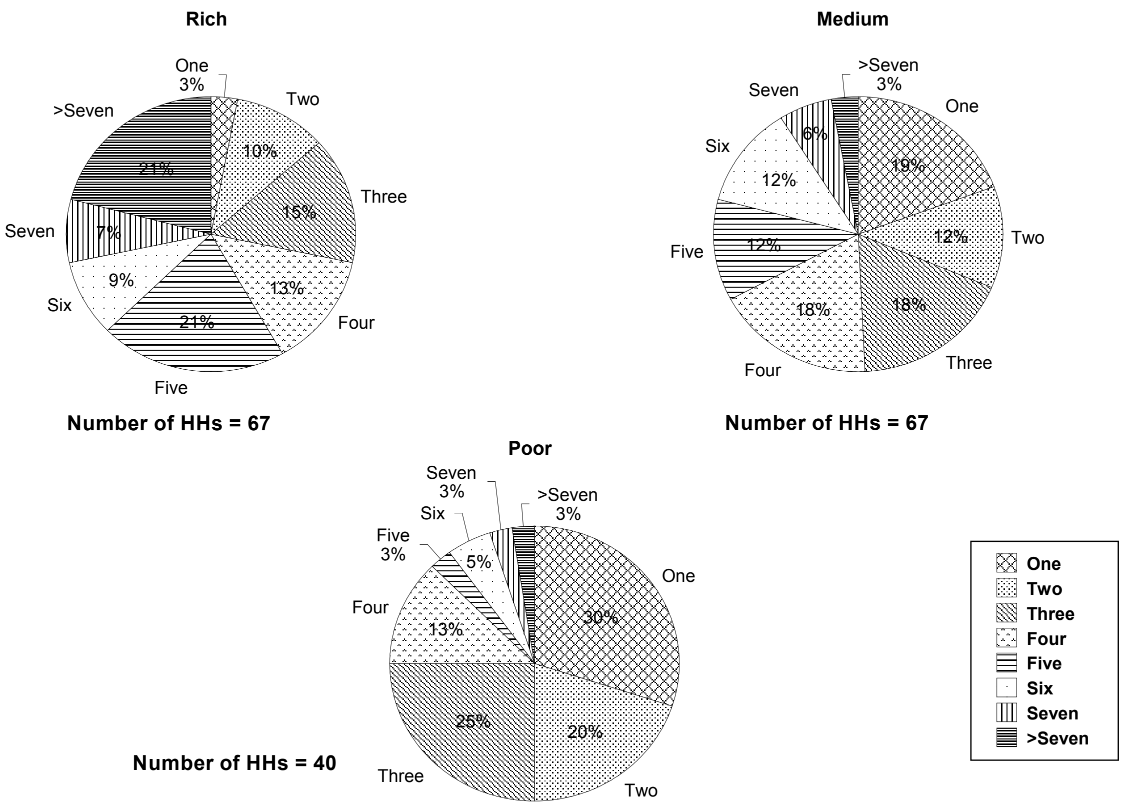

Figure 1. Number of varieties at household level across wealth categories at Begnas.

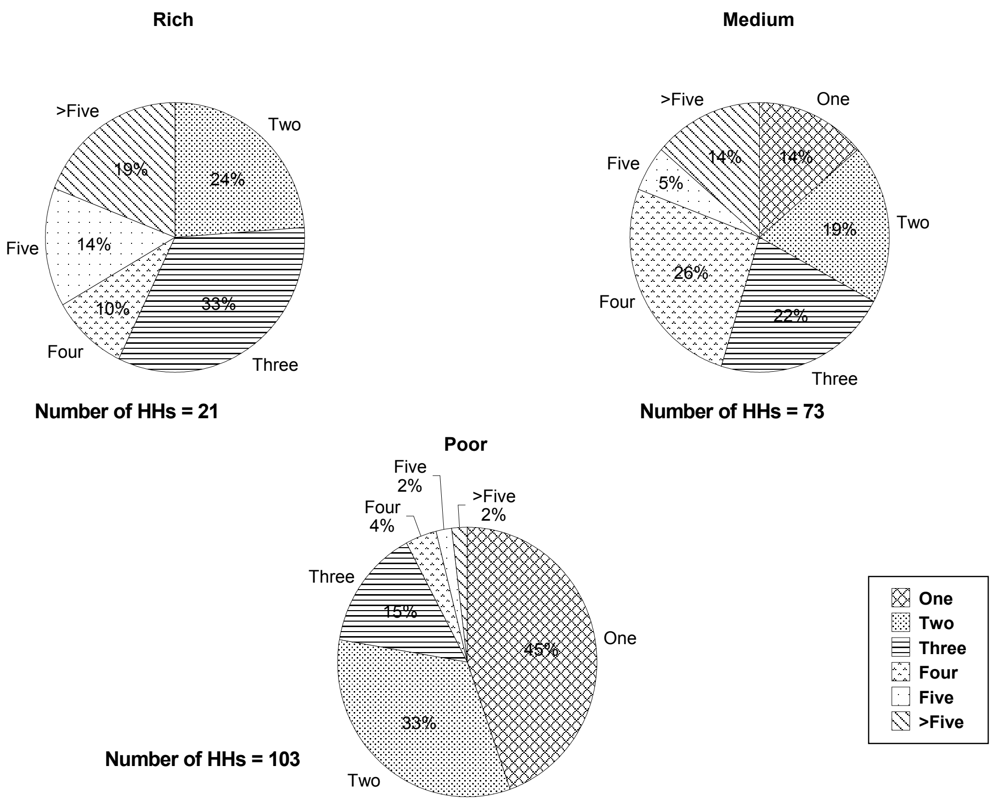

Figure 2. Number of varieties at household level across wealth categories at Kachorwa.

An important aspect of varietal diversity, in the context of discussion of how to maintain it *in situ* is to look at the maintenance of 'vulnerable' rice varieties which are seen as under threat of genetic erosion from the community. For the purpose of this study, these were defined as varieties maintained by few (5 or <5) households in a given community. Out of 56 varieties in Begnas, 35 landraces (63%) were each grown by 5 or <5 households (Table 5). Varieties grown by a limited number of households in a community have a higher risk of being lost or 'eroded' from the farming systems than ones grown by many households in larger areas. It was important to note that 34% of varieties were each grown by a single household. Of those 19 varieties, 84% were cultivated by households from the resource-rich category, 11% by resource-medium and 5% by resource-poor households. In total, 67 households maintained vulnerable landraces that faced imminent risk of erosion. Of these 67, 70% were from resource-rich, 26% from resource-medium and only 4% from resource-poor households. The output clearly indicated that resource-rich households played a dominant role in conservation of vulnerable rice landraces.

Table 5. Vulnerable rice varietal diversity situation at Begnas and Kachorwa.

Begnas			Kachorwa		
No. of varieties	**HHs maintaining no. of varieties**	**Total HHs (no.)**	**No. of varieties**	**HHs maintaining no. of varieties**	**Total HHs (no.)**
19	1	19	19	1	19
7	2	14	6	2	12
4	3	12	6	3	18
3	4	12	1	4	4
2	5	10	1	5	5
Total = 35	–	67	Total = 33	–	58

Results obtained from Kachorwa suggested that, out of 48 varieties, 69% were each cultivated by 5 or <5 households. As a matter of concern, 19 (40%) varieties were maintained by a single household each. Of those 19 varieties, 53% were maintained by resource-medium households, whereas resource-rich and resource-poor households cultivated 21% and 26% varieties respectively. Resource-medium households definitely contributed most in conservation of vulnerable varieties. In Kachorwa, 58 households maintained 33 varieties, mostly landraces, which were threatened with erosion from the site. Of 58 households, 57% were from resource-medium, 26% resource-poor and 17% resource-rich categories.

Analysis of gender role in conservation of vulnerable varieties across ecosites suggests that males predominate in conservation of vulnerable varieties. In Begnas, of the households contributing to conservation of vulnerable varieties, 39% have women as decision-maker and the rest are men decision-maker households. On the other hand, in Kachorwa women decision-maker households contribute only 9% in maintenance of vulnerable varieties and men decision-maker households account for the rest. In Kachorwa, 19 varieties were cultivated by a single household, but not a single women decision-maker maintained such varieties. In Begnas, of 19 varieties maintained each by single household, 26% are maintained by women decision-maker households.

Table 6. Vulnerable rice varieties and gender of decision-makers across study sites.

HHs maintaining no. of varieties	Begnas		Kachorwa	
	Male	**Female**	**Male**	**Female**
One	14 (74)[†]	5 (26)	19 (100)	0
Two	8 (57)	6 (43)	9 (75)	3 (25)
Three	6 (50)	6 (50)	17 (94)	1 (6)
Four	5 (36)	7 (64)	4 (100)	0
Five	8 (80)	2 (20)	4 (80)	1 (20)
Total	41 (61)	26 (39)	53 (91)	5 (9)

[†] Figures in parenthesis indicates row percentages from within-site data.

Area and productivity of landraces and modern varieties

Another important dimension of diversity analysis is to analyze the area under different landraces and MVs at household and community levels in study sites. Along with area under landraces and MVs, information on productivity is also presented for both sites (Table 7). Subsequently, figures for area have been disaggregated by wealth category across sites (Table 8).

Table 7. Mean area covered by and productivity of rice types across study sites.

Particulars	Begnas			Kachorwa		
	Overall area†	Mean area	Productivity‡	Overall area	Mean area	Productivity
All varieties	79.4 (173)	0.46±0.03	2.24±0.1	156.6 (197)	0.82±0.06	2.25±0.1
Landraces	58.1 (161)	0.36±0.02	2.06±0.1	25.1 (85)	0.30±0.03	2.19±0.1
MVs	21.3 (90)	0.24±0.02	2.91±0.1	131.5 (184)	0.71±0.05	2.36±0.1

† Area presented in hectares.
‡ Productivity been presented in t/ha.

Table 8. Mean area of rice types by wealth categories at study sites.

Particulars	Begnas (area in ha)			Kachorwa (area in ha)		
	Rich	Medium	Poor	Rich	Medium	Poor
All rice varieties	0.62±.05 (67)†	0.39±.03 (67)	0.33±.04 (39)	2.27±.25 (21)	1.0±.07 (73)	0.39±.04 (103)
Landraces	0.43±.04 (67)	0.30±.03 (62)	0.32±.04 (32)	0.48±.12 (13)	0.32±.03 (45)	0.19±.02 (29)
MVs	0.30±.04 (42)	0.23±.03 (33)	0.16±.03 (15)	1.94±.22 (21)	0.80±.06 (69)	0.36±.03 (94)

† Figures in parenthesis indicate responding households.

Relative area coverage of landraces and MVs across study sites revealed that landraces in Begnas covered 73% of the area under rice, whereas in Kachorwa the figure was only 16%. Comparison of the mean area under rice at household level across sites indicated that farmers in Begnas cultivated 0.46±0.03 ha, which was only 56% of the area (0.82±0.06 ha) allocated by farmers at Kachorwa. The difference in area allocated to rice across sites was statistically significant ($P<0.001$). Farmers in Kachorwa, representing plain condition, cultivated larger area than those in Begnas (mid-hills). But when we analyzed the mean area under landraces across sites the result indicated that difference in area under landraces was statistically non-significant ($P=0.06$). On the other hand, the mean area under MVs between sites was significant ($P<0.001$), and farmers in Kachorwa allocated almost three times the area allocated by farmers in Begnas. The productivity figures for rice in study sites were 2.24 t/ha and 2.25 t/ha for Begnas and Kachorwa, respectively.

Difference in mean area under rice for different wealth categories indicated that the resource-rich households cultivated significantly ($P<0.05$) higher area than the other two categories in Begnas (Table 8). Resource-rich households cultivated almost twice the area under rice than resource-poor households. The difference was more striking in the case of area under MVs rather than landraces. Comparison across wealth categories indicated that resource-medium and resource-poor were more similar while allocating area for different types of rice, and resource-rich households were most dissimilar. The findings in Kachorwa were similar, but the difference in area allocated by households in different wealth categories demonstrated a higher degree of disparity between resource-medium and resource-poor households than between resource-rich and resource-medium categories. The area allocated to different rice types and the wealth category showed a statistically significant ($P<0.001$)

association. Comparative analysis of area under MVs and landraces at household level indicated that it was only in favourable environments that farmers allocated a higher proportion of their rice field to MVs. This situation was found consistent across wealth categories although the proportion of area between landraces and MVs increased when one moved from resource-endowed (25%) category to resource-poor (52%) category.

Characteristic of households that maintain landraces and MVs diversity on-farm

Farmers cultivate diversity of varieties on-farm to meet varied household needs. At household level farmers usually grow both landraces and MVs, where the growing environments are either favourable or moderately favourable in terms of abiotic and biotic factors. We first look at the coexistence of landraces and MVs in the study sites. Next, we analyze the characteristics of households who maintain only landraces, only MVs and those who maintain both landraces and MVs on-farm (Table 9).

Coexistence of landraces and MVs at household level was a common feature at both sites. Of 173 rice-growing households in Begnas, 48% relied on landraces only, whereas just 7% depended on MVs only for their rice cultivation, and a sizeable proportion of households (45%) maintained both landraces and MVs on-farm. The situation in Kachorwa was the reverse with the majority (57%) of respondents, of 197 rice-growing households, cultivating only MVs while 7% of the respondents depended on landraces only. Here too, a considerable number of households (37%) maintained both landraces and MVs on-farm. In terms of area allocation, households growing both landraces and MVs allocated the most area under rice, which was consistent across sites.

Table 9. Characteristic features of households cultivating different combinations of landraces and modern varieties in Begnas and Kachorwa.

Parameters	Begnas			Kachorwa		
	Landraces	MVs	Both	Landraces	MVs	Both
Mean food sufficiency from own prod. (mo)	7.2±0.4	5.4±1.0	10.8±0.3	4.0±0.7	6.5±0.3	7.4±0.3
Wealth category (R=Rich, M=Medium, P=Poor households)	R=25 M=35 P=24	R=0 M=5 P=7	R=42 M=27 P=8	R=0 M=4 P=9	R=8 M=30 P=74	R=13 M=39 P=20
Gender decision-maker (M=male, F=female)	M=35 F=49	M=4 F=8	M=35 F=42	M=11 F=2	M=95 F=17	M=63 F=9
Age of decision-maker (yr)	47±1.4	40.6±3.9	45.4±1.6	54.5±4.8	45.8±1.5	48.4±1.9
Education status (I=Illiterate, P=Primary, S=Secondary, C=College)	I=38 P=19 S=19 C=8	I=8 P=1 S=3 C=0	I=24 P=23 S=18 C=12	I=11 P=2 S=0 C=0	I=66 P=23 S=16 C=7	I=38 P=17 S=11 C=6
Land holding (ha)	0.7±0.1	0.3±0.0	0.9±0.1	0.4±0.1	0.6±0.1	1.2±0.1
Rice area (ha)	0.4±0.0	0.2±0.0	0.6±0.0	0.3±0.1	0.5±0.1	1.0±0.1
Rice area parcels (number)	3.3±0.5	1.6±0.2	4.5±0.4	2.3±0.5	3.0±0.2	5.1±0.4
Mean landrace area (ha)	0.4±0.0	–	0.4±0.0	0.3±0.1	–	0.3±0.0
Mean MVs area (ha)	–	0.2±0.0	0.2±0.0	-	0.6±0.1	1.0±0.1
Livestock (number)	3.3±0.2	2.1±0.3	4.2±0.3	1.6±0.2	2.0±0.1	2.3±0.2
Irrigation (Yes/No)	Yes =6 No =78	Yes =5 No =7	Yes =22 No =55	Yes =6 No =7	Yes =70 No =42	Yes =52 No =20
Chemical fertilizer use (Yes/No)	Yes =51 No =33	Yes =9 No =3	Yes =57 No =20	Yes =13 No =0	Yes =112 No =0	Yes =72 No =0

Households who maintain both landraces and MVs tend to be more food secure than households who maintain landraces only or MVs only, and the result was consistent across ecosites. The majority of resource-rich households in Begnas (63%) and Kachorwa (62%) maintained both landraces and MVs on-farm. In Begnas not a single resource-rich household depended solely on MV for rice cultivation. In Kachorwa no single household from the resource-rich category depended on landraces only. From other resource categories there were a number of households who depended on either landraces only or MVs only for rice cultivation in both the study sites. Cultivation of landraces was associated with the oldest age group and MVs with the youngest, while the intermediate age group tended to maintain both landraces and MVs on-farm. Educational status and gender of the decision-maker did not point to specific preference for either landraces or MVs or both at household level. Households with large land holdings are more likely to maintain both landraces and MVs on-farm. They also have larger rice land with more parcels compared with those households who grow landraces or MVs only. These households maintained a larger number of livestock than other households. But access to irrigation was more closely associated with cultivation of MVs in both study sites, and this finding matched with the multiple regression results.

Sociocultural use value of landraces

Rice varieties have socioeconomic and cultural (food security, market, religious and cultural uses) and adaptive (abiotic and biotic) traits that jointly represent the 'use value' of a variety, which determines the maintenance of these varieties on-farm. However, we will only deal with sociocultural use value of landraces in this section because of the focus of the paper.

Not many landraces are included in this category, and certainly not the MVs because MVs are considered 'impure' for sociocultural and religious ceremonies. Landraces falling in this category are grown by many households but in small areas. In Begnas, a total of six (11%) different landraces fall in this category. If we combine *Rato Anadi* and *Seto Anadi* and consider them as one group, then *Anadi* is the most widely grown landrace in the area but is grown in a very small area (0.02 ha/HH). *Anadi* is the only glutinous rice found in Nepal and is used for making local recipes such as *Latte*[2], *Khatte*[3] and *Siraula*[4]. Farmers believe it possesses some medicinal values as well. *Aanga* is specifically grown in most marginal environments and considered to have medicinal value. In Kachorwa as well there is no MV in 'sociocultural use' category and the number of landraces is only four (*Basmati, Sathi, Lajhi* and *Khera*). *Sathi* rice is a must in *Chath* festival, celebrated in plain southern belts of the country, for making offerings to *Chathi Maiya* (Hindu goddess), and preparing a variety of sweets and dishes during the festival. Relatively more households cultivate *Sathi* than other landraces except Basmati.

Some landraces such as *Jethobudho, Pahele, Basmati, Bayarni* and *Ramani* are aromatic fine type rice, which command a premium price in local and national markets. Therefore, many households grow them in relatively large areas, especially the former three landraces, for selling in the market. These landraces are valued for their good eating quality (soft and aromatic when cooked) and their consumption is associated with social prestige in the community. Better-off households consume one of these landraces on a regular basis whereas poor households consume them on special occasions and offer them to guests in the house.

2 *Latte* is prepared by soaking rice (de-husked) for about 12–24 hours then cooking it in ghee or oil and adding sugar while continuously stirring. Unlike normal cooking of rice, no water is added while cooking *Latte*. It is mainly consumed during '*Saune Sakranti*', a festival celebrated in the month of July, and '*Pandra Poush*', a festival celebrated in December (Rana *et al*. 2000).

3 *Khatte* is prepared by light soaking of rice (de-husked) in water then roasting, and is consumed as snacks.

4 *Siraula* is prepared by soaking husked rice then roasting until they are popped, which is left to cool followed by de-husking either by huller or paddle pounder. *Siraula* is consumed as snacks mixed with milk to add taste.

Consumption of these landraces is associated with social prestige so resource-endowed households grow them for home consumption as well as for selling them in the market.

Discussion

Socioeconomic factors and varietal diversity at household level

Farmers' management of varietal diversity on-farm is very much influenced by a complex combination of sociocultural, economic and environmental factors. The regression models successfully identified a number of factors that explained the differential number of landraces and MVs and total varieties maintained at household level. On the other hand, some socioeconomic factors were useful specifically in explaining the variation of either landraces or MVs across households. The finding is in line with our hypothesis that varietal diversity was influenced by different socioeconomic variables. Bellon (2004) reported that there are several factors that modify the demand for crop diversity. Among the socioeconomic variables, total parcels of land influenced most the landrace diversity on-farm, which agreed with the earlier finding by Brush (1995). The underlying reason is that fragmented land holdings are scattered in different ecosystems, which means different varieties are required for different ecosystems, thereby increasing the number of varieties on-farm. Number of ecosystems also has a positive influence on varietal diversity on-farm for the same reason. Total livestock number has a positive relationship with cultivation of landraces but not with MVs on-farm because of the increased amount of straw available from the former at different times, due to tall plant height and varying maturity period of landraces, for livestock feed.

Number of landraces and MVs at household level is positively associated with amount of rice field, though the association is much stronger with MVs because there are landraces which could be grown in upland condition as well, whereas MVs lack this adaptation. However, landraces and MVs diversity on-farm have a negative relationship with the amount of total land because increase in upland means growing of other crop such as maize rather than upland rice. Access to irrigation facility has influence on number of MVs but not on number of landraces on-farm because farmers deploy MVs in irrigated plots where they perform better than landraces. Likewise, the application of chemical means of controlling insect pests has a positive association with number of MVs but not with landraces. This is because farmers use control measures primarily for MVs, and farmers reported abuse of chemicals in Kachorwa during group discussion, which was later verified by field observations. The main reason cited when asked why they were using the chemicals excessively was that other farmers were doing so, and if they do not use them all the insects would come to their plots and destroy the crop.

Number of landraces maintained at household level was influenced by agroecology of study sites and gender of household head. Contrary to the findings of Prain and Piniero (1994) and Sperling and Loevinsohn (1993), which suggested women played a more important role in agrobiodiversity management on-farm, the present study indicated that male household heads maintained more varietal diversity than their female counterparts. Cromwell and van Oosterhout (2000) did not find any relationship between the sex of the decision-maker in household and crop and varietal diversity. One of the explanations for women-headed households having fewer numbers of varieties on-farm is that they come to assume the position of household head in Nepalese patriarchal society only when senior male members in the family are absent either owing to death or to out-migration for off-farm employment. In such circumstances, a female assumes the position of household head and she lacks the household labour to perform 'male-oriented' agricultural activities such as ploughing and field preparation for transplanting on time, thereby restricting her capacity to manage a large number of varieties. Furthermore, such households tend to share-out their land, again limiting the number of varieties maintained on-farm. All these findings suggest that gender role in agrobiodiversity management is rather contextual and very much influenced by sociocultural norms and values of the society. The measures of on-farm diversity used in different studies may not be exactly comparable, which could be one of the sources of discrepancy. Maintenance of diversity has been associated with old age (Valderrama and Vega 2000) but in the present study no significant association was detected.

Whether one is a member in a farmers' group has a negative influence on landrace conservation but a positive influence on number of MVs maintained on-farm. This is understandable because the government extension system provides its services through a group approach and the government promotes only MVs, not landraces. Thus, membership in groups provides wider access to genetic materials for the local community (Wood and Lenne 1997; Odero 1998). In fact, membership in groups or farmers' access to extension services promotes introduction of new diversity within the system. Variables such as respondents' education status and age did not make much difference in maintenance of varietal diversity on-farm, which agreed with previous findings by Cromwell and van Oosterhout (2000).

Role of wealth category and gender in varietal diversity at household level

Owing to practical difficulties in the field, the measurement of socioeconomic variables and relating them to household diversity is easier said than done. Therefore, the focus has been on applying the 'user friendly' rapid but fairly accurate technique of 'wealth ranking' that more or less captures socioeconomic variability. Studies from elsewhere have shown that wealth ranking can be used to stratify households in communities, and across-communities comparison is possible provided similar criteria are used in the categorization process (Turton *et al*. 1997; Franzel *et al*. 2003). A study by Adams *et al.* (1997) analyzed the construct validity, empirical validity and external validity of wealth ranking and concluded that the technique satisfied the requirement in all three criteria. Reddy (1997) compared wealth ranking with income analysis from standard survey methods and concluded the validity of the technique, and further added that in dominantly agricultural communities, as in our study, the inferences did not differ much between these two approaches.

Hence, wealth category was consistently used to observe how robust the technique was in discerning between 'diversity-rich' and other households. From the results it is apparent that we can use wealth categories for our purpose in the field. The number of varieties maintained at household level significantly varied among wealth categories, with resource-rich and resource-medium maintaining higher numbers of landraces. Resource-rich households can afford to maintain higher varietal diversity and do so, which is the reflection of their stronger livelihood status and social status (Negash and Niehof 2004). The absolute area under landraces is higher in the case of resource-rich households. Yet, the proportion of total rice area allotted for landraces was higher for resource-poor households, which agreed with the findings by Cromwell and van Oosterhout (2000).

Resource-poor households did not play a big role in maintaining varieties under the most threat of varietal loss on-farm. In fact, in most cases whatever landraces they cultivated were duplicates of what resource-endowed households already grew. Thus, the empirical evidence from the field fails to support the general perception held by researchers that the farms of the resource-poor might harbour unique diversity. Particularly for maintenance of vulnerable landraces, the role of resource-endowed households cannot be overlooked under any circumstances. Hence, the hypothesis of the study that resource-endowed households maintain higher landrace diversity holds true across sites. Unless conservation programmes at grassroots level take on board and involve resource-endowed households in conservation initiatives, the effort might be less rewarding.

The empirical data failed to support our hypothesis that women decision-makers maintain higher landrace diversity than men. There was a tendency across sites for women decision-makers to maintain fewer varieties than men, although the difference was statistically not significant. Women-headed households maintained significantly fewer landraces than men-headed households. Another aspect was to look into the role women-headed households played in conserving vulnerable varieties. Here too, women-headed households did not play a significant role in conservation of varieties that were on the verge of extinction. The role of women decision-maker households in conserving vulnerable landraces was rather limited in Kachorwa (9%), whereas in Begnas the situation was better with 39% contribution.

Coexistence of landraces and MVs at household level

Brush (1995) observed from case studies on potato (Peru), maize (Mexico) and wheat (Turkey) that landraces were grown side by side with MVs in subsistence as well as commercial production systems. Hugo *et al.* (2003) noted that for maize in Mexico the landraces persist because of their good agronomic performance in the field as well as the fact that they are highly valued by farmers for postharvest end-use qualities. Montecinos and Altieri (1992) noted that farmers blend the management of landraces and MVs without making any distinction between them. This evidence suggests that coexistence of landraces and MVs is not a rare phenomenon; rather, farmers incorporate new MVs in their varietal repertoire. While doing so, the resource-rich households by virtue of their position are most likely to maintain a combination of landraces and MVs on-farm than farmers from other wealth groups. However, we need to monitor the varietal diversity over time and space to establish that coexistence of landraces and MVs is a stable system rather than a transition process to adopting MVs.

Sociocultural use values and diversity of landraces on-farm

Owing to farmers' varied needs no single variety could satisfy all the requirements; as a result, multiple varieties are maintained on-farm to address different needs (Bellon 1996; IPGRI 2004). Farmers' decisions on choice of varieties to cultivate are primarily governed by their intended uses to support livelihood and food security (Campilan 2002). Some landraces have cultural and religious use value; thus conservation of agrobiodiversity is closely intertwined with the conservation of indigenous culture (Gonzales 2000). The main characteristic features of culturally important landraces are they are few in number but many households cultivate them in small areas. Because of their important role in religious and cultural ceremonies many households tend to grow them rather than to ask for grains from neighbours. Certain varieties contained 3–4 mg more iron and zinc than the average value and protein range (4.5–15.9%) which are often valued by farmers as medicinal and nutritional values (Kennedy and Burlingame 2003). These landraces have fair chances of survival on-farm so long as local culture thrives (Rana 2004) in the community or efforts are made to market information on nutritive and medicinal values. Increasing the market demand through urban consumers for these culturally important landraces would perhaps be an incentive for farmers to cultivate these landraces in larger areas and contribute to household income.

Studies from elsewhere (Unnevehr *et al*. 1992; Pingali *et al*. 1997) have indicated that despite the pressure of economic change and commercialization, some quality rice landraces not only survived but also thrived due to increased market demand. In the present context, we can expect that farmers would be interested in continuing to grow aromatic fine type rice landraces in the study sites because of favourable market price. On-farm conservation of these landraces would largely depend on market dynamics: demand, supply and price in local and national markets.

Conclusion

Various socioeconomic and environmental factors contributed in explaining the types of rice varieties maintained on-farm. Certain socioeconomic variables were applicable in explaining the variability in all types of rice whereas others were specific to explain the variation in number of either landraces or MVs across households. Among the socioeconomic variables, total parcels of land and total livestock number per household contributed the most in explaining the variation in number of landraces per household. Number of ecosystems, food sufficiency of households, total rice land, membership in groups, sex of HH head and agroecology of study sites are some of the socioeconomic and environmental variables that explained the variation in number of landraces maintained at household level.

Resource-rich households maintained higher levels of varietal diversity than the two other categories of farming households. This is in agreement with the hypothesis proposed at the onset of the study. Resource-endowed households also played a crucial role in conservation of 'vulnerable' landraces on-farm. In gender aspects, the study could not conclude that women decision-makers maintained higher landrace diversity on-farm than their male counterparts. Rather, the study suggested that men decision-makers seemed to maintain higher landraces diversity on-farm than women decision-makers. The gender role in agrobiodiversity conservation seems to be highly contextual.

The study revealed that socioculturally important landraces are very few in both the study sites. It was also true that a relatively larger number of households grew them but in very small areas, mainly to meet their own purpose. High-quality aromatic rice landraces contribute significantly to household economy and their consumption is associated with social prestige. These two categories of landraces could be conserved on-farm provided demand for these landraces from the urban consumers increases through consumer awareness and market-promotion activities. It needs to be emphasized that any effort to conserve and enrich agrobiodiversity has to consider the cultural diversity and social dimensions of prevailing communities.

While the incentives for farmers to maintain several landraces in Begnas ecosite exists, it is less so in the Kachorwa ecosite. Even in Begnas, with the formal system developing new MVs suitable for mid-hill conditions, there is no guarantee that farmers will remain interested in maintaining landrace diversity on-farm. With farmers' aspiration for economic and social change these landraces have to be made more competitive through technical and/or market promotion means so that they contribute to household income. Therefore, it is important to explore policy options and/or technical interventions that might support them.

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On-farm conservation of crop genetic diversity: examining farmers' and breeders' choice of rice varieties in Nepal

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Abstract
On-farm diversity is the outcome of farmers' choices to select, modify and maintain diversity. Plant breeders also influence diversity by influencing farmers' choices through the supply of new genetic materials and by making them available to farmers. This study aims to link variety choices of farmers' and plant breeders by combining revealed preferences of farmers and stated preferences of plant breeders. A household decision-making model is conceptualized using microeconomic theory and is then tested econometrically to relate farmers' preferences with that of plant breeders, which may be influenced by public investments and policies. Efforts are made to identify landraces of interest to both farmers (private value) and society (public value) including key factors determining maintenance of these landraces. The findings show that the cultivation of landraces of high private value as revealed by farmers' perception and those of high social (public) value identified according to breeders' criteria of diversity, rarity and adaptability are high in the hill ecosite of Kaski. The factors that are significant in determining diversity on-farm are livestock assets, subsistence ratio, land types, literacy level of consumption decision-makers, percent-irrigated land, external income and landraces sold. The statistical signs and the direction of effects are consistent in explaining genetic materials targeted for conservation, although the magnitude of effect differs. Households with more active adults engaged in agriculture and those with more heterogeneous farms and isolated from markets are more likely to maintain socially valued landraces. Finally, issues are raised on the development goals, incentives and equity implications of the findings for designing a least-cost sustainable on-farm conservation strategy.
Key words: Breeders' criteria, policy trade-off, on-farm conservation, private value, public value, targeting, variety choices

Introduction
Conservation of genetic resources is essential to both professional plant breeders, who need access to genes and gene complexes for current and future crop improvement, and farmers, who need to continuously select and modify their crops to meet their immediate livelihood needs in response to an ever-changing environment and circumstances (Collins and Hawtin 1999). Not only is genetic diversity valuable to farmers today, it is also potentially valuable to future generations of farmers, professional breeders and consumers elsewhere. In this context, variety choice generates both private and public value. Farmers choose to maintain the landraces they value by planting the seed, selecting the seed from the harvest or exchanging it with other farmers, and replanting. Farmers choose which varieties of a crop to grow according to their private value and their choices also determine whether or not genetic resources of social value for crop improvement continue to be grown *in situ*. The choices they make today affect not only their welfare but that of future society.

Professional plant breeders also make decisions that affect the conservation of crop genetic resources on farms that have high potential value to society. Plant breeders select and cross materials in order to develop new varieties. The choices they make shape the range of genetic resources supplied to farmers as new varieties released by commercial seed systems. Breeders can expand farmers' options by introducing new or recombined genetic materials to better meet their needs or complement those already grown. Both genetic resources stored *ex situ* and those grown *in situ* are important for the crop improvement process that generates social value through enhanced productivity and lower food prices (Swanson 1996).

However, not all genetic resources can be conserved on-farm, and not all farmers can conserve them because of the costs involved, including direct programme costs and costs in terms of opportunities foregone. Since Nepal is grouped among the lowest-income countries of the world in terms of Gross National Product (World Bank 2003)[5] the challenge for the government of Nepal is to create win-win policies. That amounts to creating incentives for continued use and maintenance of rice biodiversity at minimum cost to the society, while benefiting today's farmers with higher income levels as well as benefiting future society by supplying them with options for future crop improvements.

The value of landraces lies in their evolutionary potentials and future use in plant breeding. The challenge now is how to capture this public value. From an economics perspective, in the changing local and global context, there is a need to develop methods to identify and predict genetic resources of high private and public value in order to devise least-cost policy instruments to support on farm conservation of crop plants in a particular area. Because the social benefits of conserving genetic resources are often intangible, widely spread and not fully reflected in market prices, the benefits of conserving evolutionary potential are not reflected fully in cost-benefit analysis. Assessing values and costs of conserving evolutionary potential of genetic resources provides a basis for determining the total value of any genetic resource in traditional farming systems. When varieties such as landraces are not traded on markets, we can use farmers' perceptions of their importance as indicators of their perceived private value to them. Although the potential public value of these landraces as rare, diverse and adaptable genetic resources cannot be accurately predicted, we can use breeders' and conservationists' perceptions of the relative distinctness of varieties or the results of genetic diversity analyses as proxies for perceived public value. The varieties with both the highest current use value (private value to farmers) and the greatest potential value (public value to society in general) are those that cost least to conserve on farms (Smale and Bellon 1999, 2001).

Some empirical studies have investigated trade-offs in one type of diversity compared with another when policies promote changes in an explanatory variable, such as investments in education and infrastructure (Van Dusen 2000; Benin *et al.* 2003; Smale *et al.* 2003). These analyses were based on indices that did not capture possible differences in social value among varieties. In the analysis presented here, we relate explicitly the preferences of rice breeders and conservationists to the preferences of farmers. The choices of rice breeders and conservationists reflect their views about the potential value to society of the landraces still grown by farmers. The choices of farmers reveal their preferences in the face of numerous economic and physical constraints, indicating the private value of the varieties. This paper uses detailed sample survey data from research in Bara and Kaski ecosites of Nepal to identify the profile of farmers and target locations that are most likely to maintain landraces of high public and private value by analyzing the relationship between farmers' and breeders' choices for *in situ* conservation of rice biodiversity. The specific objectives are to (1) explore factors that explain higher levels of socially important rice diversity maintained at the farm level, (2) identify the social and economic profile of the farmers who are most likely to maintain higher levels of rice genetic diversity, and (4) predict the target location and farmers who are most likely to maintain landraces of both high private and public (social) value. The next section presents descriptions of the research methods used to collect data. The conceptual approach and econometric methods are then presented, followed by presentation of a summary of descriptive statistics and econometric results. Conclusions and implications of the findings are drawn in the final section.

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5 With a per capita income of US$269, Nepal ranked 140th in the UN's 2003 Human Development Index.

Materials and methods

This research focuses on two of the three ecological sites (ecosites) of the "*In situ* Conservation of Agricultural Biodiversity On-farm," project in Nepal. These two ecosites are Begnas (Kaski) and Kachorwa (Bara), representing hill and *terai* ecological regions, respectively. In both ecosites, rice is the major crop in the food economy and is cultivated across a range of microecological conditions—upland, lowland and swamp environments—which are often found within the same farm. Farmers typically plant several varieties of rice to match land types, soils, moisture conditions and cropping sequences. At the ecosite level, sample farmers maintain a total of 50 and 23 rice cultivars in the hill and lowlands ecosites, respectively. The sample survey research and analysis involve two different groups of surveys: (1) sample survey of households and (2) key informant survey of plant breeders. The specific details are given below.

Sample survey of rice-growing households

A survey of farming households was carried out from Bara and Kaski ecosites by listing actual farming households from the available records in the local project and administrative offices (village development council and municipality). A random sample representing 17.25% of actively farming, rice-growing households was drawn, numbering 159 in Kaski and 148 in Bara, totaling a sample size of 307. The survey instrument was a structured questionnaire administered in personal interviews. Questions covered social, demographic and economic characteristics of farmers and their households, as well as physical characteristics of their farms, economic aspects of rice production and market access. Both men and women involved in rice production and consumption decisions were interviewed. Peer review of the questionnaires was undertaken at regular intervals to check for measurement errors, ambiguities and missing information.

Key informant survey of rice breeders

A survey of plant breeders and researchers involved in the national *in situ* project and rice breeding research in Nepal was carried out in two phases. In the first phase, 16 plant breeders and researchers working on the *in situ* project were asked to rank lists of farmers' varieties identified in the farm household survey according to their importance for conservation or future use in plant breeding. This survey also enabled the identification of the criteria breeders use to select landraces as potentially useful. Criteria included: diversity (expressed as a non-uniform, heterogeneous population); rarity (embodying unique or uncommon traits) and adaptability (exhibiting wide adaptation). In the second phase of the survey, eight plant breeders were asked individually to classify rice landraces according to whether or not they satisfy each criterion, based on their experiences. The breeders' perception data of the potential value of rice landraces for crop improvement are summarized in Table 1.

Theoretical model

The conceptual approach is based on the theory of the agricultural household model (Singh *et al*. 1986), as applied to analysis of crop biodiversity by Van Dusen and Taylor (2003). Other related economic models and applications on crop genetic resources are found in various studies conducted in different parts of the world (Meng 1997; Brush *et al.* 1992; Smale *et al.* 2001; Benin *et al. 20*03; Birol 2004). In this approach, presented elsewhere in mathematical terms, an agricultural household maximizes utility over a set of consumption items produced on the farm, a set of consumption items purchased on the market, and leisure. The utility a household derives from various consumption combinations and levels depends on the preferences of it members. Preferences in turn depend on various social and demographic characteristics of the household, including its endowments of human capital and other assets, represented by the vector ($\Omega_{HH)}$. The amounts the household can produce are constrained by a production technology, given the physical features of the farm (Ω_F). The production technology combines seed and labour with other purchased inputs on the crop area cultivated each season (*A*).

The choice of crop and variety combinations and how much land area to allocate each then determines the levels of farm produce the household expects to harvest, and vice versa. The area shares for any given crop or variety can range from 0 (when it is not grown) to 1 (when no other crop or variety is grown). When these choices are made, expenditures of time and money cannot exceed full income. Full income in any season is composed of the net farm earnings (profits) from sales of crop production, and income that is 'exogenous' to the season's crop and variety choices, such as stocks carried over, remittances, pensions and other transfers from the previous season (Y^0). When markets are not functioning well for a crop or its trade is associated with significant costs of transaction (Ω_M), then production and consumption decisions cannot be treated separately and a shadow price for the crop guides decision-making rather than its market price. Shadow prices are related to the differential costs of transacting on markets that reflect household-specific characteristics (Ω_{HH}). Previous work in the study area suggests that markets are not complete for rice, and especially for landraces (Gauchan *et al.* 2005).

Table 1. Breeders' perceptions of the potential value of rice landraces for crop improvement.

Variety name	Diverse	Rare	Adaptive	Variety name	Diverse	Rare	Adaptive
Anadi Rato	0	0	1	Jhinuwa Ghaiya	0	1	0
Anadi Seto	0	0	1	Jhinuwa Kalo	0	1	0
Anga	0	1	0	Jhinuwa Pakhe	0	1	0
Badahari	0	1	0	Jhinuwa Seto	0	1	0
Basmati	0	0	0	Jhinuwa Tarkaya	0	1	0
Basmati	0	0	0	Juwari	0	1	0
Bayerni	0	1	0	Kathe Gurdi	1	0	0
Bayerni Jhinuwa	0	1	0	Kaude 1 (NL+KG)	0	0	0
Bhathi	0	1	0	Kaude 2 (Md+Mn)	0	0	0
Bichara Ghaiya	0	1	0	Kunchhale Ghaiya	0	1	0
Ekle	0	0	0	Madhese	0	0	1
Faram lalka	0	0	1	Mala	0	0	1
Gajale Jhinuwa	0	1	0	Mansara	0	0	1
Gauriya	0	1	0	Mansuli Ghaiya	0	1	0
Gurdi	1	0	0	Mut Mur	1	0	0
Gurdi Sano	1	0	0	Naulo Madhese	0	0	1
Gurdi Thulo	1	0	0	Pahenle	0	0	0
Jarneli	1	0	0	Ramani	0	1	0
Jarneli Dhave	0	1	0	Rato Ghaiya	0	1	0
Jarneli Pakhe	0	1	0	Sathhi	0	1	0
Jetho Budho	1	0	0	Seto Ghaiya	0	1	0
Jhinuwa	1	0	0	Tunde	0	1	0

1=of high potential value, 0 otherwise.

The random utility model enables statistical interpretation of the variety choice decision with sample data. The household chooses to grow any particular landrace on a portion of rice area if the utility its members expect to derive is greater than for other available alternatives ($U_i > U_j$, for any j not equal to i). Since utility levels (U) cannot be observed, the choices observed in the data reveal the alternatives that provide the greatest utility to households. Variation in these choices is explained systematically by the preferences of households and the constraints they face. Preferences and constraints depend on observable variables related to household, farm and market characteristics. Drawing data from a random sample of households introduces a stochastic component, providing a statistical context for predicting the probability that a household grows a landrace as a function of the systematic component ($\beta' X$) and random errors (ε):

(1) Probability (Landrace i chosen) =

$$\text{Probability } (U_i > U_j) = \beta_0 + \beta_H' \Omega_{HH} + \beta_F' \Omega_F + \beta_M' \Omega_M + \beta_y Y^0 + \beta_a A + \varepsilon.$$

Econometric methods

Equation 1 is the basis of econometric analysis and hypothesis tests. A Probit model is used to estimate the regression in LIMDEP (version 7.0). Probit model was suitable here since the objective was to estimate the probability that an observation belongs to one group or another for the breeders' stated data which were discrete and binary (0, 1). The model investigates which explanatory factors specified in the decision-making model significantly alter the predicted probability that the farm household grows the landraces classified by rice breeders. Each breeder or conservationist choice is associated with a unique set of varieties targeted for conservation. Increasing the likelihood that farmers will maintain varieties that are members of one core subset (e.g. diversity) may decrease the prospects that varieties in other core subsets (e.g. rarity) continue to be grown. If so, policies designed to attain one objective might have serious consequences for another. Tests are implemented by specifying regressions with different dependent variables (choice criteria) and the same explanatory variables (e.g. household, agroecological and market characteristics). Signs and significance of regression coefficients are compared. A separability test of the model was carried out to investigate whether the model used in this study is separable or not, with a joint test of the significance of the group of variables. The likelihood ratio (λ) test is carried out for separability test by comparing the values of the log-likelihood function with and without the restrictions imposed (Greene 2000:152–153).

Dependent variables

The dependent variables in the regressions are defined according to the results of the key informant survey of the plant breeders (Table 2). The survey indicated that there are three important criteria on which core subsets of rice varieties grown in farmers' fields might be selected for on-farm conservation by plant breeders and conservationists. These criteria include diversity (expressed as a non-uniform, heterogeneous population), rarity (embodying unique or uncommon traits) and adaptability (exhibiting wide adaptation). These criteria could be measured with isoenzyme techniques, molecular methods, or analysis of agromorphological traits.

Table 2. Definition of dependent variables in the Probit Regression Models.

Diversity	Non-uniform, heterogeneous population	Yes=1, Otherwise =0	any landrace satisfying this choice criterion
Rarity	Unique, uncommon traits	Yes=1, Otherwise=0	any landrace satisfying this choice criterion
Adaptability	Wide adaptation	Yes=1, Otherwise=0	any landrace satisfying this choice criterion

Summary statistics, explanatory variables and hypothesized effects

Table 3 presents the summary statistics of dependent and explanatory variables for the two study ecosites. It also outlines definition and hypothesized effects on diversity of each variable. Descriptive statistics of the results indicate that a higher percentage of households in Kaski is more likely to grow genetically diverse, rare and adaptable landraces compared with households in Bara. Farm households in Kaski also grow a greater number of rice varieties and maintain more spatial diversity. Kaski households are also more isolated from a market, own more heterogeneous farms (upland, lowland, mid-land), and are richer in livestock assets. The education level of women decision-makers is also higher. However, households in Bara have a higher subsistence ratio (ratio of production to consumption) and are more involved in the sale of modern varieties than Kaski farmers.

Table 3. Summary statistics of dependent and explanatory variables and expected sign.

Variable name	Variable definition	Ecosite		All N= 307	Expect-ed sign
		Bara (N=148)	Kaski (N=159)		
Dependent variable					
Diversity	Percent households growing diverse landraces (+)	2	50.9	27.4	
Rarity	Percent households growing rare landraces (+)	2.7	20.8	12.1	
Adaptability	Percent households growing adaptable landraces (+)	0.7	74.8	39.1	
Explanatory variables					
AGEPDM	Age production decision-maker (yrs)	48.27	46.20	47.20	(+)
EDUPDM	Education of production decision-maker (yrs)	3.0	3.95	3.52	(+, -)
EDUCDM	Education of the consumption decision-maker (yrs)	0.48**	1.99	1.26	(+,-)
AAGLABR	Active adults working on-farm (no.)	2.52	2.51	2.52	(+)
FAADTPCT	% Female of actively-working adults	0.27	0.28	0.28	(+)
LANIMLV	Value (NRs) of large animals (bullocks, dairy animals)	10270**	18490	1452 7	(+)
TOTEXP	Monthly household expenditure (NRs.) (exogenous income)	2483	2581	2533	(+, -)
SBRATIO	Ratio of 5-year average rice produced to rice consumed (kg)	1.40**	0.76	1.07	(+, -)
IRPCNT	% rice area irrigated / source of water	0.42	0.39	0.407	(+,-)
LNDTYPS	Number of rice land types	1.54	1.49	1.517	(+)
RDPLCULH	Total walking distances (mins) from the house to the rice plot(s), divided by cultivated hectares	120*	146	134.5 8	(+)
TMKTDS	Total walking distance from the house and farm plots to market (mins)	163**	340	255.1 4	(+)
LRSOLD	Landrace grain sold by the household in preceding season (kg)	16.89	43.68	30.76	(+)
MVSOLD	Grain of MV sold by the household in the preceding season (kg)	971**	38	487.8	(-)

Note: Pairwise t-tests show significant difference of means at *P*<1% (**) and *P*<5% (*) between Kaski and Bara Ecosites with 2-tailed test, equal variance assumed. (+); χ^2 tests show significant difference (*P*<5%) between Bara and Kaski ecosites.

Econometric results

Factors that predict whether private values (farmers' choices) and social values (breeders' choices) coincide are shown in Table 4, according to each choice criterion (diversity, rarity and adaptability). These are the factors that significantly affect the likelihood that farmers will grow landraces identified by rice breeders as important. Among household characteristics, education, labour composition and livestock assets are statistically significant predictors that households will grow landraces that are considered important for future crop improvement. Human capital appears to be critical. The more educated the decision-maker in rice consumption (typically a woman), the greater the likelihood that a household grows a landrace that is genetically heterogeneous. More adult labour engaged in agriculture has a large effect on the probability that adaptive landraces are grown, also contributing significantly to cultivation of genetically diverse landraces. A higher percentage of women among active adults in the households means that a rare landrace is more likely to be grown. An earlier study by the project team revealed a greater role of women in rice landrace seed maintenance and cultivation (Subedi *et al.* 2000).

Table 4. Factors predicting that farmers will grow landraces that breeders identify as potentially valuable in two ecosites of Nepal, by choice criterion.

Explanatory variables	Choice criterion of rice breeders		
	Diversity	Rarity	Adaptability
CONSTANT	–0.6221***	–0.4289***	–2.6499***
SITE	0.2792***	0.1074***	1.0596***
AGEPDM	–0.000029	–0.00058	0.000387
EDUCDM	0.0218**	–0.00483	–0.00679
EDUPDM	–0.0101	0.00212	0.00931
FAADTPCT	–0.03892	0.13687*	–0.05048
AAGLABR	0.04315 **	0.01702	0.14948***
LANIMLV	0.000005*	–0.0000019	–0.000002
TOTEXP	–0.000023	–0.000018	0.0000003
SBRATIO	–0.09510	–0.02833	0.05185
IRPCNT	0.080216	0.005799	0.1390
LNDTYPS	–0.05990	0.06588***	0.03843
RDPLCULH	0.000029	0.000056	0.001112**
TMKTDS	0.00040**	0.000137**	0.000665*
LRSOLD	0.00021	0.000111*	–0.000094
MVSOLD	–0.00004	–0.000005	–0.0001188
Log likelihood function	–93.79	–75.50	–54.65

Note: N=307. The regression model used in all cases is a Probit. One tailed Z–tests significant at P< 0.01 (***), 0.05 (**), 0.1(*) percent level. See Table 3 for variable definitions. Z–statistic is relevant for maximum likelihood estimation. The values reported in the table are marginal effects that are computed at the means of explanatory variables.

The more endowed with livestock assets (buffalo, cattle and bullocks), the more likely the household is to grow landraces also selected by rice breeders as diverse. External income is of no apparent significance, since growing landraces does not cost money. The number of rice land types (diverse farm production niches) increases the chances that a rare landrace is grown, and the dispersion of rice plots relative to the total area cultivated contributes positively to growing adaptive landraces. Location in the hills ecosite and isolation from markets are associated with higher probabilities of growing any landrace that is identified as potentially valuable to future crop improvement by rice breeders.

For statistically significant predictors that are common across landrace subsets, the direction of effect is the same though the magnitude of effect differs (ecosite location, proportion of active adults engaged in farm production, total walking distance to market). Three policy-related variables have non-neutral effects. First, women's education and involvement in farm production predicts only that the household will grow rare or diverse landraces, and the magnitude of effects differs. Second, past sales of grain from landraces is significantly associated with growing rare landraces, but not diverse or adaptive landraces. This finding suggests that specialized markets may provide incentives for farmers to continue cultivating rare landraces. Third, the dispersion of farm plots, normalized by farm areas, is a predictor that the household will grow adaptable landraces. Tenure and land use practices are factors that underlay the spatial distribution of plots.

Targeting locations and households for conservation

A least-cost approach to conservation of crop genetic diversity on-farm is to identify target locations where farm households have a high likelihood of cultivating landraces of both high private and public value (Bellon and Smale 1999) because these are most likely to be the households for which incentives for diversity can be created at the lowest cost. Meng *et al.* (1998) report that identification of locations and households with the highest probabilities of cultivating landraces require the minimum amount of external incentives for de facto *in situ* conservation.

The predicted proportions of households growing diverse, rare and adaptive landraces are significantly higher in the hills where Kaski is located than in the more fertile, accessible plains of the *terai*, including Bara District. The predictions (Table 5) based on the regression model (Table 4) reinforce statistically the actual pattern observed in the sample means and proportions (Table 3). To the extent that social value is expressed by any of the three criteria identified by rice breeders, targeting a location like Kaski increases the likelihood that landraces with social value would be conserved (Gauchan 2004).

Table 5. Predicted proportion of households growing diverse, rare and adaptive landraces.

Type of household	Ecosite		Both sites (N=307)
	Bara (N=148)	Kaski (N=159)	
Growing genetically diverse landraces(+)	0	47.8	24.8
Growing rare (unique) landraces(+)	0.7	10.7	5.9
Growing adaptable landraces (+)	0	79.9	41.4

(+) χ^2 tests show significant difference (*P*<5%) in percentages of households growing different types of rice landraces between ecosites.

Within this ecosite, however, there are clear differences between the households with high and low likelihoods of growing any landraces classified as socially valuable (Table 6). The households most likely to grow more diverse, rare and adaptive landraces have more adults engaged in farming and are more involved in marketing of local landraces. These households are also richer in livestock assets, although their cash income levels are similar. They have a greater number of land types suitable for rice production and their plots are more widely dispersed and farther from markets. However, there were no differences observed in age and education level of production decision-makers and female adult working in the households between those high- and low-probability households. Few meaningful differences can be observed among those conservation subsets. Relative to those growing adaptive landraces, households most likely to grow rare and diverse landraces are considerably richer in livestock, and are much more involved in sales of grain from landraces. Those households who grow diverse and adaptive landraces have relatively higher education level of women decision-makers compared with those who grow rare landraces.

Table 5. Profile of farm households with high and low likelihood of growing landraces that breeders identify as potentially important in Kaski ecosite, Nepal, by choice criterion.

Characteristics	High predicted probability of:			Low probability of growing diverse, rare and adaptive landraces (N=81)
	Grow diverse landraces (N=20)	Grow rare landraces (N=17)	Grow adaptive landraces (N=76)	
AGEPDM	46.25	49.17	46.96	45
EDUPDM	4.75	3.82	4.27	3.71
EDUCDM	3.35	0.82	2.14	1.80
AAGLABR	3.75	4.05	3.48	1.62
FAADTPCT	0.26	0.31	0.28	0.27
LANIMLV	26050	25823	21934	15407
TOTEXP	2327	2039	2526	2673
SBRATIO	0.83	0.90	0.85	0.68
IRPCNT	0.36	0.44	0.41	0.37
LNDTYPS	1.60	1.94	1.67	1.33
RDPLCULH	225	261	207	90
TMKTDS	998	973	557	132
LRSOLD	119.7	123	60	25
MVSOLD	41.55	48	35.97	40

Note: Since the subsets of farmers with high predicted probabilities of growing diverse, rare, or adaptive landraces are not mutually exclusive, statistical tests on differences of means among them could not be conducted. However, tests comparing any one of these groups to the group with low predicted probabilities show significant differences in almost all means, except those for AGEPDM, EDUPDM, EDUCDM, FAADPCT, TOTEXP, IRPCNT, MVSOLD. High probability households are those, whose probability of cultivating is above 90% for diverse and adaptive and above 50% for rare landraces, whilst low probability households are those with less than 10 percent of probability of cultivating them. The values are predicted from Probit Regression Model. See Table 2 for variable definitions.

Conclusions and implications

The study shows that household, agroecological and market characteristics are important in maintaining rice diversity that is important for plant breeders. Among household characteristics, education, labour composition, and livestock assets are statistically significant predictors that households will grow landraces that are considered important for future crop improvement. Human capital appears to be critical. Market distance is an important predictor of farmers growing diverse, adaptable and rare landraces. Similarly, agroecological heterogeneity is important for growing rare and adaptable landraces. With respect to policy trade-offs associated with the choice of criteria for conservation, our results show no such conflicts. That is, increasing the likelihood that farmers will maintain varieties that are members of one choice set may not decrease the prospects that varieties in other sets continue to be grown. Therefore policies designed to attain one objective might not have negative consequences for another. They do suggest, however, that the policies designed to support the continued cultivation of rare landraces are different from those required for diverse or adaptable landraces.

Regression results and summary statistics suggest how sites and households might be targeted for local conservation of rice biodiversity. Clearly, any rice-growing household in the hill ecosite (Kaski) is more likely to grow genetically diverse, rare or adaptable landraces. Rice-growing households in lowland ecosite (Bara) grow and sell more modern varieties of rice. Though they are better able to satisfy their consumption needs through their own production, women decision-makers are less educated; households in this location are poorer in assets, and no better off in terms of external income. The findings also indicate that not all households, and not all landraces in Kaski, are equally promising candidates for conservation. Households with more active adults engaged in agriculture are more likely to maintain landraces of social value, so that increasing opportunities for off-farm employment may have a negative impact on prospects for conservation. Households with more heterogeneous farms that are more isolated from markets are more likely to maintain genetically diverse, rare and adaptable (socially valued) landraces. The evidence that farmers more likely to grow rare landraces also sell the grain locally suggests that the development of specialized, controlled markets may provide an incentive for maintaining such materials—although the feasibility and costs of implementing such a programme would require further investigation. Finally, targeting may involve other trade-offs in terms of equity considerations. Those most likely to grow socially valuable landraces are also richer in livestock assets. Even though most farmers on the hillsides of Nepal are ranked as poor by global standards, targeting the locations and households relatively more likely to maintain valuable landraces is by no means equivalent to targeting the poor.

Future focused studies will be required by combining household socioeconomic information with accurately measured genetic data for identifying rare, diverse and adaptable landraces that will shed more light on where the pockets of the most unique and socially valued landraces are still found within the study locations, communities and specific group of households (poor or rich). A study that covers households located across a large range of diverse communities and locations will provide better pictures of cultivation of socially valued landraces and capture the dynamics of wider variations of locations and communities.

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Farmers' perceptions on rice segregating PPB populations in Kaski and Bara districts of Nepal

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Abstract
Participatory plant breeding (PPB) is a new crop improvement approach, which involves selection of early segregating populations by farmers and plant breeder together. PPB has been considered as a strategy for on-farm conservation of agrobiodiversity for the *in situ* global project in Nepal. In Nepal PPB activities started in 1999 and by 2003 a total of 74 farmers had received F_2 to F_5 rice segregating populations from the project. The study aims to monitor the spread of F_2 to F_5 bulks to assess the status of the farmers' participation and their perceptions on these rice segregating populations A survey was conducted by contacting all 74 farmers participating in PPB and receiving early generations in Bara and Kaski. Farmers' perceived expectations from the PPB process were to receive better and high-yielding varieties more quickly than the existing cultivars. In Kaski, many farmers were not aware of PPB. Some farmers discontinued growing segregating PPB populations mainly because of their highly segregating nature (highly variable), which was associated with a high level of crop damage by rats, birds, animals, insects and monkeys; also because of less yield, more work, tedious to handle, etc. A few farmers wish to continue to plant segregating populations, thinking that they may possess potential economic traits; however, actually very few farmers continued to grow different generations of a particular cross and their neighbouring farmers also were not optimistic about the segregating materials. The participating farmers were not aware about the values of segregating populations. Many farmers want homogenous, high-yielding, early maturing and high-quality lines. It seems that it may not be possible to test highly segregating populations in farmers' fields. It is recommended to change the PPB approach and strategy by providing more advanced materials to the interested and capable farmers only. The study suggests that farmer's involvement during goal-setting and on-farm selection at the F_5 to F_6 stages is appropriate in Nepalese conditions.
Key words: Farmer’s perception, Participatory Plant Breeding (PPB), on-farm conservation, monitoring impact, rice, segregating populations

Introduction
So far, only 48 improved rice varieties are recommended for general cultivation in Nepal (NARC 2002). Varietal diversity is advisable in order to meet varied agroclimatic conditions and the needs of farmers. The diffusion of improved varieties developed by traditional breeding is slow and farmers are not accepting these varieties widely. In recent years, farmers have been involved in a plant breeding and varietal selection programme in the presence of plant breeders and others. Participatory Plant Breeding (PPB) is a process of involving scientists and farming communities in breeding activities in order to increase the value of crops by an improvement of their genetic material (Eyzaguirre and Iwanaga 1996). PPB is the selection of segregating lines by farmers in collaboration with breeders in their target environments using their own selection criteria (Sthapit *et al.* 1996). PPB has been proposed as a method to create new varietal diversity for the targeted environment. According to Witcombe *et al.* (1996) and Ceccarelli *et al.* (1996), PPB is more likely to be successful in producing a farmer-acceptable variety than a conventional breeding programme. This is because genotype × environment interactions are greatly reduced, selection is always done in the target environment and under actual management conditions of farmers, and at least one parent is well-adapted to the local (target) environment. Large F_2 and F_3 populations are grown to increase the possibility of identifying transgressive

segregants, and farmer participation at early stages eliminates the chance of releasing a poor variety in terms of its acceptance.

PPB combined with decentralized selection under high stress conditions has arisen as a breeding strategy to attempt to improve the performance of formal breeding for different environments. PPB involves farmers selecting genotypes from genetically variable, segregating material (Witcombe and Joshi 1996). PPB addresses the need to scale up farmer participation in research and seed production so that technology testing can be carried out in numerous, diverse microenvironments without incurring excessive expenses and compromising the quality of participation (Ashby 1990; Bebbington *et al.* 1994; Okali *et al.* 1994). Brown and Young (2000) have described PPB as a recent approach, about which relatively little can be known about its impact on the conservation of crop biodiversity. They assesses the potential impact of PPB on biodiversity according to breeding system (self-pollinated, outcrossing and clonal).

The global *in situ* project "Strengthening the scientific basis of *in situ* conservation of agricultural biodiversity on-farm" has adopted PPB as a strategy to conserve local crop genetic resources by adding values to them. Under this project PPB began in 1999 in Kaski and Bara ecosites. In Nepal PPB was started in high-altitude rice in 1993 (Sthapit *et al.* 1996) and a cold-tolerant variety was released in 1996 (Joshi and Witcombe 1996). PPB basically helps to develop farmers' varietal choice and to disseminate technology faster. Benefits may be social, economic or genetic, in both long- and short-term aspects. To measure its impact, we need many years, but a possible impact can be discussed. This paper discusses the possible socioeconomic and genetic impacts of measuring the effect of early segregating PPB materials on local crop diversity and livelihoods. To know the farmers' perceptions about the segregating populations this study was carried out in Kaski and Bara sites; monitoring was done on the spread of PPB materials in terms of area, frequency of household and the farmers' reasons for adopting that material.

Materials and methods

Project initiation and selection of farmers

Participatory plant breeding is one of the thematic areas of the global project "Strengthening the scientific basis of *in situ* conservation of agricultural biodiversity on-farm" started in 1997 and continuing up to 2004. The PPB team started working on rice in Kaski and Bara *in situ* ecosites in 1999. The participating farmers were selected based on their willingness to cooperate, their familiarity with the project and the nearness of the testing fields to a road or path.

Farmer consultation

The PPB team discussed the methodology to implement this activity in the group. The team visited the villages and discussed PPB with the farmers and educated them. In consultation with the farmers, the technical team selected landraces and modern varieties for fulfilling the special purposes as demanded by the farmers. The parents selected for Kaski and Bara were as follows:

Site	Landraces	Modern varieties
Kaski	*Biramphool, Naulo Madhise, Thulo Gurdi, Ekle, Sano Gurdi, Anga, Mansara, Jethobudho*	Himali, IR 36, NR 10286, Khumal-4, NR 10285, NR 10291, Pusa Basmati
Bara	*Lajhi, Mansara, Lalka Basmati, Dudhi Saro, Nakhi Saro*	Rampur Masuli, IR 62161, IR 59606, BG 1442, Sabitri

Survey on farmers' perception

Except in one case (*Pusa Basmati* × *Jethobudho*), the landraces were used as female and the modern genotypes were used as male. The hybridization was conducted at LI-BIRD field site, Chitwan in 1999; 19 F_1 populations were grown there in 2000 and F_2 seeds were obtained. The segregating populations were provided to 53 farmers in Kaski and 21 farmers in Bara during 2001–2003. A list of all the farmers was prepared and all farmers receiving F_2 to F_5 segregating populations were visited in 2003. A short description of PPB activities of Kaski and Bara is presented in Table 1a and 1b, respectively. The observed segregating populations were planted by farmers as usual. A semistructured checklist with 11 questions was used to collect the information and perceptions of the participating farmers. Out of 53 PPB farmers in Kaski, information was collected from only 48 farmers because 2 did not plant the seeds, rice seedlings of 2 farmers were damaged by an ox and the seedlings of 1 farmer died. Similarly in Bara, out of 21 participating farmers, information was collected only from 15 farmers because PPB seeds did not germinate in 3 farmers' fields and 3 farmers failed to produce the seedlings from the PPB materials. All the data were computerized.

Table 1a. Suggestions for conducting PPB, Kaski.

Particular	No.	Percent
Provide uniform high-yielding material	35	73
Provide early maturing, adaptive, high-yielding and drought-tolerant variety	4	9
Train the farmers about PPB	3	6
PPB materials may be good in large area	3	6
PPB can be effective method to develop the variety	2	4
Provide PPB materials to bigger farmers only	1	2
Total	48	100

Table 1b. Suggestions for conducting PPB, Bara.

Particular	No.	Percent
Technical services to farmers	4	27
Public sector should provide variety	3	20
Train the farmers about PPB	2 (1)[†]	13
Uniform variety is better	2	13
Conduct trials on leased/hired land	2	13
Provide compensation for yield loss	1 (2)	7
No segregating material	1	7
Do not discontinue PPB	(1)	–
Total	15 (4)	100

[†] Some farmers provided more than one suggestion and figures within parentheses represent the number of farmers providing second or third suggestions.

Results

Farmers' expectations of segregating materials

When the farmers received rice segregating populations from the project, their expectation was high for finding very high-yielding varieties (65%) in Kaski (Table 2a), and short plant (semidwarf) (80%) and high-yielding (80%) varieties in Bara (Table 2a). Only 8% of farmers grew these populations just to try in Kaski. In Kaski, about 50% of farmers had no idea about PPB; however, 80% of Bara farmers knew about PPB (Table 3).

Table 2a. Expectation of farmers of PPB materials, Kaski.

Particular	No.	Percent
High yielding	31	65
Better than the existing varieties	11 (6)†	23
Try to test by planting	4	8
Better adapted	2 (3)	4
Better quality type	(4)	–
Other (disease-resistant and early maturing)	(3)	–
Total	48 (16)	100

Table 2b. Expectations of farmers of PPB materials, Bara.

Particular	No.	Percent
Short plant type	7 (5)	46
High yielding	6 (6)	40
Better eating quality and colour	(4)	–
More tillering	1 (1)	7
Yellow grain colour	1	7
Total	15 (16)	100

† Some farmers have more than one expectation and the figures within parentheses represent the number of farmers providing second or third expectations.

Table 3. Knowledge of farmers about PPB, Kaski.

Particular	Kaski			Bara		
	No.	Percent	Remark	No.	Percent	Remark
Don't know about PPB	20	42		3	20	
Know about PPB	18	38	After training	12	80	After training
Know a little	4	8	Heard from others	–	–	
No response	6	12		–	–	
Total	48	100		15	100	

Farmers' perceptions of segregating materials

In Kaski, 77% of farmers did not want to continue the planting of segregating materials in the next year and in Bara, 52% of farmers discontinued the planting of segregating materials in the next year. After looking at the standing crop, the farmers rejected the material. The reasons for rejection were highly segregating (46%), damaged by rats, birds and insects (21%) and no or very low grain yield (19%); very few farmers reported that seed was lost or mixed, or not a good plant type, etc. in Kaski. In Bara, 36% of farmers said that segregating materials yielded less, 36% of farmers found these materials were segregating and damaged by animals, others said that seeds were not repatriated, were more work, not good material or seed had not germinated.

On the other hand, in Kaski, farmers wanted to continue the segregating materials because they thought these may be good in future (29% of farmers), the materials were good (21%), were not damaged by rats and birds (14%) and seed was repatriated from the project staff (14%). In Bara, farmers wanted to continue because the segregating materials had short plant height (39%), higher yield (31%), may be better quality (15%), or had more tillering and other positive features (15%). However in Kaski, only one farmer continued to grow the advanced generation of the same crosses and in Bara, four farmers continued growing the advanced generations of the same cross.

Farmers’ field practices and neighbours’ reflections

In Kaski, 58% of farmers did not follow selection from the segregating materials; however, 21% selected ears by themselves and project staff helped 19% of farmers with selection. In Bara, project staff helped 67% of farmers in selecting ears, staff themselves were involved in selecting plants for 20% of farmers, and very few farmers selected the plants by themselves.

In Kaski, the participating farmers reported that most of the neighbouring farmers did not like segregating populations. And about 8% of farmers complained that due to the segregating nature of the material these populations were damaged by rats or birds, and they damaged their neighbour's crops also which was not common previously. However, in Bara, 27% of the neighbouring farmers liked the segregating populations. As decided by the PPB team, the project staff took the selected materials and repatriated them for the next season planting. According to farmers, in some cases, seeds were not repatriated and farmers were not happy about that.

Farmers' perceived impacts of PPB on agrobiodiversity and crop production

In Bara, 54% of farmers think that PPB increased agrobiodiversity, but in Kaski only 38% of farmers believed that. About one-third of farmers were not sure whether PPB increased or decreased agrobiodiversity in both sites. Farmers of Bara (80%) strongly think that PPB increased crop production, and 32% of Kaski farmers think it decreased crop production. In Kaski, out of 48 farmers, no one has provided the segregating materials to any other farmers because these materials were not doing well in their own fields and no one has asked for seeds. Again, out of 48 farmers, 46 said that their objectives in growing segregating populations were not fulfilled, and only two farmers said that their objectives were partially achieved. Similarly, in Bara not a single farmer has taken segregating populations from the participating farmers and only one farmer said that CBO might take seed next year. Again, out of 15 farmers, 9 said that their objectives may be achieved and 6 farmers said that their objective would not be fulfilled.

Farmers' opinions about segregating materials of other crops

In Kaski, 61% of farmers do not want to plant segregating populations in other crops, but 23% of farmers want to follow this method in maize and wheat, and about 14% want to follow PPB in other crops. Some farmers think that maize can be a very easy crop to handle heterogeneous populations due to its plant stature and it being planted near their house. In Bara, about 60% want to follow or test segregating populations in other crops.

Problems and suggestions for testing of segregating populations

In Kaski, 65% of farmers reported that the crops were damaged by rats, birds, insects and monkeys, 75% of farmers faced diverse maturity and plant height problems due to segregation; less yield and tedious to handle segregating populations are other problems related to these populations. Similarly in Bara, the problems of PPB were lower yield (33%), segregation for maturity (26%) and selected seeds were not repatriated (13%). About 73% of farmers from Kaski wanted uniform materials, and they preferred finished, early maturing, adapted, high-yielding varieties (9%). About 6% of farmers demanded PPB training. In Bara, 27% asked for technical services, another 20% for PPB training; 20% of farmers think that PPB should be done by public sectors only and 13% asked for the uniform varieties.

Discussion

First some general comments on two surveyed sites, as outlined below.

Kaski

1. The expectations of farmers were high, but due to high segregation in F_2 to F_5 generations, farmers faced the problem of crop damage by rats, birds, insects and monkeys and had crop management problems. Thus, there is a need to change the strategy of providing more homogenous lines to them.
2. Two trainings were conducted in the site, which had stimulated farmers to work on PPB. It would be better to capitalize on this situation by modifying the PPB approach to meet the needs of specific areas.
3. Project staff helped interested farmers in selection and took some selected seeds, so farmers did not have a strong sense of ownership. It is better to involve farmers in the PPB process as strongly as possible.
4. For the highly segregating and damaged crops, most of the non-participating farmers did not like segregating populations. So providing segregating populations to many farmers in a small area will have a negative impact. It is better to select a representative area, train the interested few farmers and conduct PPB on their farms.
5. Most participating farmers were not aware of segregating populations and not a single non-participating farmer asked for seed of that material. So, before providing these types of populations, extensive PPB training to farmers at different crop stages is necessary.
6. Some participating farmers think that PPB may increase the diversity and crop production, so there is a future for PPB with innovative farmers.
7. Some participating farmers are willing to practise PPB in maize and wheat crops also. This is an encouraging indication to continue work on PPB.
8. Farmers are very much concerned about the segregation and they know that it is difficult to manage and is time consuming. Thus, there is a need to have some sort of incentive package for the participating farmers.
9. The segregating materials were mostly grown at 1–150 m^2 with average area 21 m^2 where 25–3750 or an average of 525 plants were grown. This average population size is less for effective selection.

Bara

1. Farmers have very focused expectations from PPB and many farmers knew about PPB, so some farmers wanted to continue PPB in future. A few farmers observed the problems associated with PPB and wanted to discontinue it. Some farmers asked for compensation for lower yields and suggested conducting PPB in leased areas.
2. Most of the participating farmers were involved in selection of segregating materials, which should provide some positive impact in future.
3. The segregating populations did not impress the non-participating farmers, so no demonstrative effect of PPB occurred; it can be done in specific and limited areas.
4. Many farmers knew about the segregating populations and the problems associated with them. They requested an improvement of PPB by providing training, technical services and supervision and involvement of other offices which may make this PPB approach effective in future.
5. The segregating populations were grown in areas of 16.6–332.6 m^2 (1 to 20 *Dhur*) with average area of 147.6 m^2 where 415 to 8315 plants or average 3690 plants were grown, which seems satisfactory for selection.

Participatory Plant Breeding was introduced in Nepal with an objective of identifying suitable rice varieties quickly for different niches. The expectation was that farmers will benefit by participating in selecting segregating populations in their field and they will be able to select genotypes for their needs. Testing segregating populations in the farmers' fields was a very new approach in Nepal. So, during PPB travelling seminars, the team suggested increasing the population size and taking the selected populations to the project office. They then decided to promote the three better-performing crosses—*Mansara* × *Khumal-4*, *Pusa Basmati* × *Jethobudho* and *Ekle* × *Khumal*. However, when F_2 to F_5 populations were grown in the farmers' fields, most farmers were not happy with the segregating populations. Actually, they were looking for nearly homogenous lines and very quick outputs from the distributed materials. Hill farmers were less interested in segregating populations because they are unable to bear the risk. The survey indicates that farmers are less aware of the value of segregating populations and efforts for capacity-building of PPB farmers to manage these materials are needed for efficient and effective use of materials.

Conclusion

Given the results of the study, it can be said that it is difficult to test the segregating rice materials in many farmers' fields in Nepal. So, there is a need to change approach in handling the segregating populations and the associated strategy; and to try to implement that at field level. The following suggestions can be useful:

- Involvement of the farmers, initially in goal-setting and parent selection.
- Make different crosses and develop fairly uniform lines.
- Select some prominent domains of a location and take a number of uniform lines (F_5 onward).
- Follow selection together with farmers.
- Teach the participating farmers about PPB.
- Provide other incentives for the participating farmers.
- Assign a PPB expert to each area and follow up with strong monitoring and evaluation systems.
- Keep the selected lines in the farmers' conditions and plant next season.
- Train farmers to maintain the selected lines and to produce quality seed.
- Conducting PPB activities on leased land may be good in initial stage.

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Stability of farmers' networks and nodal farmers in *terai* and hill villages of Nepal: implications for agrobiodiversity management on-farm

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Abstract

In 2001, a study was undertaken in the villages of Begnas and Khola ko Chheu of Kaski district and Kachorwa of Bara districts to understand and examine farmers’ informal seed flow systems. The study showed that farmers’ networks and nodal farmers play significant roles in the flow of genetic materials and in maintaining crop diversity and its processes on-farm. But in any given social system, networks change over time for different reasons. A network will have less importance in the effects of any development intervention unless there is a certain degree of stability in a system. This will be more so particularly if the conservation of agricultural biodiversity with community participation is to be effectively planned. Hence a study on the networks, nodal farmers and their stability was carried out in the same villages again in 2004. The study revealed that farmers' informal systems and networks are still very important in the flow of genetic materials and in this process nodal farmers do play a significant role. There is a certain degree of stability of network links and the nodal farmers over time. While up to half of the network members and nodal farmers are found to have stability, new network members and nodal farmers have emerged owing to internal and external factors within the household as well as in the community at large. This has resulted in two types of nodal farmers: the system nodal farmers and subsystem nodal farmers, who can play different but significant roles in the conservation and utilization of agricultural biodiversity on-farm.

Key words: Networks, nodal farmers, stability, agricultural biodiversity and conservation

Introduction

Farmers are not only the custodians but also managers in maintaining the dynamic processes of crop diversity on-farm. Farmers' informal seed systems play a significant role in agricultural biodiversity conservation and utilization. Farmers' networks are one of the major components of farmers' informal seed systems through which seed and other genetic materials flow among the farming community members. Within these networks, certain members in the community appear to play a major role in managing the process of genetic flow and crop diversity (Subedi *et al.* 2003a, 2003b). Along with the material flow, knowledge-based information is also disseminated from farmer to farmer through similar networks (Subedi and Garforth 1996).

In order to examine the role of farmers' networks in the informal flow of genetic materials and to identify nodal farmers and find out who maintains genetic diversity, a study was undertaken during 2001 in three villages, namely Begnas and Khola ko Chheu of Kaski district and Kachorwa of Bara districts where the project "Strengthening the scientific basis of *in situ* conservation of agricultural biodiversity on-farm" was implemented. The 2001 study revealed that farmers' networks and nodal farmers in the communities of the study villages played significant roles in managing agricultural diversity on-farm, at both household and community levels. However, a network is also dynamic in nature, which may change over time due to various factors that influence the social structure of a community. For any intervention to be effective, it will be important to determine how much the networks are stable over time. Hence a stability analysis of the networks and examination of those who occupy central positions in the networks, i.e. nodal farmers, is important. This requires temporal data, and in particular two data sets of the network links at a minimum. Hence with the major objective of determining just how much the networks and nodal farmers examined during 2001 have been stable over the last 3 years, a network stability study was undertaken during 2004. The findings of this stability study will be useful to strengthen farmers' informal seed systems for agricultural biodiversity conservation and utilization initiatives.

Materials and methods

The 2001 study had employed a sociometric survey using snowball-sampling[6] technique to collect the network data 8 weeks after the planting season and the survey lasted for about 4 weeks. The study used an initial sample of 24 respondents as the starters, and consequently followed the sociometric names in the second and third stage as the respondents identified in each stage thereafter as a receiver or giver of seed. These initial respondents were drawn on the basis of stratified random sampling from the list of a baseline study (n=206 at Begnas and 202 at Kachorwa) (Rana *et al.* 2000). In the 2004 study, the same 24 initial starter respondents of the 2001 survey were taken as the first-round starters. The respondents, thereafter, were taken from the sociometrically identified individuals in each stage of interviews. The snowballing was carried out until the third stage. The respondents were asked to provide the names of the farmers from whom they had obtained the seeds or to whom they had given the seeds during the last 3 years. From the relational data thus obtained, network sociograms were mapped manually. Stability of the network and its members was then examined and measured by comparison with 2001 data. Network stability is the degree to which the same network links occur at two or more points in time. Nodal farmers were identified by using the criteria such as frequency of mention of their names, their number of links in the network, source of information and perceived knowledgeable persons on seed-related matters. These results were then compared with the results of 2001 survey.

Results

Flow of genetic materials

The current study revealed that informal seed flow through exchange and gift is still a predominant system across the study villages (Table 1) in addition to the self-retained seed exchange that remains the major mechanism of the seed flow, although there is a variation in the degree of seed flow through exchange when compared between 2001 and 2004. There has been an increase in exchange of seed in Begnas, while it has decreased in Khola ko Chheu and Kachorwa. Seed flow through gift has remained the same in Begnas as well as in Khola ko Chheu; but has decreased in Kachorwa. But procurement of seed through purchase has drastically increased in Kachorwa during 2004 (39% in 2004 compared with 9% in 2001). This is mainly due to the introduction of modern varieties in the Kachorwa area where farmers have been attracted more toward such varieties. The introduction of MVs has implications for landrace conservation, and if this trend increases in the future then only a very limited number of landraces that have more economic value (e.g. *Lalka basmati*) will remain as long as such landraces can compete in the market with the MVs. Kachorwa is closer to markets including those in India across the borders, and farmers have been exposed to research and extension institutions, and therefore they have easy access to the MVs.

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6 Snowball sampling involves an initial sample of respondents as ‘starters’ from whom data on their network links are collected. The sociometrically indicated individuals in the first round of starters then become the second-stage respondents. These second-stage respondents consequently lead to the third-stage respondents and so on. Thus the snowball sampling follows a multistage design in which respondents at each stage sociometrically determine who the respondents will be at the following stage (Burt 1980; Knoke and Kuklinski 1982; Rogers and Kincaid 1981; Scott 1991).

Table 1. Comparison of means of informal flow of seed materials of rice through farmers' networks between 2001 and 2004 surveys.

Means of flow	% flow of genetic materials					
	Begnas		Khola ko Chheu		Kachorwa	
	2001	2004	2001	2004	2001	2004
Exchange	53	64	58	54	64	56
Gift	31	30	36	38	17	5
Purchase	16	6	6	8	9	39

Farmers' networks and stability

The study has revealed that although old network links within the community do exist, new network links have emerged over time in all three villages. A comparison of the old network links during 2001 and 2004 shows that 62%, 44% and 56% of the previous network members are the same in Begnas, Khola ko Chheu and Kachorwa respectively as those in the previous networks over this period. The rest of the current links are new members. New members of the networks are attributed mainly to natural calamity (heavy hailstone occurrence in 2002 in Begnas and Khola ko Chheu) while it is the easy access of markets as source of seed of new varieties in Kachorwa area that led to an opportunity for new contacts to obtain seeds. The heavy hailstorm in Begnas and Khola ko Chheu in 2002 during the crop-maturing stage severely destroyed the crop, which had an impact on total crop production and hence availability of enough seed for planting for the next season. Most farmers therefore retained seed lots from the available production instead of keeping for consumption.

Nodal farmers and their stability

While examining the network links on who occupies central positions in the seed network and in the flow of genetic materials, the study indicates that there are still some key nodal farmers[7] who are playing a significant role in the flow of genetic materials in the community; and these nodal farmers have been instrumental in managing the process of varietal diversity at both the household and the community levels. The numbers of such nodal farmers in each of the three study villages have remained almost similar over time. However, not all the nodal farmers identified in 2004 are the same as those in 2001 (Table 2). The study reveals that only 22% in Begnas, 53% in Khola ko Chheu and 35% in Kachorwa are the same individuals who have remained as the nodal farmers over the two time points, i.e. 2001 and 2004. These farmers are considered the stable nodal farmers in the seed flow networks over the last 3-year period. Of these stable nodal farmers, the ratio of female nodal farmers has decreased with 20% in Begnas compared with 45% in 2001, 25% in Khola ko Chheu compared with 40% in 2001, and 14% in Kachorwa compared with 17% in 2001. This decline of women nodal farmers is accompanied by the emergence of new network memberships with more men dominating the networks. However, the role of women farmers is still higher in the hill communities than in the *terai* community.

Table 2. Comparison of nodal farmers and their stability over time (2001 and 2004).

Begnas			Khola ko Chheu			Kachorwa		
2001	2004	Same	2001	2004	Same	2001	2004	Same
22	23	5 (22%) 4 males, 1 female	14	15	8 (53%) 6 males, 2 females	24	20	7 (35%) 6 males, 1 female

[7] Nodal farmers are identified from criteria such as higher number of network links in terms of giving out and receiving seed, perceived as the most knowledgeable person in terms of seed-related matters and those who are maintaining more diversity in terms of number of varieties/landraces.

Respondents were asked to give their perceived reasons for change in their sociometric network links in terms of seed flow (as receiver as well as giver within the network members) over the last 3 years. The reasons for changes over time in networks and nodal farmers have been perceived as shown in Table 3.

Table 3. Reasons for change in network members and nodal farmers as seed source.

Reasons	Begnas	Khola ko Chheu	Kachorwa
Variety/landrace not available at home	√	√	√
Own seed not sufficient at home mainly because seed lost due to natural calamity	√	√	—
Quality of own seed decreased/seed replacement needed	√	√	√
Better-quality seed available from new source	√	—	√
Change in generation	√	√	—
Search for variety/landrace for more production / productivity	√	—	—
New and better variety introduced or available from market (e.g. hybrid and other new varieties)	—	—	√

The major reason across the three villages was that most farmers wanted to grow a particular variety/landrace that they had not grown earlier. Such varieties/landraces did not necessarily exist with the nodal farmers or the farmers with previous network links. Majority of the respondents revealed that this was due to their exposure to diversity fairs, which created awareness among the farmers about the importance of agricultural biodiversity conservation and creating varietal diversity on their farms, and also the knowledge on who had maintained which variety and/or landrace.

However, the important factor in Khola ko Chheu on the breaking down of the previous links was the devastating hailstorm during rice crop maturity period in 2002, which damaged more than 75% of rice crops in the area, and most farmers in the village lost most of their landraces. This forced farmers to obtain seed from outside the village, thus affecting their seed flow networks but their first preference was the landrace that they had grown before. The same natural calamity also affected Begnas area but to a lesser extent and most farmers could still retain their own seed although the quantity available to them was not enough, and hence several Begnas farmers also had to access seed from farmers outside the village. In Kachorwa, there have been more new varieties including hybrids from the market and farmers were attracted to these new varieties for more production and other economic reasons.

Discussion and implications

The present study has empirically demonstrated that certain individuals and their networks in the community do play significant roles in the flow of genetic materials and the process of agricultural biodiversity management at household and community levels. A certain degree of stability of the networks and the nodal farmers does exist over time, despite the fact that some external and internal forces affect the network links and social structure, resulting in a change in stability of the networks and the nodal farmers over time. From interpretation of the results of the study, two kinds of nodal farmers have been identified: the system nodal farmers and the subsystem nodal farmers. The stable nodal farmers are the system nodal farmers recognized by the communities at large over different periods of time, while subsystem nodal farmers are the ones who have evolved as new focal contacts demanded by the emerging needs and in spatial proximate circumstances. Subedi and Garforth (1996) also observed similar system and subsystem leader farmers with regard to the flow of information and communication among the hill farming communities of Kaski and Syangja districts of Nepal. These two categories of nodal farmers can be mobilized in distinct roles. Because of the stable nature of the system nodal farmers, they can be effectively involved in diversity deployment through participatory plant breeding (PPB), participatory variety/landrace selection (PVS/PLS), seed production and as resource persons for training activities. The subsystem nodal farmers can be effectively involved in awareness and farmer-to-farmer dissemination at different subsystem/settlement levels. However, strong coalition of the system and subsystem nodal farmers is important to strengthen the network linkages among these two kinds of nodal farmers, which will enhance the informal seed supply system. This approach will effectively and efficiently contribute towards conservation and utilization of agricultural biodiversity at the household as well as landscape levels, while also facilitating wider diffusion of genetic materials at the landscape level and beyond, contributing to conservation of agricultural biodiversity.

Conclusion

Network and network analysis has little predictive value unless there is a certain degree of stability in a system. It is assumed that network stability changes over time. Complete stability neither continues to exist nor is there incomplete instability in a social system. Thus over time the network data are necessary to determine the effects of certain interventions and its consequences in a system. Such a study is even more important to understand the dynamics of the social system in relation to a longer-term objective of understanding how the informal systems that prevail in the farming communities can be better strengthened in the conservation and utilization of agricultural biodiversity. Continuous longitudinal data are necessary in order to have a complete understanding of the network, nodal farmers, and their stability in a given community. Such investigation and understanding over time will firmly contribute to management of agricultural biodiversity and would help plan the conservation initiatives effectively.

Acknowledgements

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Enabling and empowering

Community biodiversity register (CBR): lessons learned from the registers maintained at Begnas village of Nepal

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Abstract
Community biodiversity register (CBR) is a participatory tool to monitor local crop diversity, empowering farmer's decision-making, creating awareness and enhancing local seed systems. In Nepal, CBR was initiated by the Global On-farm Diversity Project in 1998 to strengthen *in situ* conservation of crop diversity on-farm. Initially, CBR was piloted in Nepal in three different villages: Talium, Begnas and Kachowra representing high-hill, mid-hill and *terai* agroecosystems, respectively. In Begnas, CBR was implemented with 18 farmers' groups for the mandate crops (rice, finger millet, taro, cucumber and sponge gourd). Each household of the community-based organizations recorded the information by themselves for 2 years (1999–2000 and 2000–2001) to see changes on varietal diversity.

A database of the CBR register for the 2 years from Begnas was analyzed with the objective of sharing results with the community. At household level indicators for monitoring local crop diversity were identified. Comparative information between 2 years of varieties grown, area coverage, source of seed, amount of seed used, production rate, lost varieties, threatened varieties, newly introduced varieties, agroecology, use values associated with each individual varieties was provided. At community level, varieties dynamics were measured by analyzing the relationships between number of farmers and area coverage/or number of vines grown. Farmers and community-based organizations (CBOs) maintaining unique and large diversity were identified; varieties grown by few households in a small area were listed. The results, methods and approaches will be shared with farmers, farming communities and other concerned stakeholders. It is too early to conclude whether CBR information will empower the communities to manage their valuable biodiversity through a community management plan. However, we can predict that it will be useful to farmers, farming communities, private entrepreneurs and research and development workers for the management of agrobiodiversity at community level.
Key words: Community biodiversity register, community-based organizations, mandate crops, four cell method, on-farm conservation

Introduction
In recent years, different methods to document the knowledge base on genetic resources held by local communities have been initiated such as Community Seed Register and Village Community Register (FRLHT 1998) and Peoples' Biodiversity Charter (Gagdil and Rao 1998) in India. In Nepal, a Community Biodiversity Register (CBR) was initiated by the global On-farm Diversity Project in 1998 to strengthen *in situ* conservation of crop diversity on-farm. Initially, CBR was piloted in Nepal in three different villages: Talium (Jumla); Begnas (Kaski) and Kachowra (Bara) representing high-hill, mid-hill and *terai* agroecosystems, respectively to inventory local genetic resources and knowledge base of farming communities. The purpose of CBR is to build capacity of local institutions to manage information at community level for on-farm management of agrobiodiversity for social, economic and environmental benefits. CBR refers to "a record, kept in a paper or electronic format by community members, of the genetic resources in a community, including information on their custodians, passport data, agroecology, cultural and use values" (Sthapit *et al.* 2001).

During the process, the potential benefits of CBR were identified at different categories of stakeholders—primary (e.g. farmers), secondary (e.g. promoters, researchers) and tertiary (e.g. development workers)—and found supportive to (Rijal *et al.* 2003):

- record inventory of all crop genetic resources linked with their livelihoods
- strengthen access to information and crop seeds
- strengthen market and seed networks
- document status of crop resources with reasons for maintenance
- records database useful to research and development (R&D) workers
- help the process of developing sense of ownership at grassroots level
- help in describing ecology and diversity with area-specific needs identified

Thus, CBR as a method can be used for a number of purposes from developing R&D bases through to strengthening grassroots in monitoring local crop diversity, empowering farmer's decision-making process, creating awareness and enhancing local seed systems and other information in an effective and participatory manner. The concepts of CBR in Nepal, the objectives, rationale, process and methodology, the opportunities and challenges of CBR, and its importance and potential role in strengthening on-farm conservation of agrobiodiversity in Nepal are well discussed by Rijal *et al.* (2000, 2003).

Despite having noble aims and objectives, translating the CBR concept into reality on the ground proved much more difficult than initially thought by the project team members. Farming communities and researchers both realized that the CBR implementation process as adopted by the project was time and resource demanding. Farmers had difficulty understanding the immediate benefits from the collection of such information. Dwindling farmers' interest to participate in maintaining CBR registers illustrates that the value of CBR is not well understood. Therefore, it has been realized that the current CBR process needs to be reviewed with consideration of the lessons learned during implementation and future sustainability of CBR for on-farm management of agrobiodiversity. Once the review was agreed, a series of village-level workshops at project-site level were conducted where farmers and project site staff shared their experiences and analyzed the existing problems and constraints during implementation of CBR (Paudel *et al.* 2003). On the basis of feedback from communities, National Project Management Team (NPMT) members critically reviewed the process and suggested sets of priority action plans to further improve CBR methodology.

The rationale behind the present data analysis is to address some of the priority action plans listed by NPMT for the refinement of CBR methodology. The primary aim of the exercise is to share the results with communities and identified CBR stakeholders to document their decisions made over the conservation and utilization of agrobiodiversity including the review of the CBR method. The results are the outcomes from the exercise of CBR data analysis of Begnas (Kaski) ecosite only. In Kachorwa (Bara) only a few households recorded the information in registers; therefore, further data recording is underway. In Talium (Jumla) we have initially recorded in a few households. Since the site itself was rejected from the *in situ* project, there has been no continuation of CBR activities.

CBR implementation process

At community level

CBR has been implemented through farmers' groups (CBOs) coordinated by nodal local institutions for the identified mandate crops (Table 1). Local resource persons were developed through training and orientation within each CBO who had facilitated the documentation and entered information in registers. Registers were maintained at community level and CBO members entered the data during their monthly meetings.

Table 1. CBR villages, agroecosystem, crops and CBOs.

Village	Agroecosystem	Crops under CBR	Nodal CBO	CBOs	HHs
Talium (Jumla)	High-hill (2200–3000 masl)	Rice, finger millet, buckwheat, barley, taro, cucumber		19	759
Begnas (Kaski)	Mid-hill (600–1400 masl)	Rice, finger millet, taro, cucumber, sponge gourd	DEPC	22	941
Kachorwa (Bara)	*terai* (80–90 masl)	Rice, finger millet, taro, cucumber, sponge gourd, pigeon pea	ADCS	21	914

Source: Paudel *et al.* (1999), Rana *et al.* (2000).

At Begnas ecosite, of the 22 CBOs existent, 18 were involved in documentation of CBR information. The local club—Development and Environment and Protection Club (DEPC)—was selected as the nodal local institution for the coordination and effective implementation of CBR, on the basis of its existing strength. Each household of the CBOs recorded their information on mandated crops for 2 conservation years (1999–2000 and 2000–2001) to see changes in varietal diversity.

At site and project levels

Project site staff, representative members of CBOs, and thematic team members constituting the Local Project Management Team (LPMT) were involved in providing training and orientation to local resource persons and CBOs on CBR documentation. LPMT is responsible for field-level planning and implementation of CBR activities (Figure 1). It is also involved in monitoring of field activities to ensure work quality during data entry. All thematic leaders constituting a multidisciplinary team were involved in conceptualizing the CBR method, setting goals, its approaches and importance, process and methodology. NPMT jointly with field-level experiences and feedback of LPMT took responsibility to formulate protocols of CBR. Similarly, NPMT members were involved in awareness-creation activities at local, regional and national levels.

Methods and materials

Baseline information

The farmers' groups for CBR implementation were selected from among the sampled farmers of Baseline survey 1999 categorized through wealth ranking at Begnas ecosite (Rana *et al.* 2000). The Baseline survey findings on the key crops such as rice, finger millet, taro, sponge gourd and cucumber were an important reference to help analyze the records of CBR.

Data analysis

Participatory meetings

To be clear on the principle behind the data analysis of CBR, meetings were organized with nodal farmers, project site staff and thematic team members of the project. In the process, individual members shared their views regarding the process, steps and methods to be followed during CBR data analysis. On the basis of discussion, a draft protocol on CBR data analysis was prepared and shared among the professional team members for their feedback.

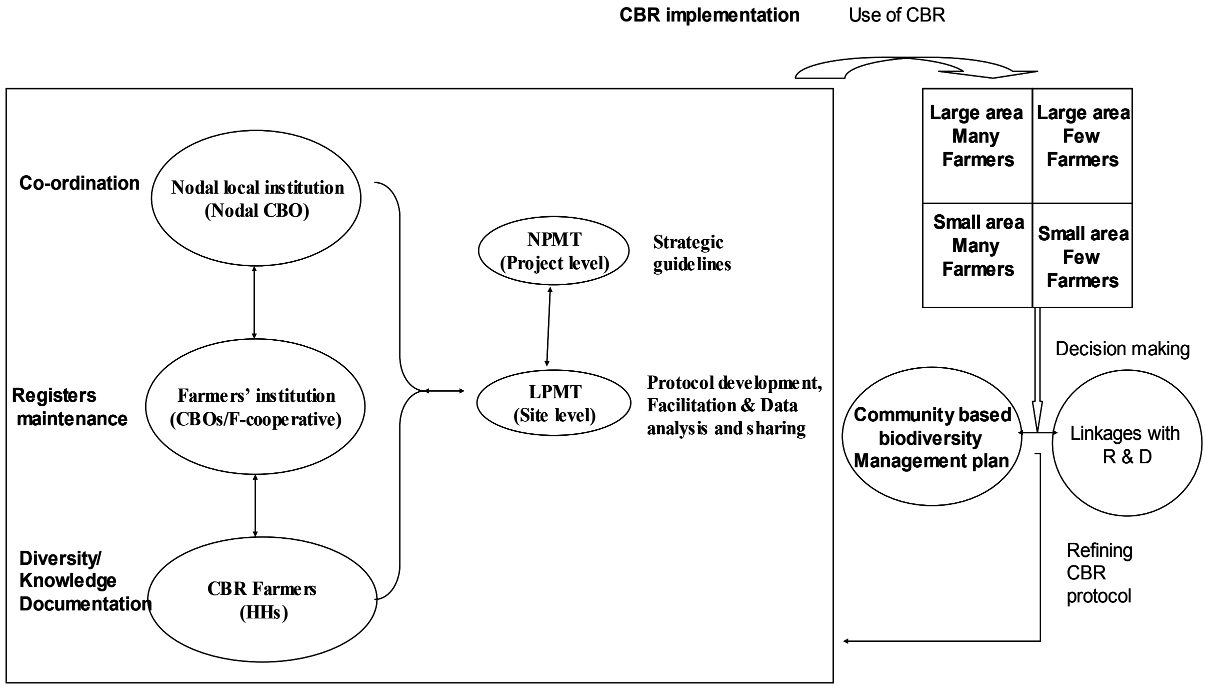

Figure 1. CBR implementation framework.

Review of literatures and CBR registers

Since the project has limited practical knowledge on the process of data analysis of CBR, available documents related to CBR were reviewed (Rijal 2000; Rijal *et al.* 2003). During review of CBR registers we found that information was missing, repeated or unclear. Therefore, all registers were reviewed and checked for ambiguous, missing, repeated or unclear information with the help of nodal farmers and field staff. In the process, local measurement units for area; seed quantity and production were converted into a standard unit.

Data entry and analysis

Statistical tools like Microsoft Excel and SPSS were identified for data entry and analysis of CBR, respectively. The qualitative traits of mandated crops were first listed, then coded. The area status of farmers for consecutive years also was coded. Descriptive statistics, report case summaries, frequencies and four-cell methods were employed for data analysis. Summary tables of landraces and modern varieties of rice, list of rare cultivars that are grown by fewer than five households, common and potentially threatened cultivars, list of farmers maintaining highest diversity, list of farmers' groups maintaining highest diversity, total number of cultivars maintained by each farmers' groups were analyzed and identified.

Four-cell method

Four-cell has been increasingly used to make conservation decisions for a particular variety or landrace growing in specific environments. Landraces/varieties falling in different cells will have different use-values, which are very important for conservation purposes. It is generally used to classify different landraces/MVs based on the current 'use value' to the farmers. The objectives behind the use of four-cell analysis in CBR data analysis are:

- to share the CBR results with farmers in a simple and easy way
- to record the community decisions over the CBR results and document why a particular variety has been grown in a large area by many farmers while some varieties have been grown in a small area by a few farmers
- to further validate the four-cell methodology in conservation and utilization of plant genetic resources.

However, identifying the cut-off point in four-cell is a very delicate process. Slight changes in scale it could produce different results. A review of the literature with concerned crops had shown insufficiency in identifying the cut-off point. Therefore, a series of discussions was held with *in situ* project professionals to get more information, and to identify the cut-off point of mandated crops, interviews or focus group discussions with 54 key male and female informants were carried out to record their knowledge and perceptions (Table 2). The minimum, average and maximum area coverage or number of vines grown for the particular variety in each household of the community were identified; from this, a cut-off point for each crop was calculated.

Table 2. Cut-off point for mandate crops.

Crop	Cut-off point
Rice	500 m^2
Finger millet	1000 m^2
Taro	64 m^2
Sponge gourd	3 vines
Cucumber	2 vines

Source: Rana *et al.* (2000), Focus Group Discussions, 2004.

Limitations of data-analysis

Existing registers contained insufficient data for a detailed and accurate analysis. Analysis of only 2 years' data does not provide the exact status and trends in crop genetic diversity. In some cases, consecutive-year records and certain fields (data) on CBR were missing. Production rate of sponge gourd and cucumber could not be analyzed because the production units were so diverse it was impossible to validate in the field. Some cultivars were merged into one with the help of FGD with nodal farmers and field staff's experiences without any isoenzyme tests in laboratory. The four-cell method lacks concrete methodology for determining cut-off points of different crops although the cultivars are placed in four cells according to the FGD and Project baseline report 1999.

On the basis of information entered in registers, we could not present the answers to why certain varieties have been maintained in a large area by many farmers while others have been maintained by few farmers in a small area. This needs to be discussed with farmers on the basis of present four-cell study results.

Results and discussion

Varietal dynamics at Begnas ecosite

The total number landraces/varieties recorded in CBR for all crops was higher than the number reported in baseline reports (Rana *et al.* 2000). In 2 years, some changes were observed in number of cultivars and area coverage of rice and finger millet within the community (Table 3). Two landraces of rice (*Barmeli* and *Parampyuri*) grown by farmers in 1999–2000 were not grown in 2000–2001, but two new cultivars (*Chinia* and *Khalti khole*) were introduced. Two landraces of finger millet (*Choto jhyape* and *Seto dalle*) were not grown in 1999–2000 but were introduced by farmers in 2000–2001. For other crops, within 2 years there is no observation of any significant changes (Table 3).

Table 3. Status of rice, finger millet, taro, sponge gourd and cucumber at Begnas in CBR registers, 1999–2000 to 2000–2001.

Crop	Total HHs		Total varieties		Seed requirement		Area coverage (m² or vines)		Production (kg)	
	99–00	00–01	99–00	00–01	99–00	00–01	99–00	00–01	99–00	00–01
Rice	426	420	76	76	82339	8179	2349153	2323423	1557197	321991
Finger millet	296	291	28	30	1008	981	571508	630703	55058	43362
Taro	354	356	17	17	6281	6605	76625	78639	30312	26033
Sponge gourd	400	397	12	12	1831†	1866†	1832‡	1867‡		
Cucumber	269	272	9	9	1376†	1284†	1376‡	1284‡		

† Number of seeds.
‡ Number of vines.

Although a number of landraces/varieties have been maintained by farmers owing to specific agroecology requirement and local use–values, a few varieties have been grown in larger areas for their potential use values. In rice, *Ekle, Mansuli* and *Madhese* occupied 32% of total area of rice. *Jhyape, Dalle kodo*, *Kalo jhyape* and *Seto dalle* occupied a major portion (81%) of the total area of finger millet. In taro, *Hattipau*, *Khari* and *Ratomukhe* occupied 62% of total area. *Bhakapure*, *Madale* and *Kheer kakro* occupied 77% of total area of cucumber cultivars. In sponge gourd *Hariyo choto* and *Hariyo laamo* occupied the major portion (76%) of total area of sponge gourd cultivars.

Status of landraces and modern varieties

The landraces of rice were more dominant than MVs. Modern varieties occupied 29% of total area in both 1999–2000 and 2000–2001, whereas landraces occupied about 71% of total rice area. Only 14 MVs were grown by 290 households and 64 landraces were grown by 405 households. Out of a total of 78 rice cultivars, more than 50% were grown by fewer than five households; these are rare cultivars. Two years of data on this revealed that 20 cultivars in 1999–2000 and 23 cultivars in 2000–2001 had been grown by single households, respectively. The data analysis of CBR also recorded information on farmers growing rare landraces/varieties in Begnas ecosite.

In finger millet, all varieties grown are landraces. Of the total 30 cultivars, 17 are rare (Figure 2). In taro, some of the rare landraces of taro were cultivated by fewer than five households, accounting for 23.5% of total taro cultivars. Of 17 taro landraces documented in CBR records, 4 were rare and grown by fewer than five households in 1999–2000. In 2000–2001 there were only 3 rare landraces.

In cucumber, local varieties of cucumber were more dominant at Begnas ecosite than MVs, which occupied 36% (493 vines) and 29% (367 vines) of total area in 1999–2000 and 2000–2001, respectively. The total area coverage of MVs decreased in 2000–2001 but the number of households cultivating them increased, whereas the area coverage of landraces increased and households growing them were approximately same.

In sponge gourd, there were only 2 modern varieties out of a total 12 sponge gourd cultivars. In 1999–2000, of a total 400 households only 5 HHs (1.25%) grew modern varieties of sponge gourd and in 2000–2001, out of 397 households only 7 HHs (1.76%) grew MVs. Modern varieties occupied about 0.55% of total area in 1999–2000, and 0.75% of total area in 2000–2001. The sponge gourd landraces occupied nearly 99% of total area in both years. The total area coverage and number of households of modern varieties slowly increased, whereas the total area coverage for landraces increased and the number of households growing them decreased in 2000–2001.

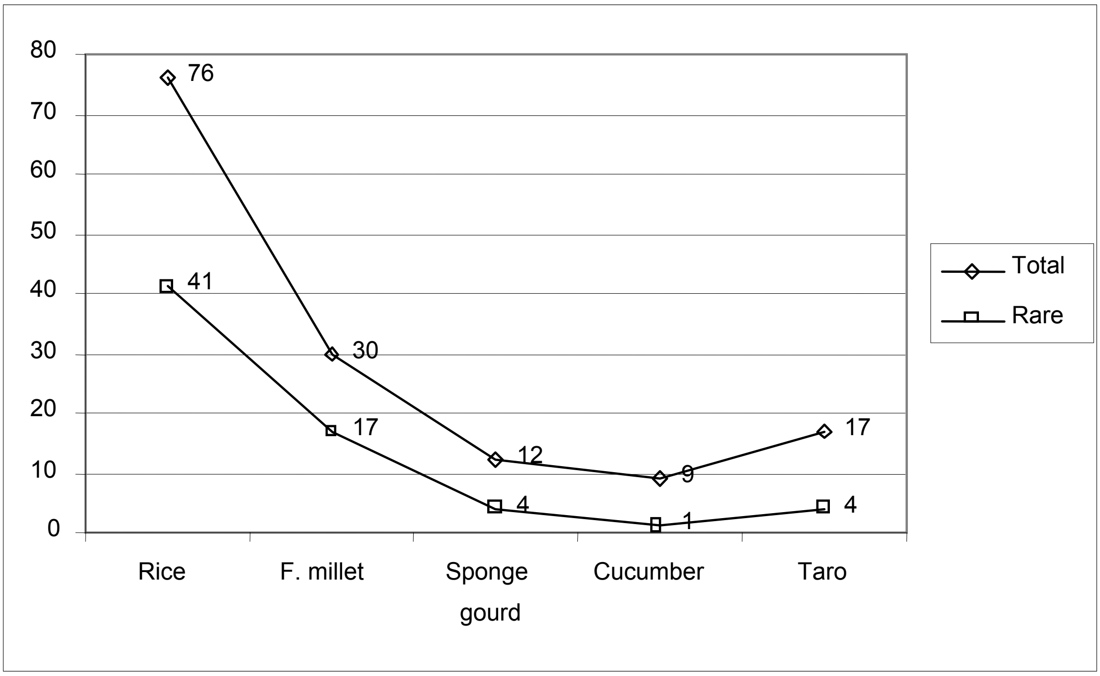

Figure 2. Varieties grown by fewer than 5% sample households at Begnas ecosite.

Common and potentially threatened cultivars

The four-cell method was used to study potentially threatened and common landraces/varieties. A summary of results of four-cell studies is given in Table 4.

Altogether, 41 landraces/varieties were found as rare (grown by fewer than 5 HHs) which accounts for 52.5% of total varieties of rice as shown by the CBR information. *Thulo madhese* and *Radha*-9, cultivated by many farmers/large areas in 1999–2000, were cultivated by few farmers/large area in 2000–2001. *Jyaudi khole*, grown in large area/few farmers in 1999–2000, was grown in small area/few farmers in 2000–2001. Similarly, new cultivars introduced in 2000–2001 also fall under large area/few farmers, whereas *Parampyuri* was not found to be grown in 2000–2001. *Makwanpure* and *Darmali*, grown in small area/few farmers in 1999–2000, were grown in large area/few farmers in 2000–2001, whereas *Barmeli* was not found to be grown in 2000–2001. The cultivars in small area grown by many farmers were similar in both years.

In finger millet, fewer than five households grew 56.6% of the total landraces. Among these, 7 cultivars were grown by single households in both years. The number of landraces grown in both large and small scale by many households were the same but *Setodalle kodo* replaced *Dhani kodo*; *Dhani kodo* was grown in small area/few households that year. *Choto jhyape*—introduced in 2000–2001—was also grown by a single household.

Four landraces of taro were cultivated by fewer than five households in the first year; by the next year, there were only 3 rare landraces. *Panchamukhe* was grown in large area/few farmers in the first year, and by many farmers in 2000–2001. One household grew *Setomukhe* in both years.

In sponge gourd, most cultivars were grown in a small area. Four rare cultivars were grown by fewer than five households, accounting for 33.3% of the total sponge gourd cultivars grown at Begnas. Only one cultivar (*Seto lamo*) was very common, grown in large area by many households. One household grew the *Tirai* landrace.

Most cucumber cultivars were grown in a large area/many households, except *Barse kakro*, grown by only two households. *Majhaula kakro* was grown in small area/many households. *Local kakro*, grown in small area/few households in 1999–2000, was grown in a large area by few farmers in 2000–2001.

Table 4. Status of landraces/varieties of mandate crops at Begnas ecosite.

Crop	Large area/many farmers	Large area/few farmers	Small area/many farmers	Small area/few farmers
Rice	*Ekle, Gurdi, Kathe gurdi, Mansara,* ***Mansuli****, Madhese, Thulo madhese, Jetho-budho, Pahele,* ***Radha-7****,* ***Radha-9****,* ***CH-45***	*Thulo kalo gurdi, Thulo seto gurdi, Lahare gurdi, Majhathane gurdi,* ***Thulo mansuli****,* ***Sano mansuli****, Naulo madhese, Sano madhese, Raate, Laame, Jhauri, Biramphul, Jyaudi khole, Gauria, Ramani,* ***Chaite****, Seto ghaiya, Rato ghaiya, Gurdi ghaiya, Jiri ghaiya, Manamuri, Nepte, Parampyuri, Khalti khole, Chinia*	*Dhabe jarneli, Jhinuwa, Seto anadi, Rato anadi*	*Paakhe jarneli, Paakhe jhinuwa, Tunde, Aanga,* ***Chote dhan****,* ***Janaki****, Mala,* ***Sabitri****,* ***Makwanpure****,* ***Chote makwanpure****, Ramshali, Basmati, Kohili, Naltume, Bayarni, Kalo bayarni, Makai khole, Marsi, Adhere marsi, Ruduwa, Sidali, Juwadi, Paakhe Ramani,* ***Chaurasi****,* ***Taichin****, Ghaiya, Jhinuwa ghaiya, Mansuli ghaiya, Kanajiri ghaiya, Bale, Khumal, Thapachinia, Darmali, Krishnabhau, Jirasari, Barmeli, Phalyangkote*
Finger millet	*Jhyape, Kalo jhyape, Seto jhyape, Dudhe kodo, Dalle kodo, Kalo dalle*	*Mangshire jhyape, Seto larke jhyape, Laamo jhyape, Kalo kodo, Pahelo kodo, Ashoje, Seto dalle, Sirkutane, Nawalpure, Dhani kodo, Kartike dalle, Thulo kodo, Charme kodo*	*Samdhi kodo, Hetaude*	*Choto jhyape, Seto kodo, Lafre, Kukurkane, Barse kodo, Pangdure kodo, Aarbali dalle, Rato jhyape, Urcho kodo*
Taro	*Aasame pindalu, Hatipau, Khari, Khujure, Rato khujure, Seto khujure, Ratomukhe*	*Gyante pindalu, Panchamukhe, Setomukhe, Seto thado pindalu, Thado khari*	*Kalo pindalu, Lahure, Seto pindalu*	*Juke pindalu, Thaune pindalu*
Cucumber	*Sano hariyo kakro, Thulo hariyo kakro, Bhudke, Madale, Kheer kakro,* ***Bhaktapure***	*Barse kakro*	*Majhaula kakro*	*Local kakro*
Sponge gourd	*Seto laamo*		*Hariyo chhoto, Hariyo laamo, Hariyo madhyam, Seto chhoto, Basaune*	*Majhaula, Khirauli, Tirai, Jhingeni,* ***Baishaki****,* ***Heude***

Note: **Bold face** varieties represent the changing dimensions in two years.

Seed flow and storage

Most of the records in CBR lacked information regarding seed quantity and production. For cucumber and sponge gourd, farmers used diverse measurement units according to the yield as high, consistent and low. This has created difficulty in standardizing farmers' production units. Most of the farmers preserve their own seed as a seed source for the coming year and some depend on neighbours, different farmers' groups, villages, nodal farmers and organizations working in the community. In 2000–2001, the production of rice decreased and farmers recorded the information that there was heavy hailstorm in that year.

Unique use values

For each mandated crop, farmers documented their information on agroecology, crop biology, morphology and sociocultural use values. The important information perceived by farmers in describing the cultivars and their use values documented from CBR are broadly illustrated in Table 5.

Table 5. Farmers' descriptors and local use values of mandated crops.

Crop	Farmers' descriptor(s)	Unique use values
Rice	Aromatic, early maturity, non-lodging, produced in off-season, delay appetite, disease resistant, flood resistant, drought tolerant, shade bearer, low moisture and nutrient required more tillers and long straw.	Cultural value, good quality of *Latte*, *Siramla*, *Chiura*, *Khatte*, Medicinal value (specially for cooling effect and suitable for maternity period), straw mat, quality cooked feed for livestock
Finger millet	Early maturity, disease resistant, less damaged y birds, large and compact head, white flour, easily digestible, long straw with more tillers, high yield.	Cultural value, medicinal value, *Puwa*, *roti*, porridge, quality cooked feed for livestock
Taro	Early maturity, found in off-season, insect resistant, large corms, many cormells, more no. of eyes, non-acrid, high yield	Cultural value, medicinal value, food. Corm: boiled and eaten, pickle, curry Cormel: boiled and eaten Karkalo: masaura, khasaura, tandra, gava, bhujuri, stem pickle, curry, suira
Cucumber	Early maturity, late fibering, found in off-season, high yield	Medicinal value, pickle, salad
Sponge gourd	Early maturity, found in off-season, aromatic, late fibering, high yield	Cultural value, medicinal value

Diversity of mandate crops at farmers and community level

The average varieties grown for rice, finger millet, taro, cucumber and sponge gourd varieties by individual households of Begnas was found 4, 2, 2, 1 and 2, respectively. Average varieties of these crops per farmers' group was 20, 7, 9, 5 and 6, respectively. However, few farmers and farmers' groups have been maintaining unique diversity of mandate crops (Tables 6 and 7). It is worth mentioning here farmers' group, e.g. *Dadathar, Aduwabari*, *Paurakhe, Rupasrijana, Archalthar* and *Kotbari*, are maintaining more than 80% of diversity alone.

Table 6. Status of number of varieties of mandated crops maintained by farmers' groups or CBOs at Begnas.

Farmers' groups/CBOs	Rice		Finger millet		Taro		Cucumber		Sponge gourd	
	99–00	00–01	99–00	00–01	99–00	00–01	99–00	00–01	99–00	00–01
Aduwabari	28	27	7	8	8	9	4	4	5	5
Archalthar	25	25	7	8	9	9	6	6	6	6
Bibekshil	6	5	0	0	0	0	0	0	3	3
Bishaunethar	19	21	7	8	9	9	5	6	6	6
Chaur	10	10	11	12	7	9	5	5	3	4
Dadathar	40	41	13	14	12	12	6	6	7	7
Devistan	15	16	0	0	0	0	0	0	0	0
Jamankuna	17	17	6	7	8	8	4	4	4	5
Kholakobesi	13	15	7	7	8	9	5	5	4	4
Kotbari	25	25	10	11	12	12	6	6	4	4
Majthar	24	24	11	11	10	10	5	5	8	8
Paudelthar	11	10	4	5	7	7	4	4	3	3
Paurakhe	28	28	6	7	9	9	8	8	5	5
Rupasrijana	26	23	4	4	11	11	4	5	6	7
Simalpata	8	9	4	4	6	6	3	3	4	4
Talpari	19	19	7	11	10	10	7	7	7	7
Unnatishil	25	25	9	10	10	10	4	4	8	8
Uppalo talbesi	15	15	5	5	9	9	4	4	3	3

Table 7. List of farmers maintaining the highest diversity of mandate crops at Begnas ecosite.

Name of farmer	No. of cultivars		Name of farmer	No. of cultivars	
	99–00	00–01		99–00	00–01
Rice			***Cucumber***		
Bishnu Hari Tiwari (Archalthar)[†]	20	19	Ganga Adhikari (Dadathar)	4	4
Ganga Adhikari (Dadathar)	16	16	Taranath Tiwari (Paudelthar)	4	4
Somraj Sapkota (Paurakhe)	15	15	Kali Pandey (Kotbari)	3	4
Padam Kumari Adhikari (Bisaunathar)	15	15	Srikant Sapkota (Talpari)	3	4
Finger millet			***Sponge gourd***		
Lila Pandey (Kotbari)	7	7	Ram Chandra Adhikari (Unnatisil)	5	5
Ganga Adhikari (Dadathar)	7	7	Somnath Kandel (Aduwabari)	4	4
Bishnu Hari Tiwari (Archalthar)	5	5	Sumitra Tiwari (Archalthar)	4	4
Sharda Adhikari (Bisaunathar)	5	5	Thirraj Tiwari (Archalthar)	4	4
Padam Kumari Adhikari (Bisaunathar)	5	5	Padam Kumari Adhikari (Bisaunathar)	4	4
Taro					
Saraswati Kandel (Aduwabari)	7	7			
Srikant Sapkota (Talpari)	7	7			
Taranath Tiwari (Paudelthar)	7	7			
Ganga Adhikari (Dadathar)	7	7			
Bayan Thapa (Archalthar)	6	6			
Bel Subedi (Bisaunathar)	6	6			

[†] Name in parentheses indicates the respective name of their group or the CBO.

Discussion

Lessons learned from the CBR data analysis

Although farmers have maintained the CBR for a 2-year period, it is not adequate to understand clearly the trend of different cultivars. However, analysis of the CBR registers of 2 years has provided important information on the mandated crops. During analysis, we encountered several problems that were solved through discussion as a team or through a literature review or with FGD with farmers.

Recording information in registers

This was the most complicated and challenging work in data analysis. A slight change in community perception may give different results. On the other hand, we found several ambiguous, repeated and missing information sheets which were later resolved through field validation (FGD with key resource persons or interview with concerned personnel). In particular, we found several such problems in the column for seed sources, unique use/values and production rate. Similarly, the farmer units employed for area coverage and production were so diverse and different that lots of field exercises are needed to change them into a standard unit. Therefore, implementation of CBR should have sufficient resource materials, training and orientation. Developing separate resource persons to facilitate the documentation is not always viable; therefore, it should be explored from within the CBO.

What are the methods to share the results?

During data analyses, a constant consideration was how the information should be shared and interpreted with farmers and other stakeholders, and in what forms. We have focused on tabular and graphic means. The four-cell method was selected to determine the changes in status of cultivars and to use the conservation decisions of the local community to record the varieties in the different cells.

Meeting with CBR hypothesis and objectives

CBR basic objectives like documentation, inventorying and monitoring of agrobiodiversity can be well illustrated with present registers information. The CBR has strength for recording information on varietal diversity, its dynamic, seed requirement and production. However, to record farmers' knowledge on specific use-values and agroecology, criteria given in the registers seem insufficient and need to be reviewed through consultation with farmers. Similarly, we need to strengthen the capacity of CBR resource farmers on recording such information in the registers.

Lessons learned from the CBR process

In one sense, the progress achieved so far by the farming communities and project during implementation of CBR was restricted to entering information in the registers and building some local capacity to facilitate the process. However to achieve the anticipated CBR goals and objectives, we still should strengthen and review our approach and methods, and incorporate the lessons learned while implementing CBR at different levels. Therefore, we raise here the relevant issues which are based on lessons learned during the CBR data analysis and discuss them broadly on three levels: community, project and national/policy levels.

At community level

During the initial stage of implementation, we are conceptually clear about the potential use/values of CBR but we do not have any case examples to share with farmers to demonstrate that CBR will result in tangible benefits for them and will enhance on-farm agrobiodiversity management. Recording and documenting information in registers was found to be complicated and time consuming tasks for farmers since there was no immediate benefit from it. Therefore, the project has adopted process-led and participatory approaches. Local communities were involved right from the setting of CBR goals, objectives, working principles and modalities. CBR was implemented through farmers' groups, coordinated by nodal local institutions and facilitated by resource farmers (nodal farmers) during recording of the information. The following observations and issues were documented at community level.

Positive changes at community level

- Increased awareness about the importance of CBR in the community; this is indicated by 18 of 21 CBOs in the project village maintaining their registers.
- Identifying group meetings as a venue to record the information in registers.
- Increased awareness/information on the species/varieties diversity of mandated crops through sharing and discussion in family members and in their groups.

Problems, constraints and gaps felt at community level

- Lack of adequate technical capacity at local communities to record information in registers, especially what types of information should be recorded in registers.
- Discontinued support from resource persons (nodal farmers) during documentation due to weak monitoring and follow-up system for CBR by the project.
- Lack of refresher training and orientation to resource person and CBOs to update their skills.
- Recording information at HH level was felt to be more time and resource demanding; therefore, dwindling active participation of CBOs farmers indicated a need for an alternative method.
- No sharing of recorded information in registers in villages/communities. It is suggested that every year, once the data recording process is completed by CBOs, the data should be analyzed and shared with farmers, e.g. What are the results and How we should plan further?
- Restricted to farming communities (CBOs only), no initiatives have been taken to link CBR activity with schools, VDC, clubs and other local stakeholders.

At project level

The representatives of CBOs, field staff and project professionals constituting LPMT were directly involved in field implementation of CBR. The thematic team members of the project constituting the NPMT are responsible for providing strategic guidelines for CBR. As the project has been piloting the CBR in different ecosystems, it is vital to refine and review the methodology for several issues pertaining to effective CBR. The following issues were experienced at project level.

Positive changes at project level

- CBR goal, objectives and methods set up to enhance on-farm management of agrobiodiversity.
- A functional working modality at grassroots level has been set up to implement the CBR activities.
- CBR methodology has increased interest among the farmers in recording their information in the registers thereby contributing to agrobiodiversity conservation.

Problems, constraints and gaps felt at project level

- Lack of effective mechanisms to build local capacity to record and maintain the registers (no follow-up/refresher training to resource persons and CBOs).

- Project should rethink the CBR unit (HHs or CBOs or Village) and method of recording since farmers have increasing feedback on CBR as a time- and resource-demanding tool.
- No follow-up and periodic review mechanisms adopted while implementing CBR; therefore, there is ambiguous, repeated and missing information in registers (especially in the criteria like specific use/values, farmers should be oriented to record the unique use/values, e.g. not that sponge gourd is used for curry only).
- Resource persons are not adequate in number in comparison with CBO's involvement.
- No effective collaboration observed with range of stakeholders identified for CBR, such as VDC, local clubs, schools, private entrepreneurs.

At national and policy level

Within a short period of time, the contribution of the *in situ* project for on-farm management of agrobiodiversity has become well recognized at the national level. CBR is one of the few good practices piloted by the project, and has influenced other activities at national level. The noteworthy examples are: the Ministry of Forest and Soil Conservation (MoFSC) of Nepal has underway the implementation of CBR in a wider geographic area, with coverage reaching 29 districts of Nepal, and the Ministry of Agriculture and Cooperative (MoAC) has been planning to implement CBR in three districts to encompass livestock and fisheries besides agriculture crops.

Positive changes

- Piloting CBR methodology in Nepal in different agroecosystems, contributing to on-farm management of agrobiodiversity.
- Contributed to increased awareness on importance of documentation of diversity and knowledge at different levels (community, R&D workers and policy bodies).
- Contributed to increased national interest on CBR methodology (for example: MoFSC piloted CBR in 3 villages, MoAC piloting in 3 districts, other local NGOs like TOLI/Ecocentre, USC Nepal have been implementing CBR).
- National recognition of CBR methodology (MoFSC is identified as focal point to implement and coordinate the CBR activities in Nepal).

Problems, constraints and gaps felt at national and policy levels

- Lack of adequate national capacity to effectively implement CBR.
- Mechanisms for demonstrating the sustainability of CBR and its potential benefits to different stakeholders are not clearly envisioned.
- Lack of effective collaboration between CBR-implementing agencies in Nepal.
- Lack of identification of national priority areas and diversity for documenting CBR.
- No mechanisms to link CBR information with access to and benefit-sharing mechanism at community level.

Conclusion

A database for CBR using Microsoft Excel and SPSS was prepared and information of mandated crops (rice, finger millet, taro, cucumber and sponge gourd) of Begnas ecosite was analyzed. The total number landraces/varieties recorded in CBR for all crops is higher than the number reported in baseline reports of 1999. In 2 years, some changes have been observed in number of cultivars and area coverage of rice and finger millet within the community. Two landraces of rice (*Barmeli* and *Parampyuri*) and finger millet cultivars (*Choto jhyape* and *Seto dalle*) grown by farmers in 1999–2000 were not grown in 2000–2001 but two new cultivars (*Chinia* and *Khalti khole*) were introduced. Two landraces of finger millet were not grown in 1999–2000 but were introduced by farmers in 2000–2001.

The average varieties grown for rice, finger millet, taro, cucumber and sponge gourd varieties by individual households of Begnas was 4, 2, 2, 1 and 2, respectively. Average varieties of these crops per farmers' group were 20, 7, 9, 5 and 6, respectively. It is noteworthy that farmers' groups—*Dadathar, Aduwabari, Paurakhe, Rupasrijana, Archalthar* and *Kotbari*— are maintaining more than 80% diversity alone. The four-cell method was used to study potentially threatened and common landraces/varieties. Altogether 41 landraces/varieties of rice (52.5% of total), 7 landraces of finger millet (56.6% of total), 4 landraces of taro (23.5% of total), 4 landraces of sponge gourd (33.3% of total) and one landrace of cumber were found as rare and grown by fewer than five HHs. Most of the farmers preserve their own seed as a seed source for coming year and some depend on neighbours, different farmers' groups, villages, nodal farmers and organizations working in the community. Farmers documented their knowledge and information on agroecology, crop biology, morphology and sociocultural use/values for each mandated crop.

The ways forward

To achieve the anticipated CBR goals and objectives, we still need to strengthen the CBR approach and methods, and incorporate the lessons learned while implementing CBR at different levels. Therefore, positive changes and problems/constraints identified at community level, project level and national/policy level should be considered in the next phase. Especially at the community level, various capacity-development activities need to be explored based on the gaps/constraints and participatory meetings with project farmers. Data recording at the HH level seems not feasible in a community since it is a time- and resource-demanding exercise. Major constraints are faced during recording of the information in registers. The SGP-GEF/UNDP funded project on CBR successfully documented the information in registers at CBOs level using diversity fairs as a methodological tool. The diversity fair was also used to validate the recorded diversity in registers (Subedi *et al.* 2003). Therefore, such methodology, which needs minimum time and is cost-effective, should be integrated into CBR.

The next step of the project is the sharing of results with farmers, CBOs and concerned stakeholders through village-level workshops, rural radio and four-cell methods. The project should facilitate communities in recording their decisions during a CBR result-sharing process, which will result in priority action plans of CBR. On the basis of those priority action plans, the project should facilitate the establishment of networking and linkages with different stakeholders for piloting activities. This will encourage the continuous maintenance of registers in village.

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Community biodiversity management (CBM): lessons learned from the *in situ* conservation project

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Abstract
Community biodiversity management (CBM) is a community-based participatory approach to strengthen the community's capacity through management of their own knowledge based systems. It helps to identify, conserve, manage, add value and exchange on-farm local crop diversity through community actions. It aims to improve and increase the access of knowledge, information and education, genetic materials, market and consumer needs, financial and physical assets by their own initiatives. This method will result in more delegation of authority to the community, develop ownership of the project and support on-farm conservation and sustainable livelihood options without external inputs and risks. The CBM approach has been currently implemented in two contrasting villages in terms of agroecosystems and sociocultural background: Begnas and Bara ecosites. Key stakeholders were identified and the capacity of nodal local institutions was strengthened to coordinate a network of farmers, nodal farmers and community-based organizations (CBOs) at these ecosites. Farmers and researchers jointly identified and implemented new methodologies, technologies and approaches (good practices) of on-farm conservation of agrobiodiversity. The project carried out SWOT analysis and reviewed the project working modality with CBOs. A series of village-level workshops with farmers and local stakeholders was organized to find the problems and barriers. Protocols and activity plans of the project were also reviewed. After an institutional review, it was learned that in most cases the CBOs support the programme or capacity-building activities for farmers, which had been done on and *ad hoc* basis for project needs. At Begnas village, farmers have been implementing value-addition, diversity fairs, CBR, and participatory plant breeding (PPB) activities along with the social and community development works in an organized way, whereas in Bara, a community seed bank has been established to conserve local agrobiodiversity. Guiding principles, process/methods, norms and rules, good practices, and implementation procedure of CBM are highlighted in this paper along with the findings of farmers' initiatives.
Key words: Community biodiversity register (CBR), community biodiversity management, capacity-building, on-farm conservation, farming communities, local institutions

Introduction
Since 1995, the International Plant Genetic Resources Institute (IPGRI), together with national programmes from nine countries—Burkina Faso, Ethiopia, Nepal, Vietnam, Peru, Mexico, Morocco, Turkey and Hungary—have been implementing a global project entitled "Strengthening the scientific basis of *in situ* conservation of agrobiodiversity". The global project aims to understand where, when and how *in situ* conservation of agrobiodiversity will be successful, what are the factors that influence *in situ* conservation, and how this information adds direct and indirect values to diversity in terms of social, economic, environmental and genetic benefits (Sthapit and Jarvis 2003). With this overall context of the project, collaborating partners have developed their specific national workplans using a goal-oriented process. Collaborating partners have developed a functional working modality, linkages, networks and partnership with a broad range of national and local stakeholders to support their workplans.

In Nepal, three ecosites representing high-hill (Jumla district), mid-hill (Kaski district) and *terai* (Bara district) agroecosystems were selected for the implementation of project activities. The project has adopted participatory, multidisciplinary, decentralized delegation of authority, and community mobilization as the major working principles at national and grassroots levels. At the national level, a technical coordination committee (TCC, later named National Project Steering Committee) and National Project Management Committee (NPMT) was established. At ecosite level, Local Project Management Committees (LPMT) were formulated with specific interlinkage roles and responsibilities (Upadhyay and Subedi 2003). LPMT plays a supportive role to strengthen community-based organizations (CBOs) and local farmers' groups in planning and implementing project activities. The objective of CBM approach is to empower farming communities by developing leadership of local institutions and create ownership for on-farm conservation by encouraging, planning and implementing project activities. In the process, CBOs and or/farmers' groups have been either revitalized or created to form self-help groups. Due effort was given by the project to coordinate a network of farmers' groups through nodal CBO in each sites.

In Kaski ecosite, 22 farmers' groups or CBOs were involved in project activities under the coordination and network of a local club, the Development Environment and Protection Club (DEPC). Community biodiversity registers, participatory plant breeding, landrace enhancement, value-addition and market linkages, diversity fairs, diversity blocks, etc. are the major activities of the project. In Bara initially there was a total of 21 farmers' groups but they lacked a coordinating mechanism within and between the groups. It was learned that the project was not able to set a functional working modality with a range of farmers' groups. In 2002 when the project was initiated to revitalize the groups in Bara, only a few farmers' groups were found functional. Finally, four groups jointly established a nodal CBO, the Agriculture Development and Conservation Society (ADCS), which was later officially registered as the district development committee. Through the coordination and networking of the ADCS, various project activities such as PPB, CBR, community seed bank, diversity fairs and diversity blocks have been implemented at different stages.

Learning from the first phase of the in situ *project*

During this phase, many innovative approaches and methodologies were identified or developed jointly by the farmers and researchers (Upadhyay and Subedi 2003). Creating an institutional framework and management of the project at different levels (site, national and global), sensitization and strengthening the local community, locating genetic diversity and custodians of local knowledge, characterization of landraces *in situ*, understanding the value of genetic diversity, developing options for enhancing benefits of crop genetic resources to ensure *in situ* conservation were the major areas where considerable progress was achieved by the project (Sthapit and Jarvis 2003). These good practices of on-farm management contributed significantly to the development of local and national capacity on agrobiodiversity conservation in Nepal and agrobiodiversity is now distinctly recognized as one of the major component of biodiversity in Nepal.

However, there are challenges on how these good practices could be translated at community level—the ultimate decision-makers or custodians for the management of agrobiodiversity. At the same time, we were continuously monitoring the farmers' groups or quality of CBOs participation in the project activities over the years, which were dwindling; in addition, adoption of good practices was found limited in a very few CBOs only. It was realized that most of the local institutions were overdependent upon project support. To solve this underlying ownership problem, the LPMT meeting decided to carry out a participatory joint review of the project. Therefore, village-level workshops across the ecosite were organized with support from nodal CBO, nodal farmers, project CBOs and field-based staff. Each member of the review team critically reviewed the project, including self-evaluation through the strength, weakness, opportunity and threat analysis (SWOT) exercise and documented all the feedback from communities (Paudel *et al.* 2003). The participatory review exercise was able to reflect the progress and gaps of the *in situ* project at the community level. The following four broad areas were identified for progress at the grassroots level:

- recognizing the value of on-farm management of agrobiodiversity at community level (in particular, market potential of local biodiversity and contribution to their livelihood was well demonstrated)
- working through the group approach and its positive strength was recognized for biodiversity conservation work
- use of local resources as assets for CBO development
- self-recognition of some nodal farmers and their local institutions with their own innovation.

Similarly, the review process identified the following three broader gaps where the project should focus:

- understanding of local institution's own livelihood assets, understanding local context to appreciate farmer's own priorities and interests during protocol preparation and its implementation in the field. Often activities were designed to achieve the project objectives and this has serious implications on ownership-building and good practices for scaling-up the project
- in most cases capacity-building activities of local institutions had been done on an *ad hoc* basis or on the basis of project needs
- mechanism of constant monitoring of capacity-building activities targeted to CBOs was missing (especially, what are the field-level monitoring tools and indicators on CBO capacity-building were not clear) The result is that many CBOs were out of the network from nodal CBOs or had decreased quality participation in the project activities.

To address the above issues, the project has organized a series of meetings with CBOs, consultation meetings with project professionals to review the workshops findings and identify further process, steps and methods. From the discussion, we have understood that basic requirements for on-farm management were created at the community level. At this point, we need to know what minimum capacity of local CBOs should be strengthened, and then what are our next strategies and approaches that create the options for a community to manage its agrobiodiversity through their own initiatives in a sustainable way.

Community-based on-farm management of biodiversity

In order to address the shortfalls of community-based activities, the CBM approach is employed to strengthen the capacity of communities and their institutions for managing biodiversity for social, economic and environmental benefits (Sthapit and Eyzaguirre 2005). The rationale of the approach is that the community should have a decision-making power in all the developmental aspects and in the process their capacity could be further strengthened to identify, conserve, manage, add value and exchange on-farm local diversity. It aims to improve and increase the access of knowledge, information and education, genetic materials, niche market, consumer and financial, physical resources by their own initiatives. This will result in more delegation of authority to the community, develop ownership and support to on-farm conservation and sustainable livelihood options without external inputs and risks.

Guiding principles of a community biodiversity management plan

Access to information and awareness creation

Traditional knowledge on biodiversity management is disappearing with increasing modernization and urbanization. Access to knowledge and materials for common people is limited at the community level as well. Increased access to information on the extent, distribution of local biodiversity and use/values of their biowealth will empower the farming communities in decision-making processes of on-farm management of biodiversity (Figure 1). In the past, such information has been intensively generated, documented, published and shared by researchers and their communities; however, the participatory methods for sharing such knowledge and materials were not in place (Sthapit and Jarvis 2003). Experiences have shown a willingness among farming communities to continue those methods which are farmer-led, cost-effective and generate benefits for them. Diversity fairs and community biodiversity registers are a few such methods that can meet multiple objectives of farming communities to manage their biodiversity. These methods not only are important to document the diversity and associated local knowledge system, and to strengthen informal seed systems, but are equally important to explore niche market potential of local varieties (Rijal *et al.* 2003).

Access to seed sources (choice of diversity)

Local varieties can turn over rapidly without any change in the number of varieties cultivated. In recent years modern varieties have been promoted, aiming to address food security. With increasing pressure of such introduced varieties, locally valued crop landraces and processes are being threatened daily. It is important to have a system in place that allows easy access to the modern or local varieties that farmers prefer. If a farmer has the ability to search, select and exchange materials and knowledge from existing diversity this dynamic form will result in maintenance of varietal diversity at the landscape level. On-farm conservation projects tend to focus on persuading farmers to continue planting local varieties. They will do this until they value them. Giving up varieties is often seen to be dangerous. Yet diversity is not measured in such a simple way. As our results show, genetic variation is not static, but is continually being renewed and the geneflow of the informal system is a very important mechanism. Research that takes account of social interaction supports an increasing trend toward regarding populations of varieties as 'metapopulations' of fields interconnected by varietal exchange. Work focusing on the networks of exchange that make varieties available to farmers suggests that greater attention needs to be given to supporting existing local systems of exchange, even where they do not necessarily result in increased diversity.

To provide appropriate options, local crop diversity needs to be promoted, particularly in areas that are complex, diverse and risk-prone, as peoples’ needs and preferences are still diverse. To improve farmers’ access to seed of preferred varieties and knowledge associated with them, the *in situ* project has been employing a participatory plant breeding (PPB) and landrace enhancement programme, participatory variety selection (PVS), diversity kits and community seed bank (CSB) as strategic methodologies for on-farm management of agrobiodiversity where options of diversity and relevant local capacity have been developed.

Access to market and consumers

An important sphere where the project has made considerable progress with the potential to impact farmers' livelihood is value-addition initiatives. The project has been successful in raising the value of local agricultural biodiversity by economic means. In this regard, the project has accomplished much in creating demand (consumer awareness) for local products as well as linking production units to markets (strategic networking amongst players in the commodity chain. Farmers' access to market through the mechanism of a collection centre, as intermediary institution, has not yet been established as a viable option for small producers. Furthermore, more research needs to be done to ensure a supply of quality products in the market. Scaling-out of successful technologies beyond the project sites may have to be accomplished to meet the increasing demand for local produce, and to derive benefits from their efforts and establish the link between agrobiodiversity and conservation and rural livelihood. Linking farmers to market is one of the key strategies to raise the private value of local biodiversity; however, the impact of such intervention is potentially dangerous for maintenance of genetic diversity. The project aims to market diverse types of product as market diversity also shapes the genetic diversity of crop diversity.

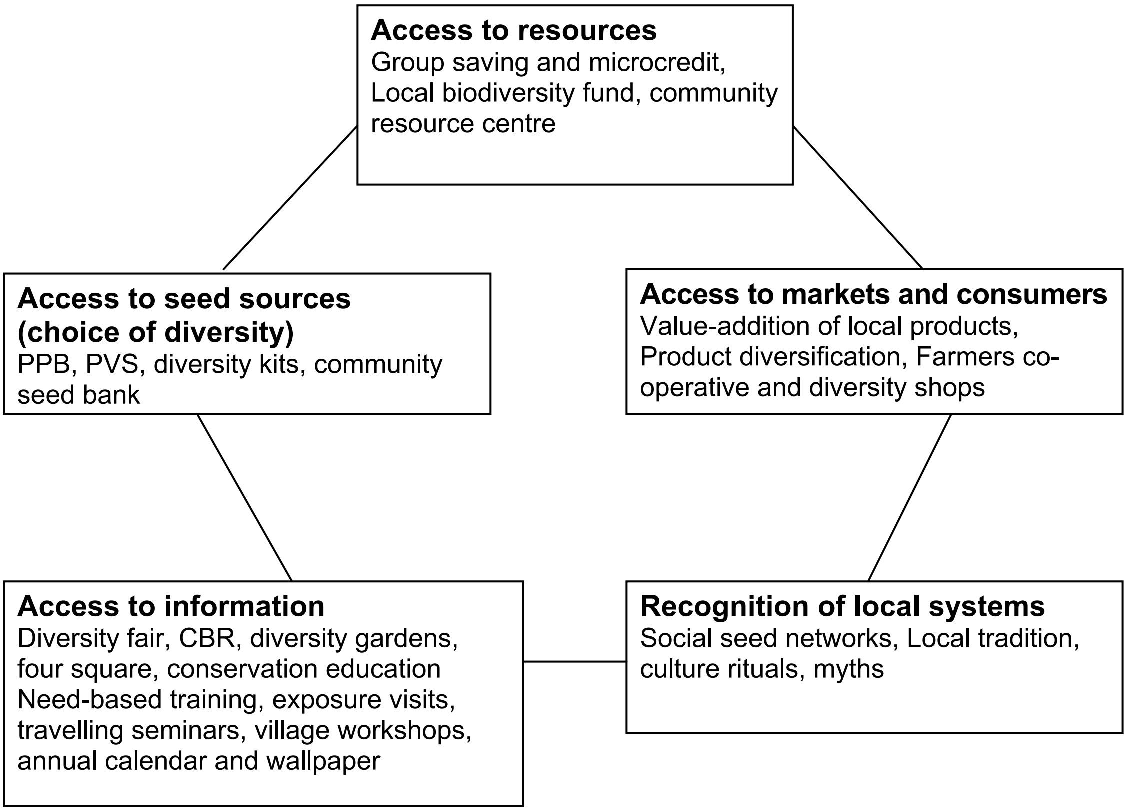

Figure 1. Guiding principles and a set of good practices of community-based biodiversity management plan.

Access to resources (physical, human and financial)

Realization of the potential value of biodiversity among the farming communities is reflected in an increasing interest to establish small-scale community biodiversity management plans. This is the positive indicator of institutionalization or adoption of good practices of the project at community level. To support these initiatives, the community needs different resources which may vary according to the nature of community action plans. It may be a requirement for adequate technical capacity at local level (human capital) or a need for construction materials or establishment of group saving and microcredit systems (financial capital) or needs that combine the efforts of all. Ensuring that these community priorities will be well considered by a research-based project like the *in situ* project is less achievable. Therefore, building multistakeholder institutional linkages and collaboration to support community initiatives will be the right approach where efforts should be made by the implementing agencies. Efforts were made to build the capacity of communities and local institutions to explore their assets profile and use a sustainable livelihood framework to develop livelihood strategies and outcomes. Similarly, at the same time we should secure, at community level, self-contribution and identification of their own available assets which are supportive to their own management plan where the project needs to play facilitating roles. Our experiences have shown that groups operating 'monthly savings and microcredit' programmes were found more likely to be cohesive; planning and meetings on a regular basis should be conducted for different community development activities (Rana *et al.* 2003).

Recognition of local system

Community biodiversity management is embedded in existing social structures and local institutions ranging from families to markets. Local systems of classification of crop and species diversity reflect sociocultural perspectives for recognizing and using genetic diversity and its institutions for agricultural and forestry biodiversity management including home gardens and agroforestry systems. Seed diversity and its associated knowledge are regulated by a set of specific rights, responsibilities and division of labour, often related to gender and age. Farmers are rich in social capitals which can be mobilized to generate other resources. Social capital may consist of a social seed system, networks, groups, trust, access to wider institutions, ability to demand, and others. Setting up diversity fairs, or establishing community-level seed banks, may be valuable innovations, but they should not undermine the existing local systems that link together people who trust one another's judgment and exchange seed along with other forms of goods, aid and information. Priority should be given to understanding how local diversity is sustained, so that modern introductions do not threaten local systems.

Piloting community-based on-farm management of agrobiodiversity in Nepal (Steps, process and activities)

During the second phase of the *in situ* project, a model of community-based biodiversity management is underway in Kaski and Bara ecosites. Through the participatory meetings, review and discussions with farmers, CBOs and concerned stakeholders have formulated a conceptual framework of CBM implementation (Figure 2).

Understanding local capital assets

A community situation analysis was carried out involving local stakeholders of the project sites. Stakeholders had identified their available local assets for CBM which have supportive roles to enhance their daily livelihoods options, i.e. social, ecological, physical, financial and human capitals. In this process, critical assets available to resource-poor farmers for managing vulnerability, uncertainties and shocks in order to improve access to and control for such resources also were identified. To support the activity of a participatory community-based biodiversity database (CBR), diversity fairs and participatory institution analysis were identified as community actions.

Understanding social seed networks

The *in situ* project has clearly shown the evidences of existence of social networks in the community, which play significant roles in the flow of genetic materials, technology and in maintaining the local biodiversity on-farm (Subedi *et al.* 2003). The nodal farmers and their networks were recognized through their commitment to CBR data-sharing, seed distribution and training/capacity development activities to the farmers of their network.

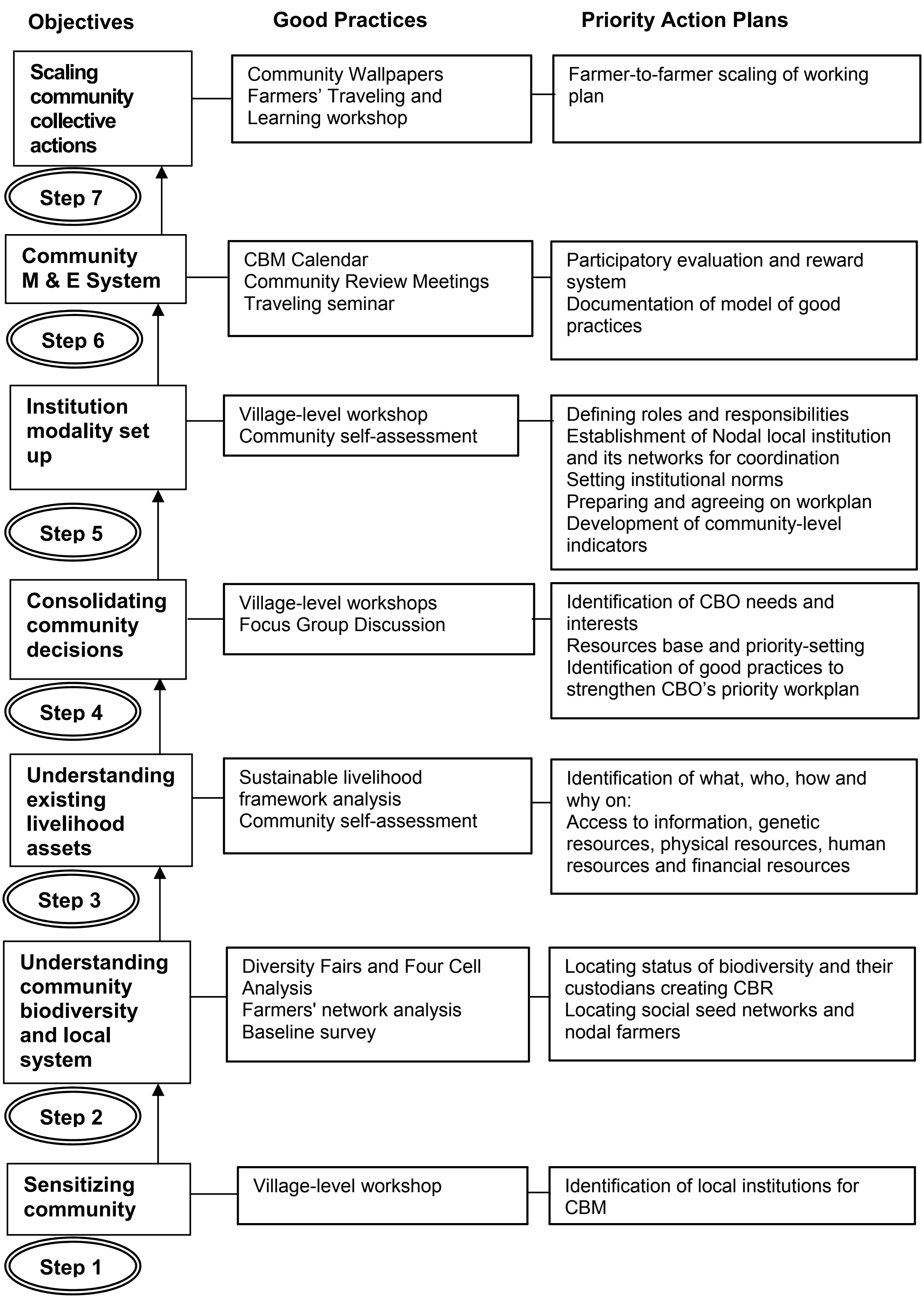

Figure 2. Steps, process and activities in implementing community-based biodiversity management plans in Nepal.

Setting an institutional framework
Participatory meetings were organized with the local institutions to formulate institutional modality or linkages of CBM. Involved stakeholders did SWOT or PIL analysis to identify their own institutional interests, strengths and weaknesses. From the institutional analysis, nodal CBOs, schools and local clubs were identified as potential local institutions to manage CBM activities in their village, whereas the project identified different agencies such as government/non-government organizations, private entrepreneurs and market chain to support the community action plans (Figure 3). Specific roles and responsibilities of each stakeholder will be identified and agreed upon.

Preparing the community management plan
Nodal local institutions have organized a series of participatory meetings to identify the issues to be considered under the CBM plan. Sharing of CBR information with communities was found to have a positive role in identification of priority community actions. In this process, CBOs critically reviewed their own available local assets and their contribution to the implementation of activities on the basis of institutional analysis findings (Tables 1 and 2). Given the available resources, priority action plans were formulated and respective contributions of CBOs and the project were identified.

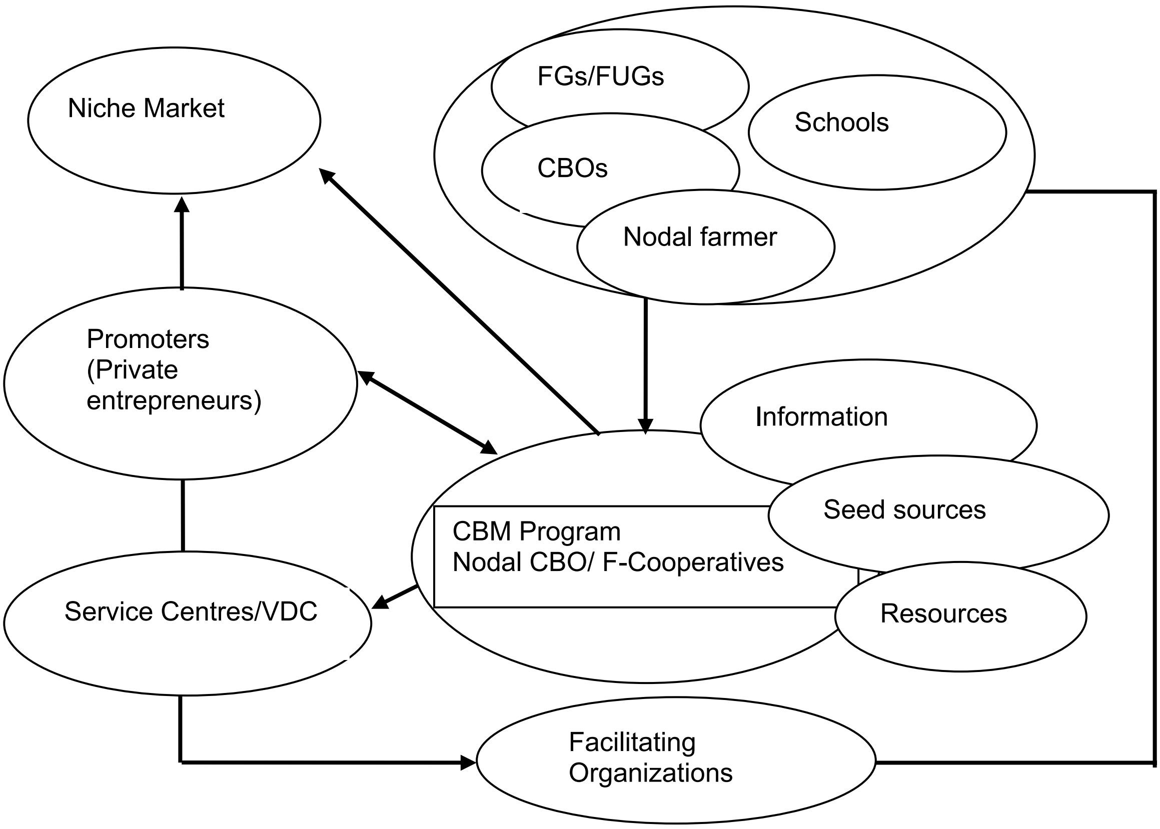

Figure 3. Institutional setting and linkages of community-based biodiversity management plans.

Community fund management
Group saving and microcredit system have been well strengthened within each participating CBOs through necessary training and orientations. A 'CBM fund' has been established in the community with support from project and cofunding from participating CBOs. Fund management guidelines were prepared in the participatory process. The CBM fund has two

distinct fund-supporting mechanisms, consisting of seed money and a revolving fund system. Primarily the CBM fund is targeted to support priority community action plans that retain the capacity of measurable impact on local biodiversity conservation works contributing to local livelihoods in a sustainable manner. Value-addition and market linkages of local agroproducts, management of diversity blocks and community seed banks are the noteworthy community plans supported through the CBM fund.

Setting CBM norms at community level

The goal of the CBM project is to build local farmers' capacity for the sustainable management of local biodiversity for their livelihoods. Therefore, the project facilitated the preparation of guidelines or institutional norms in a participatory manner, which motivated the community to manage local biodiversity. Examples are 'Saving Own Seeds', 'Seeds for Neighbour', and 'Increasing crop production through protection of pollinators'. 'Recording knowledge for their children's sake' is one working principle set out by the CBM group.

Community evaluation of CBM

All the activities and details identified in CBM were listed in a *Farmers annual calendar*, which is distributed to all CBM members. This calendar not only includes information on CBM activities, but also provides spaces to record the major progress, problems or constraints observed during the implementation of activities. On the last day of each month, CBM members share their progress on the basis of records kept on the calendar and discuss how the group should plan for the next month. The success and failure cases were documented and published in a monthly *Farmers wallpaper*. The wallpaper and calendar have been used as local tools to monitor and evaluate the progress made by CBM.

Some existing practices of CBM at in situ *project sites of Nepal*

Local seed security and on-farm conservation of agrobiodiversity through community seedbank approach in Bara ecosite

Kachowra village of Bara district of central *terai* of Nepal represents a high-potential production environment. It is characterized by relatively good access to new technologies and inputs, road and markets. This has resulted in open access of modern varieties to the community. Within a 3–year, farmers of Kachowra village had lost 21 landraces of rice (Chaudhary *et al.* 2003). The major factor behind this tragic event is the unavailability of quality seeds to the farming communities. To overcome these problems, farmers of Kachorwa have decided to start a community seedbank programme to secure their landraces from further loss by increasing access to quality seeds within their village. However, before implementing such initiatives they realized the necessity of a nodal local institution to manage the seedbank. Therefore farmers, nodal farmers, women's and men's groups representative of Kachowra village have jointly established a nodal community-based organization—the Agriculture, Development and Conservation Society (ADCS)—and have registered it in the district administration office of Bara. ADCS now has its own rules and systems to manage the seedbank. Diversity fairs and community biodiversity registers are the two strategic approaches that have been extensively used by ADCS to search for and exchange seed materials. Seeds of both endangered and the most available and useful landraces are conserved, multiplied and marketed for the community benefit.

Table 1. Lessons learned from piloting CBM plans in Begnas sites.

Analysis—A set of good practices	Lessons learned
Enhancing human capital • SWOT assessment of CBOs • Nodal farmers • Nodal CBOs for value-addition of local products and marketing, diversity fairs and CBR • Exposure visits • Need-based trainings • Participatory plant breeding • Representation of local farmers in national meetings/workshops and rural radio programme	• Self-assessment of CBOs support to identify community-level agrobiodiversity management activities • Nodal farmers play a decision-making role in maintaining the agrobiodiversity on-farm • Nodal CBOs able to coordinate with a network of CBOs to efficiently implement value-addition, marketing of local products and CBR activities • Need-based training identified from SWOT analysis is supportive to enhance the capacity of farmers to manage the agrobiodiversity; then the project conceptualized training • Local farmers can select the preferred traits of landraces from PPB programme, then from breeders from outside village • Farmers' participation in national conferences/ workshops enhances leadership development in the community
Enhancing social capital • Capitalizing on number of farmers' groups/CBOs/Cooperatives created by CARE/Nepal • DEPC able to coordinate a network of CBOs • Increasing representation of women in conservation efforts • Social seed networks and nodal farmers	• Strengthen partnership with support to ongoing initiatives • Increases institutionalization process of on-farm management • Increased cohesiveness • Leadership development • Womens' participation increases efficient on-farm conservation • Nodal farmers recognized as local institutions
Enhancing natural capital • Value-addition and marketing of local agrobiodiversity • Participatory plant breeding • Landrace enhancement • Community biodiversity register • Diversity blocks • Biodiversity kits • Diversity fairs	• Number of HHs and area under value-added local crops has been increased due to marketing • Value-addition and marketing are two most effective approaches for sustainable agrobiodiversity management and increase rural income • PPB increases the development of farmers' desired traits in local landraces and supports on-farm conservation process of agrobiodiversity • HH-level CBR management is more resource and time demanding and therefore not feasible. However community-level or village-level CBR should be developed • Diversity fair is an effective community tool tp see, locate and exchange genetic diversity within a community
Enhancing financial capital • Marketing of value-added and local agroproducts • Link to market outlets • Group saving and microcredit • Sourcing funds to implement CBM activities (e.g. SANFEC award to resource farmers: Mr Surya Adhikari, Majhthar women's group, Innovation Fund for Pratigya, CBR conservation trust funds)	• Recognition of value-addition and marketing of local biodiversity to increase rural income through creation of small-scale private entrepreneurship • Easy access to microcredit system enhances increased farmer participation in conservation efforts • Group saving and microcredit increase social cohesiveness and formulation of various biodiversity-based income-generating activities • Capacity development of local institutions in sourcing different resources from ongoing activities
Enhancing physical capital • Nodal CBOs' own office • Land area for diversity blocks • Land area for PPB • Strengthening facility and infrastructure of Pratigya cooperative	• Having an office for CBOs in a village has strengthened the CBO's organizational development • CBO can use the office space as a village resource centre (for training, meetings and demonstrations)

Table 2. Lessons learned from piloting CBM plans in Bara sites.

Analysis—A set of good practices	Lessons learned
Enhancing human capital • Group exposure visits • Need-based training (Organizational development, group mobilization, monthly saving and microcredit) • Diversity fairs and festivals • Participatory plant breeding • Management practices of community seedbank	• Cross-site visits are an effective means of learning from and sharing with others • Need-based training identified from SWOT analysis is supportive to enhance the capacity of farmers to manage the agrobiodiversity; then the project conceptualized training • Group mobilization activities are equally important with conservation activities for ownership and sustainability of the programme • Local farmers can select the preferred traits of landraces from PPB programme and from breeders from outside village • Conservation of landraces is closely associated with access to quality seeds
Enhancing social capital • Nodal CBO: ADCS establishment • Recognition of ADCS for agrobiodiversity • Women's groups formulation • Increasing representation of women farmers in ADCS management committee	• Local institutions can manage conservation of agrobiodiversity in a sustainable manner if their capacity to do so is enhanced • Women farmers are more empowered through working in a group approach • Women can play a pivotal role in management of local institution as men farmers can do • Organizing and operating savings and credit systems is an appropriate means of local resource mobilization
Enhancing natural capital • Community seedbank • Diversity fairs • Participatory plant breeding • Community biodiversity register • Diversity blocks • Biodiversity kits	• Community seedbank approach is more effective to conserve landraces where access to modern technology is high • Diversity fair is an effective means for the community to see, locate and exchange genetic diversity within the community • PPB increases the development of farmers' desired traits in local landraces and supports the on-farm conservation process of agrobiodiversity • Nodal CBOs are able to manage CBR at community level • Diversity block can be used to recycle and multiply the stored seeds in community seedbank
Enhancing financial capital • Community seedbank • Group saving and microcredit • Outsourcing funds to support similar activities from VDC and SANFEC award	• Seedbank not only supports conservation process through increasing access of seeds in village but also is a source of rural income through linking to market (agrovets and neighbouring villages) • Monthly saving and credit activities increase the implementation of biodiversity-based conservation plans in the community • Monthly saving and credit increases cohesiveness and social interaction among the farming communities • Capacity development of local institutions in sourcing different resources from ongoing activities
Enhancing physical capital • Land support from VDC • Structure of community seedbank • ADCS' own office and various office equipment	• Local stakeholders are supportive of on-farm conservation of agrobiodiversity • Having an office for CBOs in a village has strengthened the CBO's organizational development and makes them more active due to social recognition • CBOs can use the office space as a village resource centre (for training, meetings and demonstrations)

The community seedbank secures local seeds, especially for marginal environments, and contributes to on-farm conservation and food security. Initial activities conducted by the community seedbank have shown that it can play a key role in conserving local crop landraces on-farm. Thirty-five farmers used the community seedbank as sources for local rice seed. Among them, 80% did not have their own source and 20% used the source in the belief that the level of purity is higher than their own source. Of those who used the community seed-bank as a source for local rice seed in 2004, 43% are of resource-poor category, 40% of middle class, and 7% of resource-rich households (HHs). This indicates the community seed bank is supporting to resource poor to middle class HHs for their local seed requirements.

Value-addition and market linkages of local-agroproducts at Begnas site

At Begnas ecosite, initially a total of 22 farmer groups had been involved in various activities of *in situ* project under the coordination and network of a local club, the Development Environment and Protection Club (DEPC). Research farmers and researchers jointly motivated project farmers to participate in diversity fairs, maintaining CBR, value–addition of local agroproducts, participatory plant breeding work and various on-farm conservation-related research activities. Institution analysis of farmers' groups or CBOs carried out during 2003 had shown that some farmers' groups were capable of on-farm management of agrobiodiversity activities at local level that can play a key role as nodal local institutions. Therefore, these five farmers' groups along with DEPC were identified as nodal CBOs in the community under which a network of farmer groups was set up and made functional through formulating a 'CBM committee'. Necessary guidelines, roles and responsibilities of CBM committee were made clear through participatory meetings with the farmers' groups of Begnas.

The potential benefits of on-farm management of agrobiodiversity to farming communities have been clearly observed through the successful initiatives of Partigya cooperative of Begnas village. This cooperative has been a key intermediary organization of the farming communities for the collection, processing and marketing of local agroproducts (Figure 4). Altogether 31 different products of local landraces of taro, rice and finger millet have been marketed through the channel of Partigya cooperative. To further strengthen its commitment for the benefit of its network of CBOs, it has established a market outlet in a city under the trademark '*Gaunle Pashal*'. This has not only directly benefited the village farmers in terms of cash income, but has raised their realization of the benefits from the management of landraces, which is the most noteworthy effect for the long-term conservation of landraces on-farm.

Conclusion

Sustainable on-farm management of agrobiodiversity will result with the continued support of farmers and their local institutions. Principles, options and approaches for on-farm management would be popular at the farmer's field level if the community capacity has been developed to understand and implement it. However, at each stage, the project needs to demonstrate how these options will generate social, economic and environmental benefits for the community. In the context of poverty, instability of political situation and conflict situations, an approach like CBM for on-farm management of agrobiodiversity is more likely to be successful since it can address various problems of communities in a participatory and sustainable manner. However, CBM should be tested in different socioeconomic settings and diverse agroecological environments before it is scaled up.

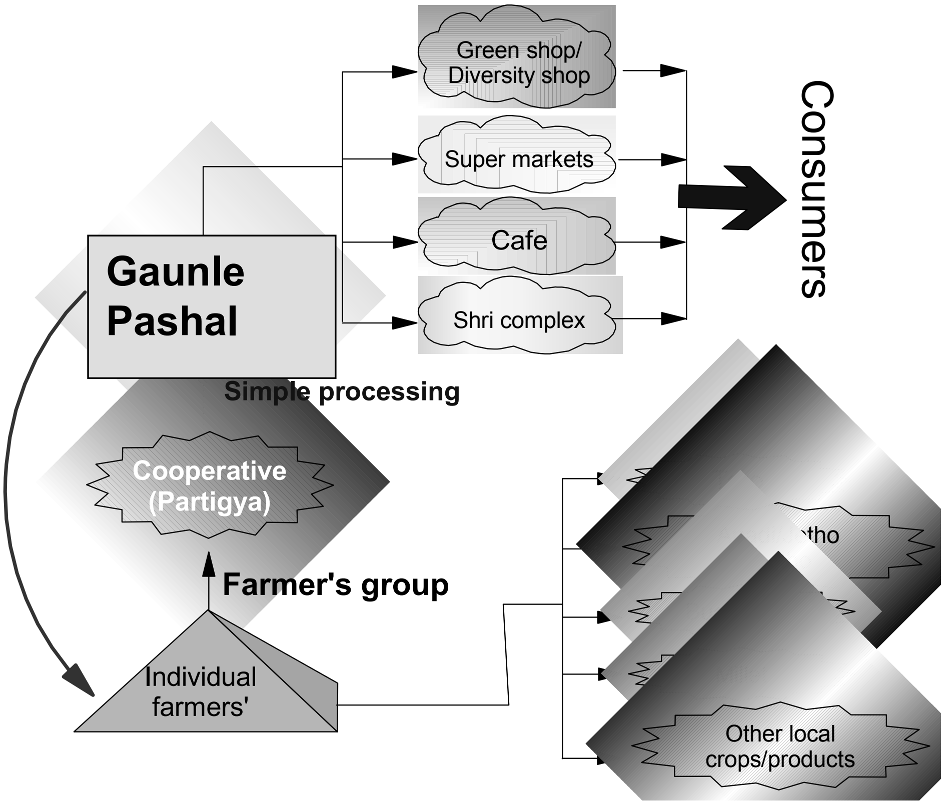

Figure 4. Local agroproducts and marketing channel of Partigya cooperative.

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Enhancing local seed security and on-farm conservation through a community seedbank in Bara district of Nepal

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Abstract

In Kachorwa, Nepal, farmers experienced rapid loss of rice landraces along with a significant decrease in the area under cultivation (from 0.3 to 0.03 ha) in a short span of time (only 5 years). This could have been due to several reasons; but we identified a threefold factor responsible for this accelerated process. First, access of farmers to better options improved, second, lack of security of quality seeds and availability of cultivation practices, and the third reason identified by us was certain policies that served as disincentives to landrace growers. The joint workshop among members of the Community Biodiversity Register Group (CBR) and *in situ* project team decided to implement Community Seed Bank approach to improve or reverse landrace disappearance. By improving economic incentives this approach enhances on-farm conservation of endangered crop landraces. To assure wide participation of the local people the CBR group renamed it the Agriculture, Development and Conservation Society (ADCS). Through a series of informal gatherings and consultation with the project team, the society explored and documented crop diversity and their status from previous records such as CBR, diversity fair and farmers' network analysis. ADCS established a small-scale seed house using locally available construction materials. The initial resources were volunteered by *in situ* staff, local farmers and project staff. Different structures used to store seeds include *mor* (made of rice straw), *ghaila* (made of mud), *kothi* (made of mud and bamboo), *chaintha* and *mouna* (made of bamboo). The society has employed a twofold strategy: ADCS distributes seeds to farmers on the condition that they will return 150% of the total amount they borrowed, and crop varieties are regenerated in locally managed diversity blocks. This paper documents the local initiatives employed for the sustainable management of local crop diversity in *terai* conditions of Nepal. Initial lessons learned are highlighted.

Key words: Community seedbank, landrace, local seed security, on-farm conservation

Introduction

Several studies have indicated that small scale farming households need different types of seeds to allow for varied physical environments, to benefit from the many end uses of each crop, and as a coping strategy for complex, diverse and risky environments (Lewis and Mulvany 1997). Certain landraces are maintained because of their religious and cultural significance in specific ethnic communities (Rana *et al*. 1999). However, along with the adoption of improved varieties and cultivation practices, a large number of landraces maintained in traditional farming systems have been replaced. This replacement not only leads to serious genetic erosion (Porceddu *et al.* 1988) but also hinders efforts to improve crop varieties further (Nevo 1995). Similar stories have been documented from Nepal *terai*. Kachorwa of Bara District of *Terai*, Nepal is a high-yield environment, which has good access to road and markets, agriculture inputs, irrigation and technical services (Sherchand *et al.* 1998). Past studies have shown that traditional varieties are being replaced with improved varieties. The unavailability of quality seed has been enabling farmers to choose the modern varieties (Chaudhary *et al.* 2001). The records for the decrease in number of landraces and the area in which these landraces were grown are alarming.

The baseline studies (1998) documented that the average area covered by landraces was 0.3 ha which decreased to 0.03 ha when monitored after 5 years (CBR 2003). Out of 33 rice landraces inventoried in the base year, the number decreased to 14 after 5 years (Table 1). Such loss is also related to the erosion of traditional knowledge and culture. This process may be accelerated further by improved access to farmers' alternative options, policy disincentives that prevail on landraces, and availability of seeds of preferred landraces. This alarming record warns that local diversity may disappear in the near future. In response to this situation, Kachorwa farmers established the Agriculture Development and Conservation Society (ADCS) to reverse this process. ADCS is represented by local farmers, nodal farmers, male and female farmers' groups. The society was legally registered with clearly defined mandate, roles and responsibilities. The main duties include coordination and linkages with farming communities, CBOs, agrovets and Non-Government Organizations. One of the key areas to address this problem was through the establishment of the community seedbank. It aimed at improving farmers' access to quality seeds, allowing traditional seed exchange and knowledge, and enhancing sustainable management of local resources. ADCS aims to gather, improve, regenerate and market seeds of endangered, most available and useful landraces involving local institution. Initially, ADCS has been managing seeds of rice, finger millet, pigeon pea and sponge gourd. In this paper, we document and analyze the process through which the seedbank was established, mechanisms through which seeds of endangered crop varieties are restored, and how seeds are managed in a sustainable manner. The lessons learned are highlighted.

Table 1. Number of farmers and area planted of rice landraces in different time periods.

Year and type of study	Number of landraces	Number of growers of sampled HHs	Total area of sampled HHs (ha)	Mean area/HH (ha)
Baseline 1998 (n=202 HHs)	33	137	26.06	0.30
CBR 2003 (n=349 HHs)	14	111	10.40	0.03

Source: Rana *et al.* (2000) and CBR (2003).

Materials and methods

In January 2003, the *in situ* project staff held a 1–day workshop with the Community Biodiversity Register group to discuss the progress, problems and importance of on-farm conservation. Another objective was to identify the way forward, once local crop diversity was inventoried. During discussions, the CBR members raised their serious concerns regarding the high rate of landrace disappearances. Along with the improper management and utilization strategies, landraces and associated knowledge were rapidly eroding. To halt this process and restore this lost diversity, in the absence of formal support programmes, the participants strongly supported the concept of a Community Seed Bank (CSB). Further discussion touched on benefits associated with CSB. The workshop recommended that the ADCS will:

- Share experience with the GEF/LI-BIRD joint CSB project implemented in Kaski to learn and refine the concept, mechanism and promotional activities.
- Initiate a CSB locally. The group will collect seeds, and store them in traditional storage structures. Locally available resources will be used wherever possible to encourage the locals to volunteer for this work.
- Conduct awareness programmes about the endangered landraces, their importance , and their short- and long-term values. The use of different means of dissemination was discussed, including pamphlets, posters and articles. The *in situ* team was given the responsibility for this programme.
- Establish diversity blocks on rice to regenerate seeds, use block as a means to make people aware, and evaluate the performance. The team decided to collect rice, finger millet, pigeon pea, taro, sponge gourd, cucumber, bitter gourd, bottle gourd and sorghum seed from farmers and neighbouring villages. It was decided that seeds produced from diversity block, and PhD research trials would be supplied to the CSB.

Search for resources

In the workshop, different ways were explored to gather resources. The participants showed a keen interest in contributing resources in kind. The project staff provided cash to purchase storage structures such as g*ahila*, *mor*, *kothi*, etc. The local team also discussed the site on which to establish a seedhouse. To implement the process, different roles were identified: (1) coordinate with farmers and farming community, local bodies and institutions, government agencies, and donor agencies, (2) seek technical support from projects, (3) explore possibilities for the appropriate site for a seedhouse, and (4) explore whether other members would be interested in volunteering.

ADCS asked the Village Development Committee for the land to construct a seedhouse. After a thorough discussion the body provided about 300.0 m² area for seedhouse. The International Plant Genetic Resources Institute (IPGRI) recognized the community's initiatives and provided USD1000 so as to strengthen capacities of community seedbank for enhancing seed security and on-farm conservation. ADCS constructed a seedhouse using locally available materials. The local authority provided NPR12 000 to purchase aluminum sheets for roofing. Apart from technical support and a facilitating role, LI-BIRD also provided NPR5400 for the construction work. Several individuals belonging to different farmers' groups including *Shanti* women group, *Adarsha* women group, *Pragati* women group and the ADCS general members volunteered 2 person-days during construction of the seedhouse. Non-members also provided bamboo materials worth NPR3500. The local elite individuals cut a tree to contribute wood required. A few group members provided their tractor for transportation of soil, sand and brick, and some provided an oxen cart. Other members served lunch or snacks for labourers. As discussed during the workshop, the local team decided to construct a seedhouse in traditional ways and use storage structures that are made locally. Members of ADCS contribute voluntarily to the management of stored seed.

Operating systems

Through discussion, several norms and rules were suggested, including:

- **Collection of seed:** all available seeds of landraces of the project were identified; keystone crop species will be collected over seasons.
- **Seed storage materials:** only locally available seed storage materials will be used for seed storage purposes.
- **Seed distribution and its selling:** the collected seeds are distributed based on the traditional *Dedha* system. In this system, after harvest the farmer will pay back 150% of source seed from where he/she had borrowed. If a farmer showed no interest in continuing the particular landrace, his/her seed will be purchased next year.
- **Maintain diversity block:** all endangered and other less popular landraces be maintained in diversity block and the population will be continuously improved through selection.
- Collection and management of seed.

To date, 37 landraces of rice, 5 of sponge gourd, 3 of pigeon pea and 2 of finger millet seeds have been collected and stored in the seedhouse (Table 2) and this number is increasing. The management of a community seedbank is based on traditional knowledge, skills and system. ADCS members look after seed drying and cleaning processes on a rotational basis. The project organized training for seed managers. The seedhouse and seed samples are checked collectively by ADCS members once their monthly meeting is over.

Table 2. Number of landraces at different times in the community.

Crop	Baseline study (1998)	Before CSB (CBR 2003)	After CSB (2004)
Rice	33	14	37
Finger millet	6	2	2
Sponge gourd	9	5	5
Pigeon pea	5	2	3

Source: Rana *et al.* (2000) and CBR (2003) and record of Community Seed Bank, Bara.

Regeneration, distribution and sale

The seeds are distributed every year. Seeds of rare and endangered landraces are regenerated at diversity block or in farmers' fields. The seedbank distributes the seeds to individual farmers, women and men group members on a loan basis—up to 5 kg seed and at cost for more than 5 kg. The quantity of loan to be sanctioned depends upon the availability of seed and number of farmers who have demanded the seed. The seeds for outsiders are sold for cash, with an objective to reduce workload and maintain quality. The seedbank members monitor and supervise farms to ensure the return of pure seed of high standard. If any farmer is not able to pay back the seed, then another source is identified for collection.

Training on quality seed selection and management

An *in situ* complementary project called 'Social Analysis and Gender analysis' (SAGA) was implemented in the community. Through this, training on rice landrace seed selection and management was conducted. Two women's groups and ADCS members were given this training. This training programme was organized twice: before planting and just before harvest. This helped farmers to know how to maintain high-quality seed either in the seedhouse or under field conditions.

Results and discussion

The *in situ* team and CBR members jointly organized a mass meeting in the community and discussed with community people the need for a nodal CBO and CSB for sustainable on-farm biodiversity management and community development. CBR members agreed to establish the Agriculture, Development and Conservation Society (ADCS) for the above purpose. They broadened the membership base to include women's group representatives, formed rules and regulations and registered the ADCS at the District Administration Office (DAO).The farmers collected 19 rice landraces from *in situ* site office to store in the seedhouse. The local team prepared a bamboo rack, purchased *ghaila,* prepared *mor*, and stored them in their seedhouse on 13 March 2003.

Farmers' response to improved seed security

Various surveys and studies conducted at the community during the project period already proved that the most landraces are grown by few farmers in small area, which were categorized as rare and endangered species. After community seedbank initiatives, the number of rice landraces has been increased from 14 to 37 (Table 2); other crop landraces also have increased. These all have been planted in diversity block to increase seed quantity in the 2004 season. Therefore, the community seedbank has contributed to seed security of local crops and landraces.

Contribution to on-farm conservation

Initial activities conducted by the community seedbank showed that it can play a key role in conserving local crop landraces on-farm. Thirty-five farmers used the community seedbank for local rice seed in 2004 (Table 3). Among them, 80% did not have their own source and

20% used the seed bank for its higher level of purity than their own source. Of the seed users, 43% were resource-poor, 40% were middle class and 17% were resource-rich households. Therefore, the contribution of a community seedbank is not only to increase farmers' access to seeds but also to support resource-poor farmers who do not have the capacity to save or purchase quality seed.

Table 3. Summary of community seedbank users and their socioeconomic status.

Year	Number of farmers per category			Total number
	Rich	Medium	Poor	
2003	5 (12)†	19 (48)	16 (40)	40
2004	6 (17)	14 (40)	15 (43)	35

† Figures in parentheses indicate the percentage of users.

Model of community biodiversity management

Seed collection, management, exchange, regeneration, distribution and sale mechanism of community seedbank initiatives in the Bara site are recognised as 'good practice' effective for on-farm conservation. Farmers' increased access to seeds may enhance on-farm conservation. This approach may not be applicable equally to all crop landraces. Figure 1 presents the existing community biodiversity management practices.

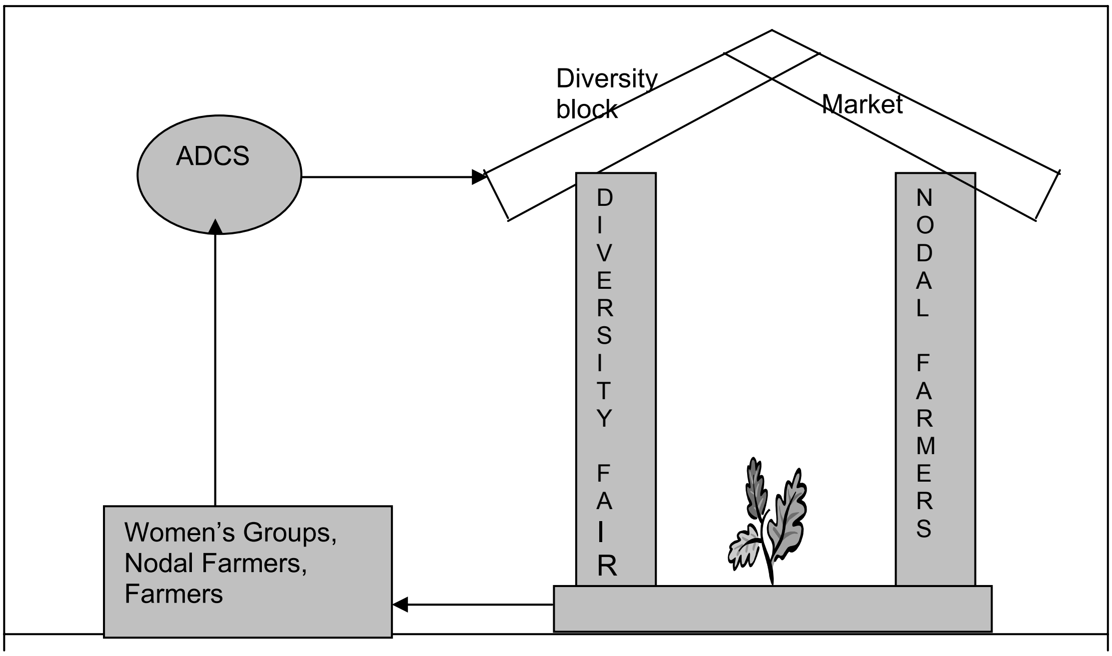

Figure 1. Community biodiversity management model of Bara ecosite for on-farm agrobiodiversity conservation.

Sustainability issue

The community seedbank is a joint effort of farming communities and the *in situ* conservation programme. Sustainability of this system largely depends upon the quality of seed and services provided by the community seedbank. The present community seedbank members have been involved since the beginning of the programme. As the seedbank was established to meet the needs of the local people, the likelihood is that the bank will operates smoothly over time.

Group members have been operating a savings and credit programme which helps in building cohesiveness among members, they hold meetings on a regular basis, share with each other their ideas and knowledge, plan and conduct different community development activities and, overall, have enhanced ownership of programme. The other source of income for the community seedbank is selling seed of landraces. The loan system of seed distribution and return has a multiplying effect. The group also made a rule that each member has to grow at least one landrace.

ADCS is gradually building its capacity on coordination and fund attraction. Understanding the value of plant genetic resources and importance of community seedbank, the Kachorwa Village Development Committee donated the land and cash resources. The cash contribution from IPGRI and Using Diversity Award to support local initiatives helped improve the seed security situation, thereby enhancing biodiversity conservation.

Conclusions

The community seedbank is leading to sustainable local seed security. It fulfills the community's requirement for quality landrace seed and helps to increase farmers' access to quality seed as a means of conserving local crop diversity to maintain on-farm. The level of awareness of community people on conservation of agricultural biodiversity and capacity of CBO has been enhanced after establishment of a community seedbank at Kachorwa. However, research and development effort is still required to ensure conservation and utilization of agricultural biodiversity with increasing income and economic status of the people. This approach is an based on indigenous knowledge and is low cost, managed by the local community without facing major technical and financial problems. Initial efforts of this community-based biodiversity management approach have shown encouraging results for on-farm conservation of agricultural biodiversity. Therefore, dissemination of this approach in other areas of the country can halt the high level of genetic erosion, especially in the case of on-farm biodiversity.

Acknowledgements

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Enhancing on-farm conservation of local rice crop through enhancing the capacity of and strengthening the local seed system in Bara

Deepa Singh, Anil Subedi and Pitamber Shrestha

Abstract

Farmer practise seed selection, seed saving and sowing by themselves on-farm, and the informal seed system plays an important role in the flow of landrace crop varieties. The lack of systematic market networking for landrace seeds is the main constraint in landrace conservation. Further, the indigenous seed selection practices of farmers in Kachorwa require improvement. The paper reiterates the findings that capacity-building of farmers on quality seed production and strengthening the local seed system contributes to on-farm conservation of local rice landraces. Quality of seed was identified as the most pertinent problem for landraces in Kachorwa; that influences the farmer's decision on cultivation of these landraces. The existing market channel was identified through a rapid market survey and focus group discussions. Training on seed selection and quality control measures for rice crop was conducted for the seed-producing farmers. The seed market network, including the formal and informal seed channels, was established with the Agriculture Development and Conservation Society (ADCS) as the main focal point for facilitation of seed flow and quality control. The social and gender dimension study indicates that farmers' choice of variety, the seed selection process, and the mechanism of seed exchange are highly influenced by the socioeconomic status of the farming community and social values of these landraces. The findings of this study also illustrate that landrace populations are by definition comprised of wide variability with mechanical or even genetic mixture of many local types; therefore repeated cycles of seed selection are essential to obtain the pure seeds of these landraces.

Key words: Mass seed selection, Community seed bank, nodal farmers, formal seed system, informal seed system

Introduction

Rice (*Oryza sativa*) is one of the major cereal crops of Nepal and is grown under different agroclimatic conditions. Nepal possesses rich biodiversity of rice due to the range of agroclimatic variation. However, the new and high-yielding varieties are replacing the landraces rapidly to the extent that some landraces that compete better than modern varieties (MVs) are becoming extinct. Of the 48 varieties of rice released, no local landraces are included.

Despite this, farmers have been maintaining biodiversity in both MVs and landraces, to meet diverse needs of farming households and, in a few instances, landraces are the only option for these marginal lands. For example, *Bhatti* is a landrace that performs best, or competes better than any MVs, in waterlogged conditions (*pokhari*). Likewise, *Sathi* is a landrace rice variety grown in *terai* for its socioeconomic and religious values. Additionally, there are landraces that contribute substantially to food security at household level, especially of resource-poor households in Kachorwa (Rana *et al.* 2000). In spite of this situation, the cultivation of landraces is decreasing gradually in terms of number and area. The reason for this decreasing trend is mainly because farmers have not been able to achieve maximum benefit from these landraces maintained on-farm. The lack of market information on quality attributes of these landraces and lack of skills and knowledge on quality seed production have limited the supply and production of quality seed, which has ultimately resulted in low yield (Gauchan 1999).

The use of local crops has been confined to the household or village level. The flow of landraces within and outside the village takes place normally through informal seed networks. A proper and systematic market network linking the small-scale seed producers with market channels is lacking. The poor link among seed producers and market channels on-farm is the major constraint, which needs to be strengthened. Farmers have not been able to have maximum benefit from biodiversity maintained on-farm.

Farmers are the main decision-makers in the Nepalese agricultural system. They adopt traditional practices in agriculture and follow their own decisions from the time of sowing to harvesting and storage. The farmer's decision-making is influenced by gender dimension and the knowledge and skills of farmers (Adamo and Harvoka 1998; Subedi *et al.* 1999). Gender holds a significant role in the whole seed system in Nepal. The seed system itself involves a series of activities and a particular person performs each activity. This division of work, roles and responsibilities is built up along with their socioculture. The knowledge and skills are acquired automatically and are passed from one generation to another. In a local seed system, a few people with social status play a significant role in introduction and distribution of seeds of different crops; they are termed nodal farmers and have maintained a network within the village (Subedi *et al.* 1999). Institutionalization of these networks is necessary for securing the seed supply and enhancing the dissemination of technology thereby contributing to an early realization of benefits accruing from adoption of technology. Farmers are still unable to access good-quality seed, even through the organized seed supply system, and are also limited in the benefits that can be obtained from the agrobiodiversity maintained on-farm. Therefore, with an objective of strengthening grassroot organizations for economic empowerment for the agrobiodiversity conservation and utilization within an ongoing project on "Strengthening the scientific basis for *in situ* conservation of agrobiodiversity on-farm" this research was conducted in the Kachorwa ecosite of Nepal.

Materials and methods

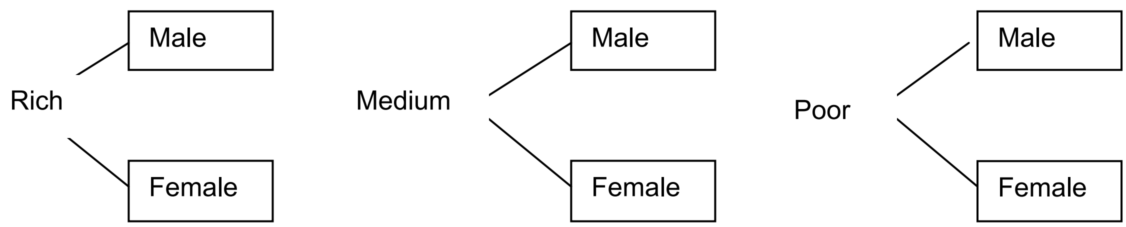
Kachorwa represents the typical *terai* village with clustered households and agricultural land surrounding the dwelling places. This site represents the low agrosystem of Nepal, with rich agrobiodiversity and high level of intervention from formal-sector research and extension agencies. A series of PRA tools was employed for the action research during the project duration and the detailed methods are described below.

Review of literature on seed systems

A review of literature on existing seed systems were done to identify the gaps and constraints in the existing policy and its implementation.

Rapid Market Survey

A series of focus groups discussions was held with women's groups, nodal farmers and seed sellers to identify the potential landraces for seed production. Market studies were conducted to acquire insights into the existing rice seed marketing systems. A total of 98 samples—both males and females from three wealth categories (rich, medium and poor)—were randomly selected on the basis of baseline categorization (see below). Visits and visual observations were made to weekly local markets (*haat bazaars*) to obtain insights into existing seed marketing in the local markets.



Training on mass seed selection

Training materials such as manuals and posters on mass seed selection in rice were prepared. The training was conducted in two phases: the first one, prior to rice planting, on seed production management, and the second on seed selection on the standing crop. The quality attributes of seed and postharvest handling like seed packaging and labelling were covered during the second phase of training. Farmers were made to practise seed selection on the standing crop. The subject matter experts from National Rice Research Station and Regional Seed Laboratory, Hetauda were invited to conduct the training on seed quality.

Workshop

A 1-day workshop on seed marketing was held in Simrongadh, Bara to create a systematic market linkage between the seed producers, promoters and seed sellers. Different potential stakeholders like Agriculture Development and Conservation Society (ADCS), seed producer groups, agrovets, *golas* and representatives from DADO offices participated in the workshop.

Results and discussion

Social and gender dimension in seed production and marketing system

Farmer's choice for varieties

Farmer's choice for varieties is different among the farmers and was found to be specific to wealth categories, which is based on the needs of individual farming households. Both landraces and MVs are under cultivation in Kachorwa to meet diverse needs of local farming communities. Production and productivity are the major preferential criteria for using improved varieties. However, in the case of landraces, despite lower productivity they are still preferred and grown by farmers for their social, religious and other specific characters. A few landraces like *Sathi* (Gamadi rice) is grown by all farmers belonging to all three wealth categories for religious purposes in small parcels of land. *Sathi* is most essential for the *Chhath* festival, which is an important and widely celebrated religious festival in *Terai*. Similarly, *Lajhi, Basmati* and *Kariya Kamod* are popular landraces in Kachorwa that possess significant taste and are used in food preparation like *khir* for special ritual functions and gatherings. Besides, *Lalka Basmati* and *Kariya Kamod* are aromatic rice, and fetch good prices in the market for the quality and taste of grains. These varieties are categorized by the local farmers as rich man's variety and they are grown mainly by rich and medium-wealth farmers. These varieties are exclusively used in entertaining guests and for specific festivals. Likewise, *Bhathi* and *Nakhi Saro* are landraces with unique adaptative traits and they are non-lodging and are grown for their high agroecological adaptability. On the other hand, *Sabitri* and *Hardinath* 1 (BG 1442) are the modern varieties under cultivation in Kachorwa that possess good market value and hence are preferred and grown by almost all farmers in large areas. *Jaya* and *Sabitri* are MVs grown mainly by the resource-rich and resource-medium farmers to pay as wages for the hired labour (Figures 1 and 2).

Farmer's choice of variety also depends upon other parameters such as straw quality, cooking quality, milling percentage, etc. These criteria in selecting the varieties are specific to women farmers, who are involved directly and regularly with other livestock and household activities.

Seed replacement and reasons for replacement

The importance of seed purity for both local and MVs was well perceived by all categories of farmers. Better production was the main reason for the maintenance of seed purity whereas uniform maturity, less pest infestation, better eating quality and better tillering are other reasons to maintain the purity.

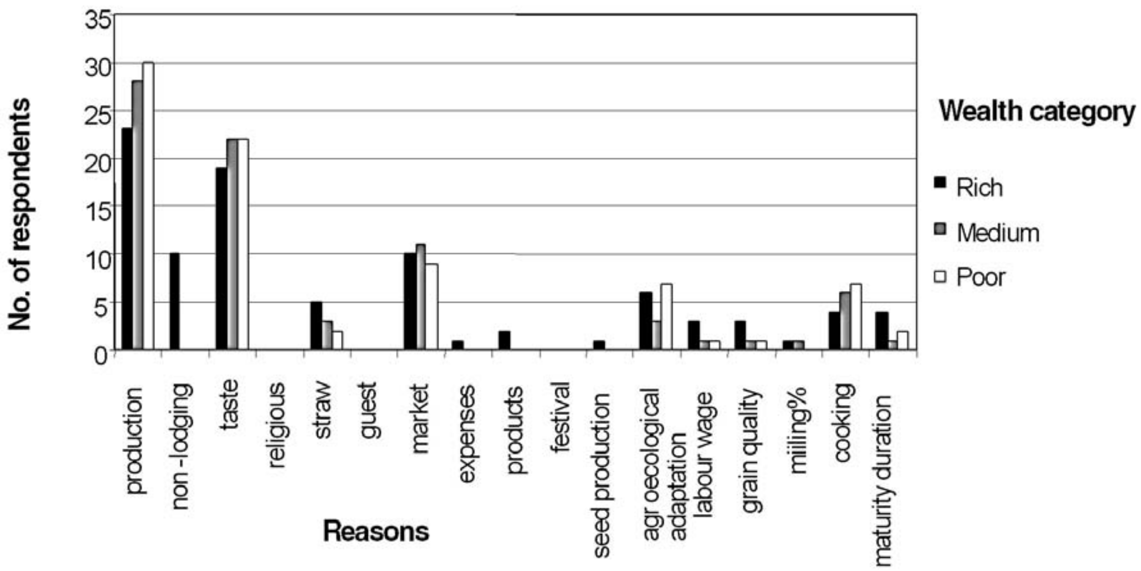


Figure 1. Reasons for growing modern varieties.

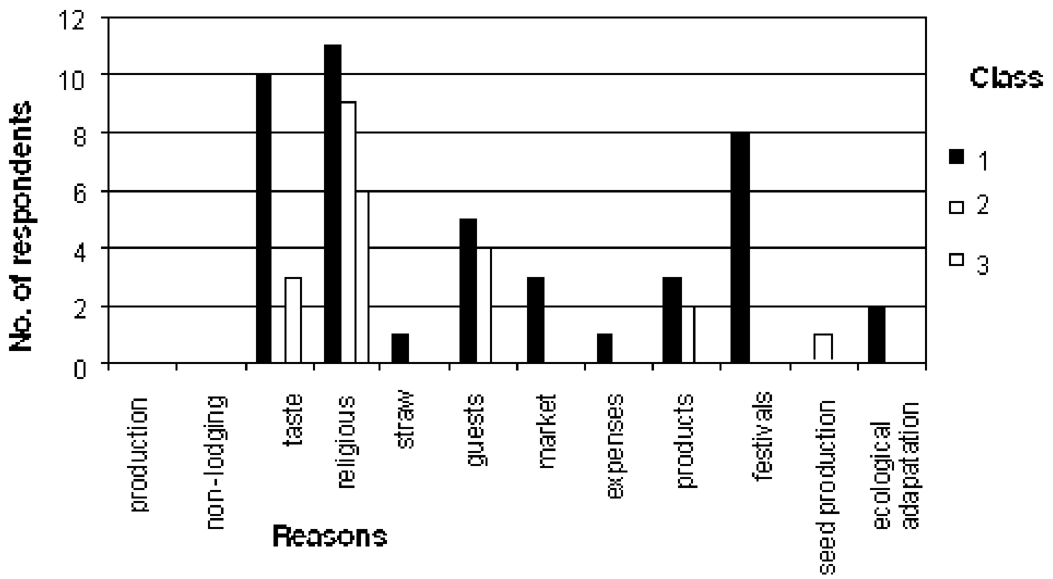


Figure 2. Reasons for growing local varieties.

Seed replacement is the usual practice for both local and modern varieties to maintain the purity of seeds. Seed mixture is the major problem in landraces. The production of off-types is due to mixed seeds which decreases the quality of the crop. In MVs, introduction of hybrids imposes the need for seed replacement every year. The rate of seed replacement and reasons for seed replacement vary with social class and variety. Seed mixtures due to outcrossing and mechanical mixing is the most prevalent problem perceived by the majority of farmers. However, the farmers' seed replacement rate varies with the variety. Off-types are a more serious problem in landraces, especially in aromatic type of rice like *Lalka Basmati*, which imposes the need to replace the seed every year. The study revealed that the seed replacement rate ranged from every year to once in 6 years. The frequency of seed replacement was more often confined to between the first and third years for all three categories. However, seed replacement every second year (2-year interval) is commonly practised by 43% of rich farmers. Similarly, 42% of poor and 39% of medium-wealth farmers replace the seed at 2- and 3-year intervals, respectively.

The resource-rich farmers in Kachorwa have better access to seeds inside and outside the village. They change seeds frequently owing to social and prestige obligations. The easy access to quality seeds of MVs provokes frequent seed replacement, which is again confined to rich farmers (Figure 3).

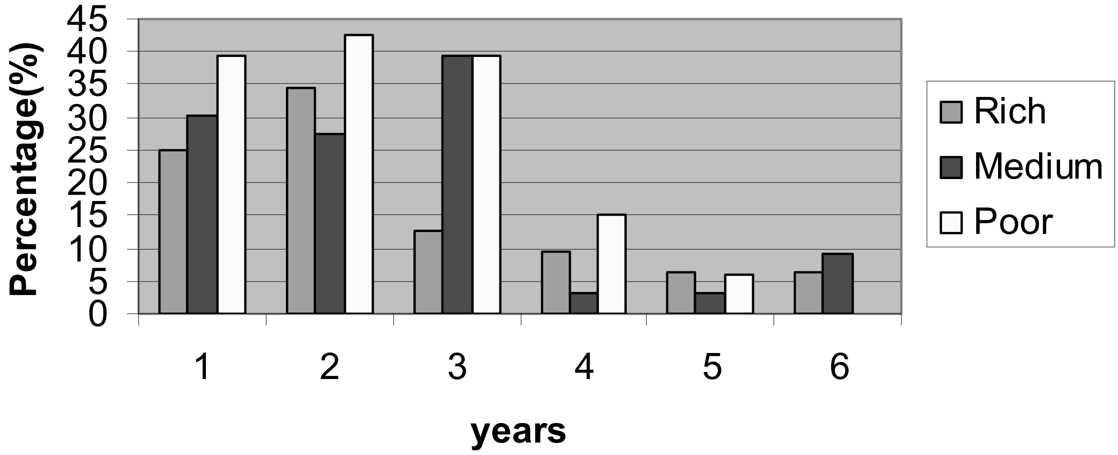


Figure 3. Seed replacement rates across wealth categories.

Seed sources

The informal seed system is predominant for both landraces and MVs in Kachorwa. It is evident that farmers are more dependent on the informal seed system for landraces whereas for MVs there are other options for obtaining the seeds. The majority of farmers from all three categories save their seed for the next year for both new and local varieties. Exchanging the seeds of landraces with neighbours and relatives and purchasing seeds from the agrovets were other ways of acquiring seeds among the rich, medium and poor farmers. Purchase of seed from the agrovets within and outside the village as well as from the Indian markets was commonly practised by the rich and medium category farmers. The medium and poor farmers depend more upon their own saved seeds than on seeds obtained from exchange with neighbours and relatives, as the seeds purchased from the agrovets are expensive and in some instances are not available on time. Farmers from the poor category use the grains obtained as a labour charge for seeds (Table 1).

One reason given for farmers depending more on their own saved seed is the greater reliability in quality. They perceive that self-saved seeds give more guarantees regarding the purity compared with seeds obtained from relatives and neighbours. The other reliable source are the agrovets and the government farms as seeds obtained from these sources are of better quality than those from the other informal sources. However, these sources deal only with MVs so farmers have no other option than the informal sources for landraces. The National Rice Research Programme of NARC is one more source for the MVs for the farmers of Kachorwa as the village is situated near the research station. The resource-rich farmers play an important role in seeking materials from different sources like relatives, neighbours within and outside the village. In a farmer's seed network, a few farmers play a significant role in trying out new varieties and facilitating in the seed flow. These farmers are termed nodal farmers and usually are rich and resource-endowed. The nodal farmers in Kachorwa are mostly of rich and few of medium categories (Subedi *et al.* 1999). Apart from these nodal farmer networks, other sources of seeds are the weekly markets called *haat* bazaar. In these markets, farmers come with small amount of seeds, especially of landraces, to sell in *haat* just before the planting season. However, this type of transaction is more prevalent for vegetables and occurs less often for rice. Seeds also are obtained from the temporary seed shops (*Beez bhandar*), which are functional just prior to the planting season and last until the planting season begins. These shops are usually operated by the richer category of farmers as they can afford to invest in bringing seeds and fertilizers from India (Figure 4).

Table 1. Seed sources for different wealth categories.

Source	No. of respondents					
	Landraces			Modern varieties		
	Rich	Medium	Poor	Rich	Medium	Poor
Own retention	15	19	5	63	65	44
Relatives	3	1	1	7	8	4
Neighbours	5	2	4	8	1	4
Labour charge	–	–	–	4	2	4
Own retention + neighbours	1	–	–	1	–	–
Own retention + relatives	–	–	–	–	1	–
Agrovets	–	–	–	10	8	5
NRRP	–	–	–	5	2	1
India	–	–	–	10	7	3

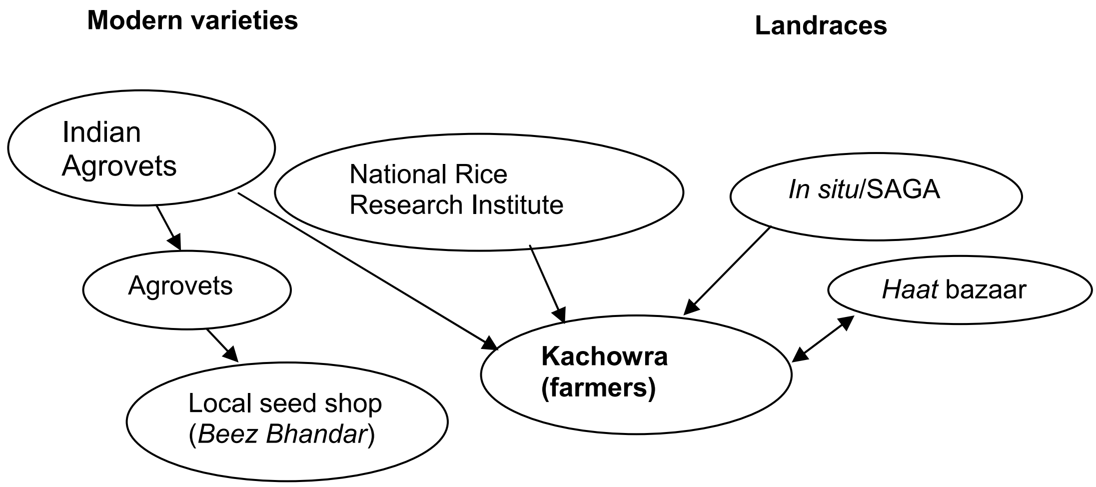


Figure 4. Existing seed market channel (Source: Focus Group Discussion, 2003).

Seed exchange system

The farmers of the study site practised two types of exchanges: seed-to-seed and seed-to-grain. Farmers exchange the seed in two ways: an equal amount of seed/grain is exchanged with an equal amount of seed/grain; this is practised when the giving and taking of seeds is done immediately. After the harvest, seeds are exchanged with the grain/seed at a ratio of 1:1.5, when the seed is given back later. The latter type of exchange occurs most frequently in the poor category of farmers for both MVs and landraces, because poor farmers usually do not have extra or stored seeds or grains; they are forced to wait until after the harvest to pay back the seeds. In contrast, farmers from the rich category are involved more in the immediate type of exchange of seeds and grains as they have sufficient or extra stored grains which they can use for the exchange (Figure 5).

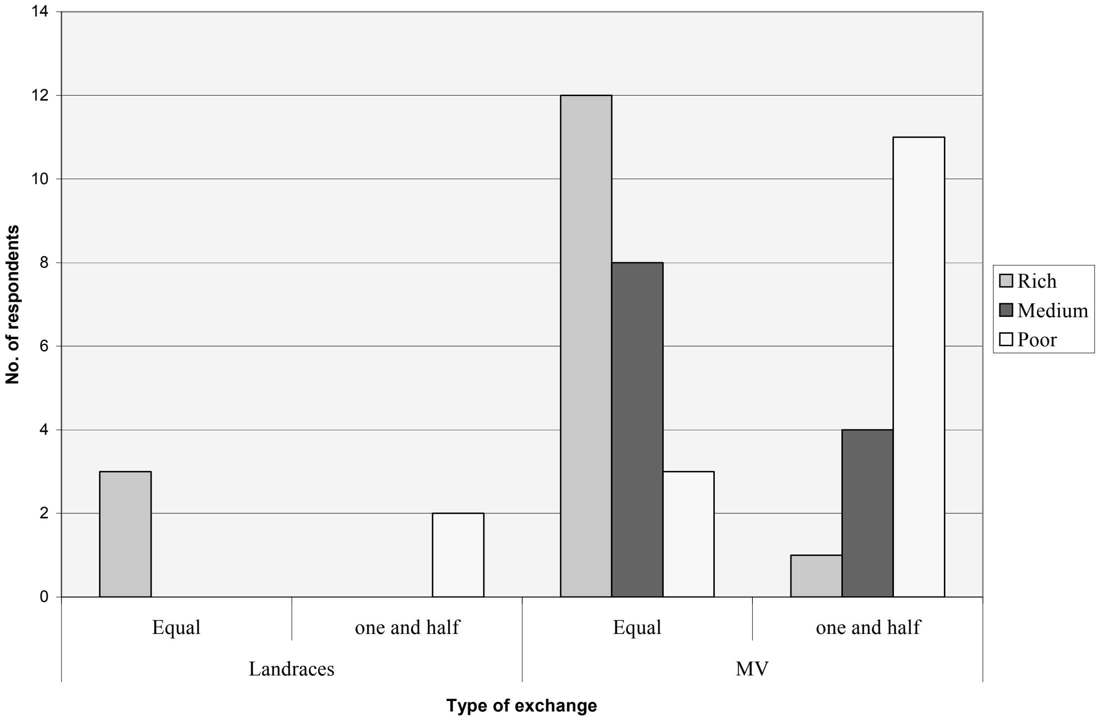


Figure 5. Types of seed exchange practised by different wealth categories.

Seed selection methods

Farmers have been carrying out different seed selection activities to maintain the purity of the harvested seeds and the crop in the following season. Farmers select seeds using the same methods for both local and modern varieties. All the seed selection activities can be grouped under five types of activities. The selection process starts at harvesting and lasts until the seeds are stored. The removal of off-types from the bundle is the usual seed selection process of poor farmers. The removal of off-types from the field, separation of a certain amount of grain for seed from the grain bulk is another way of seed selection. However, the seed selection process depends upon the amount of seed required and the cultural value of the variety. Critical and careful seed selection is carried out for varieties used for religious purposes and for making offerings to God. Seed selection practices vary with different wealth categories of farmers. The seed selection practice is influenced by the amount of seed required and the land area. If the field area and the required seed amount are large, then usually easier methods of seed selection such as removal of off-types from the bundle, and selection of good panicles after harvest are practised. However, if the seed required and the area are also less, the careful method of seed selection such as seed selection from best plot and removal of off-types from the whole plot are the usual practice of Kachorwa farmers.

Removal of off-types from the bundle is the usual practice of rich (18), medium (16) and poor (12) category of farmers which is followed by selection of good panicles from the bundle, practised by rich (14), medium (14) and poor (15) farmers. The amount of seed required and the area of the field in turn is based on the labour requirement for the seed selection process. If a large amount of seed is required, the selection requires a lot of labour and it will affect the cost and selection magnitude. Richer farmers are more particular about seed selection and often hire labour for panicle selection. However, poor farmers with lesser area usually practise the removal of off-types from a field (Figure 6).

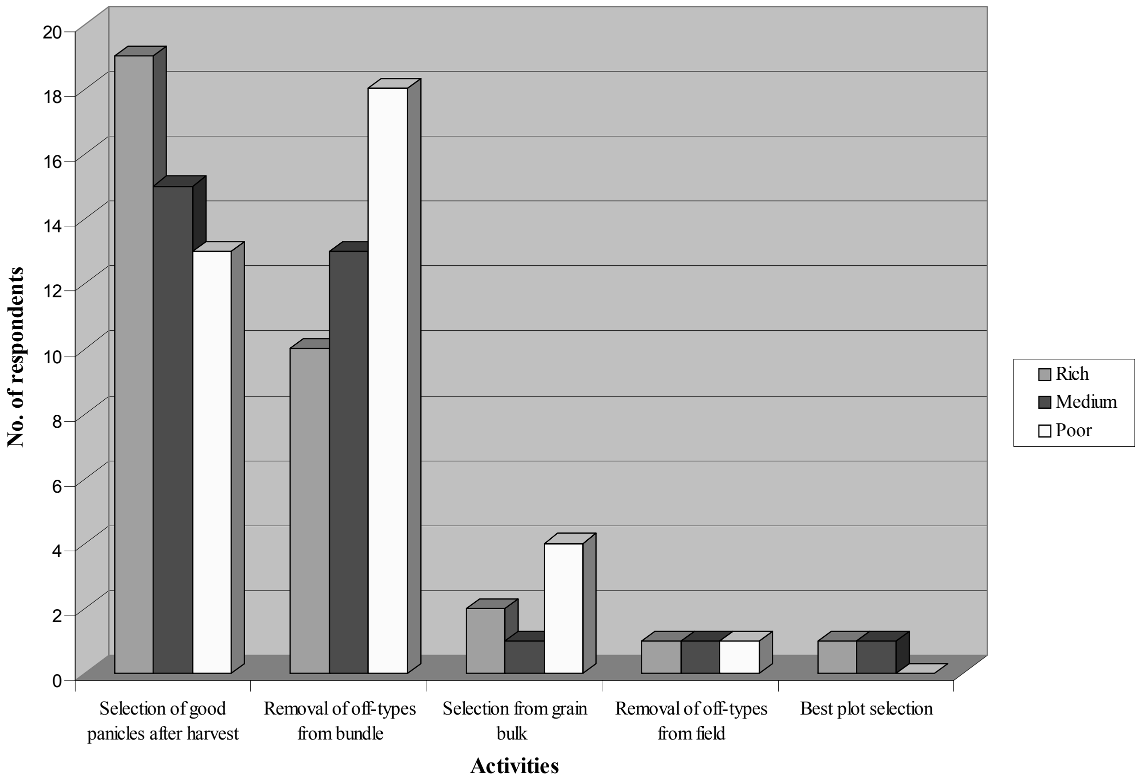


Figure 6. Seed selection methods practised by different wealth categories.

Gender dimension in seed production and marketing

The analysis of the roles of men and women in decision-making across the wealth categories showed that the decision-making process on selection of a variety was more male dominated in the richer category, whereas it was a mutual decision in medium and poor categories of farmers. Males play a dominant role in panicle selection activity in rich categories, whereas female are also involved in the medium and poor categories. But in general, both men and women are involved in panicle selection depending upon the availability of the male counterparts in that specific season. However, the postharvest operations like threshing and storage are exclusively a female activity irrespective of socioeconomic categories. The seasonal migration of males outside the village from medium and poor categories has brought the change in gender role dynamics which has resulted in more women's involvement in the seed selection activities in these categories.

Distribution of the population involved in marketing across the wealth categories indicates that only the rich farmers are involved in seed transactions. The decision on amount of seed to be saved for sowing is made by men and to some extent by women, whereas the decision on place to sell and price is more influenced by men. Likewise, men and women are both involved in selling of the seeds. Men are involved in seed transactions within and outside of the village, but women are involved only when the seeds are sold from one's own house (Table 2).

Table 2. Gender roles in seed production activities across wealth categories.

Activity	Rich			Medium			Poor		
	male	female	both	male	female	both	male	female	both
Variety selection	18	2	12	13	0	20	11	4	17
Intercultural operation	24	1	7	21	0	12	12	3	17
Harvesting	25	1	6	18	1	14	5	6	21
Panicle selection	21	0	6	19	1	11	6	4	22
Selection after harvest	26	0	4	17	0	16	10	4	18
Postharvest operation	12	14	4	5	11	16	2	25	5
Storage	3	12	5	0	23	6	2	24	2
Quantity to sell	3	2	1	-	-	-	-	-	-
Selling	3	-	2	-	-	-	-	-	-

Capacity-building on seed production and market networking

The usual practice of seed selection was not sufficient for the production of quality seed, especially for landraces like *Lalka Basmati* and *Kariya Kamod*. The off-types are a severe problem in aromatic rice landraces because of admixture in the seed or to outcrossing. The aromatic rice landraces possess higher chances of outcrossing owing to their morphological character. Thus, continuous seed selection processes are required to obtain quality seeds. Capacity-building of the community on seed selection and marketing to strengthen the informal seed system was the main intervention strategy adopted by the project. Capacity enhancement of the community through training and field visits were carried out during the project duration.

In the process of strengthening the market channels for local landraces, the SAGA project has developed a new marketing network with the integration of both formal and informal seed networks. In the process of market network establishment, the main focus of this project was to strengthen Agriculture Development and Conservation Society (ADCS), a community-based organization, on seed production and quality control. A village-level workshop with representatives of Agrovets, District Agriculture Development Office (DADO), Agriculture Service Centres and *Golas* inside and around the periphery was conducted with an attempt to set up the market network. Different stakeholders of the seed system were brought together in a common forum. This forum brought together the nodal farmers, Agriculture Service Centres and DADO offices and the roles and responsibilities of each stakeholder were identified (Figure 7).

Institutionalization of market network

Several meetings and discussions were held among different stakeholders in the process in institutionalization of the new market network. Nodal farmer's network has been considered as one of the most potential networks for seed and information flow. The nodal farmers, both male and female, are included in seed-production activity. Extensive training on mass seed selection was provided to a few nodal farmers. Nodal farmers were members of ADCS, which would help in the flow of the quality seeds through the farmer networks. Separate meetings were organized between ADCS, agrovets and *golas* of the village to identify the roles and responsibilities in seed marketing.

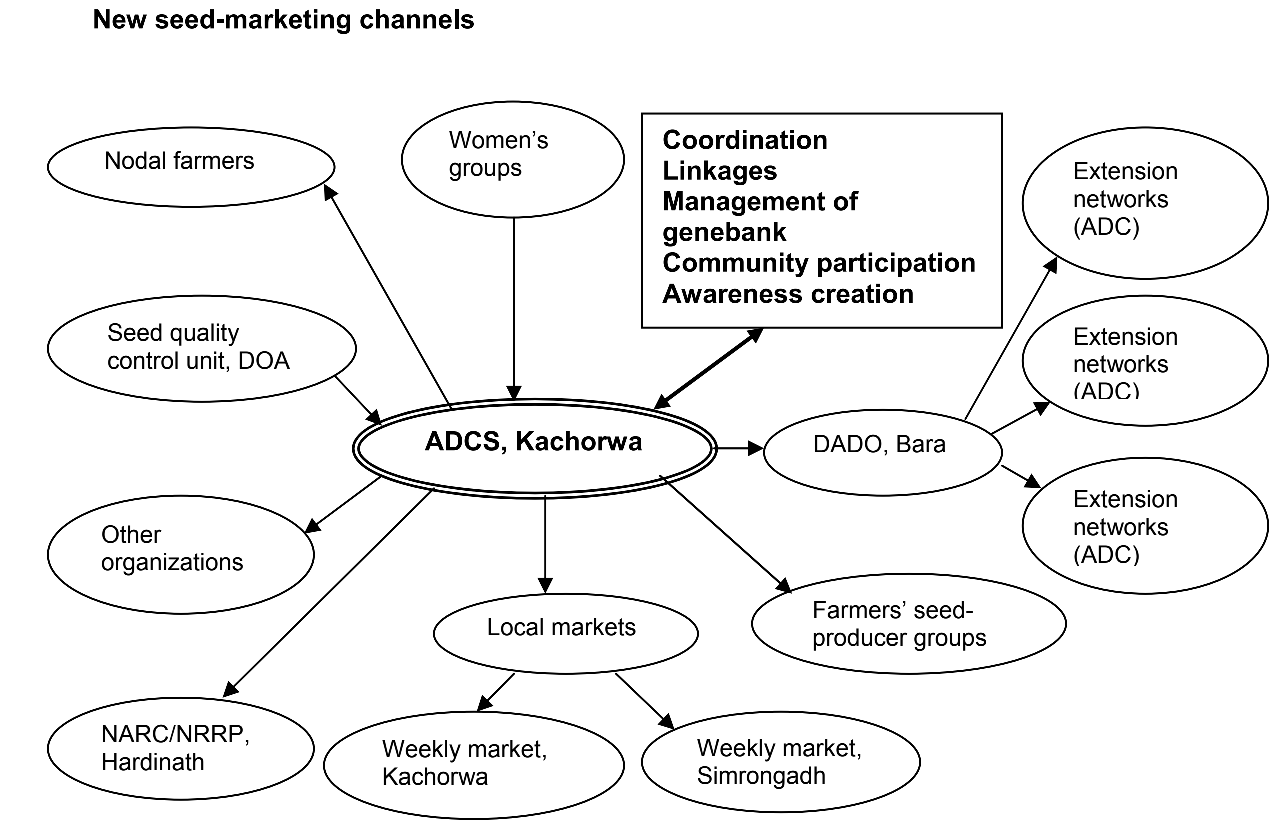


Figure 7. Strategy for local rice seed marketing.

Initial achievement in seed production

Three landraces—*Lalka Basmati, Kariya Kamod* and *Sathi*—were selected for the seed production programme. The pure source seeds of these landraces were obtained from different sources and were distributed to the farmers through ADCS on the condition of returning seeds to the village seedbank at the rate of 1:1.5.

The market network was established but the sustainability of the infrastructure depends upon the quality of seeds supplied by the seed producers and the ability of seed producers to detect the right crop variety for seed production, which depends upon the market demand. Through the same network other varieties of rice could also be marketed in future.

Conclusion

Social and gender dimensions play important roles in the Nepalese seed system. The present study revealed that the farmers grow different varieties according to farmer's diverse household needs, which vary with the different socioeconomic groups. The seed sources and seed selection practices were influenced by the wealth category. An exchange or barter system of seeds was predominant in the seed system prevailing in Kachorwa; however, type of exchange differed according to the availability of the seeds at the time of exchange.

Although the informal seed system plays a significant role, a systematic marketing system and proper seed quality control methods were lacking. Hence, capacity-building of the farmers on seed-production processes and linking of the small- and large-scale seed producers to the market can one effective mechanism through which farmers can derive maximum benefit from the diversity of landrace crops.

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Role of Pratigya cooperative in on-farm management of agricultural biodiversity and marketing

Ram B. Thapa

Farmer and Chairman of Pratigya cooperative, Chaur village, Begnas

Abstract

Pratigya cooperative is a community-based organization involved in enhancing local livelihoods through value-addition and marketing of local agro-based products. The main purpose of Pratigya cooperative is to provide economic benefit to the farmers by marketing the local products through this cooperative and to raise awareness in biodiversity conservation and local crops to further increase the production of local crops. Value-addition of taro, *Anadi*, *Jethobudho* and leaves of *Shorea robusta* (*duna tapari*) has resulted in an increase in production of these crops and also has provided economic benefits to the farmers growing them. A community biodiversity register is being maintained, installation of a cellar mill has been effected and a monthly saving credit programme has been started. All these programmes have given economic benefit to the farmers as these were income-generating programmes. Local market for *Anadi*, *Jethobudho* and taro products has increased and so there has been an increase in their production. Agrobiodiversity has a direct relation with the income-generation programme. Economic benefits and conservation are co-related.

Key words: Value-addition, cooperatives, awareness, market, economic benefit, local product.

Roles and experiences of Agriculture, Development and Conservation Society (ADCS) in strengthening on-farm conservation of agricultural biodiversity

Mahanarayan P. Yadav, Roopnarayan Yadav and Rajkali D. Gupta

Abstract

The Agriculture, Development and Conservation Society (ADCS) is a farmers' group established in Bara district of Kachorwa village, Nepal. The main purpose of this group is to develop a participatory technology through on-farm agrobiodiversity conservation of biodiversity and its sustainability. The following methodologies were used to meet the objectives: (1) community seedbank, (2) participatory plant breeding, and (3) social mobilization. A community seedbank was established to conserve seed of local landraces and quality seeds as this helps in identification, collection, conservation and distribution of the seeds. Participatory plant breeding was done in the crossing of local landraces (*Mansara, Lajhi, Dhudhisaro*) and modern varieties to develop a new variety having the characteristics of the local variety. Social mobilization resulted in the formation of 22 farmers' groups, and introduced a savings/credit programme; various trainings were organized for the farmers' group. The farmers here are now more aware of biodiversity conservation; training has resulted in the capacity-building of the farmers, which has resulted in economic benefits through agrobiodiversity conservation.

Key words: Community seedbank, participatory plant breeding, social mobilization, *in situ* conservation

Role of Dandathar women's group in raising awareness about biodiversity

Krishna K. Adhikari

Abstract

The Dandathar Women Group, Kaski includes women in community development programmes. The main purpose of this group is to make women aware about their rights in biodiversity conservation and to mobilize income-generating activities. A series of training programmes has been organized, particularly on mushroom cultivation, beekeeping, coffee plantations, ginger cultivation, community leadership and community fund regulation. As well, travelling and learning workshops were organised for farmers and programmes like rural poetry journey, folk songs and street dramas were organized to increase the level of public awareness. A community biodiversity register has been maintained to record landraces and the varieties found in the area, a diversity fair was organized, and a diversity block for rice, finger millet, taro and sponge gourd has been set up. The marketability of landraces that have cultural and religious values, such as *Anadi* and *Jethobudho*, and various products of taro has been explored. CBR has helped in knowledge transfer to the younger generations and in relocating of endangered landraces. This programme has been successful in raising awareness among women about the importance of biodiversity. Value-addition of local products has increased the income-generating activities of the group which in turn has helped in the production of these products. The group's work on on-farm management of agrobiodiversity has played an important role in collaborating with organizations like World Vision for community development.

Key words: Community biodiversity register, public awareness, community leadership, diversity fair, diversity block

Role of a local organization in on-farm management of agricultural biodiversity

Surya P. Adhikari (Nodal farmer)

Abstract

The Development and Environment Protection Club (DEPC) is a non-government organization aimed at linking the conservation of biodiversity to the development of society. The main purpose of this club is to increase people's participation in conservation of the environment and biodiversity around the Begnas and Rupa lake wetland areas. The methodology used for creating awareness about the conservation and protection of biodiversity and environment included organising a diversity fair, maintaining a community biodiversity register, a diversity block and awareness programmes like folk songs, essays, rural poetry journey, dramas, tree plantations, seminars, etc. The results have included: (1) women's groups have successfully established a diversity block of rice and taro (55 species of rice, 12 species of taro), (2) continuity of community biodiversity register, (3) initiation of a breeding programme to enhance the quality of seeds of aromatic sponge gourd, and (4) 30 species of different plants have been planted. The programme has helped in improving the livelihood of marginalized and poor farmers by conserving biodiversity and marketing it; farmers have participated in research and species selection; there has been an exchange of ideas between farmers and scientists, and farmers are now more aware and self-reliant.

Key words: Biodiversity, diversity fair, community biodiversity register, awareness, conservation, diversity block

Institutionalizing the process

Good practices of community-based on-farm management of agricultural biodiversity in Nepal: lessons learned

Bhuwon R. Sthapit and Devra I. Jarvis

Abstract

On-farm management of agricultural biodiversity is considered not only an important global strategy to conserve crop genetic diversity but also a contributor to sustainable food production and livelihood options of rural people. Agricultural biodiversity is a crucial asset available to resource-poor farmers for managing vulnerability, uncertainty, shocks and stresses, and therefore access to and control over such resources are a critical policy issue in enhancing sustainable livelihood options to the rural poor. The purpose of this paper is to document good practices of the project "Strengthening the Scientific Basis of *In situ* Conservation of Agricultural Biodiversity On-farm: Nepal Component" that strengthen the roles of farmers and community in managing agricultural biodiversity *in situ* and which are practical, cost-effective, sustainable and have potential for scaling up, with appropriate modifications, to wider geographic, institutional and sociocultural contexts. Formulation of simple steps is identified as a good practice for implementing effective on-farm conservation. A number of good practices have been identified for each step to support local crop diversity management, stakeholder involvement and market access. Participatory four-cell analysis (FCA) method has been developed to understand the factors affecting the amount and distribution of local crop diversity whereas the social seed network analysis was found to be useful for identifying custodians of genetic diversity and the system of seed flow. A range of methods such as rural drama, rural poetry journey, song/poem/painting competitions, farmer's exchange visits, rural radio, travelling seminar, etc. were found to be useful for sensitizing farming communities and policy-makers for enhancing on-farm conservation of agricultural biodiversity. Diversity fairs organized by the communities between farmers' groups were found to be the most powerful practice, not only for increasing public awareness at different levels but also for locating unique diversity and improving access to materials and traditional knowledge amongst communities. Diversity block (a demonstration plot in which the materials collected in diversity fair are grown together for community display) was a useful method for identifying farmers' descriptors to characterize and evaluate farmers' units of diversity and value of traits; also, communities could bulk planting materials for informal research and development known as diversity kits. Community biodiversity register (CBR) has evolved as a good practice to manage community-based biodiversity information systems for empowering a local community and developing ownership to monitor local biodiversity over time and space. The project was successful in bringing together local institutions to manage community-based biodiversity information systems so that their capacity to develop options for adding social, economic and environmental benefits to a community was enhanced. The local institutions were motivated to develop local-level conservation actions and influence policy for wider impacts on conservation and use of agricultural biodiversity.

Key words: *In situ* conservation, on-farm management, agricultural biodiversity, good practices, community participation, community biodiversity management

Introduction

Agricultural biodiversity includes all components of biological diversity relevant to food and agriculture: the variety of plants, animals and microorganisms at genetic, species and ecosystem level which are necessary to sustain key functions in the agroecosystem, its structures and processes (CBD COP Decision V/5)(IPGRI 2001). Genetic resources of animals and plants are the biological basis of the world's food security and livelihoods of people. Plant genetic resources (PGR) are some of the major biological assets available to the resource-poor farmers that can ensure sustainable production and improve livelihood options. Genetic diversity gives resource-poor farmers a low-cost option to manage the shocks and vulnerability of production systems by its ability to adapt to changing environments. Therefore, agricultural biodiversity has a critical public value for global food security. The Convention on Biological Diversity (CBD) and later also, the Global Plan of Action of Plant Genetic Resources for Food and Agriculture (GPA-PGRFA) have called for the conservation, sustainable use and equitable access and benefit-sharing of agricultural biodiversity. The international community has also recognized the critical role of the local institutions with genetic resources whether they are identified as farmers, indigenous or local communities and their traditional knowledge (Altieri and Merrick 1987; Brush 1995; Bellon 1996; Jarvis and Hodgkin 1998, 2000). Among other things, each of these instruments not only recognizes the countries' responsibility to conserve and use their PGRFA, but also the importance of equitable sharing of the benefits derived from the use of resources and technologies. However, many developing countries are seeking simple participatory practices that strengthen local capacity to manage on-farm conservation of agricultural biodiversity *in situ.* The genetic diversity found within a farm or communal land is of great value to ensure options. In this paper, we try to illustrate some of the good practices of successful community participation in on-farm conservation actions of agricultural biodiversity in Nepal and lessons learned from such processes.

Materials and methods

During the implementation of IPGRI's Global Project, "Strengthening the scientific basis of *in situ* conservation of agricultural biodiversity on-farm" in Nepal, a national multidisciplinary group consisting of staff from an NGO, Local Initiatives for Biodiversity, Research and Development (LI-BIRD) and Nepal Agricultural Research Council (NARC) studied the scientific basis of *in situ* conservation of agricultural biodiversity on-farm. Goal and purpose of the project and institutional mechanism of collaboration have already been reported (Jarvis and Hodgkin 1998; Jarvis *et al.* 2000b; Upadhyay and Subedi 2000).

Before the project was initiated, series of meetings were held between the contrasting partners—GO and NGO—to create a framework for implementation and management of *in situ* conservation project at the national and site levels. IPGRI had to play a critical role in bringing NARC and LI-BIRD together and agreed upon the working modality of the GO-NGO partnership (de Boef 1998; Upadhyay and Subedi 2000). Once a participatory working modality of multi-stakeholders was agreed on, based upon comparative advantages from expertise and institutional role, a number of brainstorming meetings were held to sort out the key issues:

- Identify method for selecting sites for on-farm management where private value (direct use) of local crop diversity and public value (genetic diversity for future use) for conservation are high.
- Test whether variety names could be a proxy measure of crop genetic diversity and its distribution in an agroecosystem.

Selecting sites for on-farm conservation

Nepalese sites were selected based on the physiographic regions of the country, richness of native crop diversity and access to site in terms of logistics, knowledge, and materials exchange (Paudel *et al.* 1998; Rijal *et al.* 1998; Sherchand *et al.* 1998) (Table 1). A fundamental problem faced by any *in situ* conservation effort is locating crop populations to focus on. It is essential to consider some generalized criteria for selection of sites: ecosystems, intraspecific diversity of target species, species adaptation, genetic erosion, diverse use values, and interests of farming community, partners and government agencies and logistics for monitoring (Jarvis *et al.* 2000a). One of the often-cited disadvantages of on-farm conservation is the difficulty for plant breeders of accessing the material conserved. However, this is only so because the on-farm conservation efforts to date have not been mainstreamed and not linked to national PGR efforts. In the case of Nepal, the NARC was involved, thus providing the required link from the beginning of the project. These study sites were selected with the objective of conducting on-farm conservation of agricultural biodiversity *in situ* in the context of contrasting ecosystems, market and technology access of materials and knowledge and level of technological interventions so that different methods and good practices could be tested and verified.

Table 1. Comparative description and characteristics of the three contrasting study sites of Nepal.

Site[†]	Village	Altitude (m)	Climatic zone	Level of crop diversity	Ease of access (level of intervention)
Jumla[1]	Talium and Kartikswami	High hill (2240–3000 m)	Cool temperate to alpine	Moderate to high	Difficult (low)
Kaski[2]	Begnas	Mid-hill (668–1206 m)	Subtropical	Very high	Moderate (medium)
Bara[3]	Kachorwa	Terai (100–150 m)	Warm subtropical	High	Easy (high)

[†] [1] Paudel *et al*. (1998); [2] Rijal *et al*. (1998); [3] Sherchand *et al*. (1998).

Farmer unit of genetic diversity

At household (HH) and community levels, studies have shown that farmers use names of variety as a basic unit of diversity for day-to-day on-farm management and often this is consistent at the household level and within the community and villages as they use this information to exchange genetic materials and communicate associated knowledge about the materials (Rijal *et al.* 2003a). Farmers have a set of agromorphological descriptors to distinguish the varieties and specific local names to describe such unique morphology, for example, of taro in Nepal (Rijal *et al.* 2003a). The consistency index of variety names as proxy indicator of diversity decreased as the distance from referenced villages increased (Sadiki *et al.* 2005). In Morocco, using a variety's name raises several questions as farmers recognize a set of traits for a farmer-managed landrace population and they may or may not have the same names. In Burkina Faso, one variety may have different local names used by different communities. Sadiki *et al.* (2005) reported different morphological traits for the same farmer-named varieties of faba bean; however, farmers' diversity units coincide with the units of measured phenotypic diversity. A similar observation was made in locating and measuring the diversity in rice in the mountains of Nepal. The level of consistency increased from high altitude to mid- and low-altitude villages (Bajracharya 2003). It is obvious from Morocco or Nepalese studies that the diversity decreased as the distance increased from the reference point. Therefore, it could be the ecological factor in both cases (i.e. increased distance and increased altitude).

Often for traditional crops, scientific descriptors are not available and traits used by farmers (can be termed as farmer's descriptors) are often used to distinguish the unique diversity. Farmer's descriptors for the variety names and traits have been verified using the morphological traits and SSR traits characterization. Results of IPGRI global project suggest that the concept of name may or may not represent the level of diversity. In the cases where there is high consistency in variety names, a farmer-named variety could be used as a unit for conservation (Jarvis *et al.* 2004). When the name is not consistent with the unit managed by the farmers, then other parameters need to be added in order to precisely define the unit of conservation.

Methods for implementing on-farm conservation and a set of good practices

Several processes, each consisting of a set of practices for strengthening the community role in conservation and utilization efforts, were tested (Table 2). These methods were piloted through a participatory planning process of farming communities, local institutions, and key partners.

Good practices could be considered those practices that are practical, cost-efficient, and have the potential for scaling up in wider geographical, institutional and sociocultural context. Good practice is a system, organization or process, that over time and space maintains, enhances and creates crop genetic diversity and ensures its availability to and from farmers and other actors for improved livelihoods on a sustainable basis (Sthapit *et al.* 2003a). The practices are identified as good practices when the project team, community, local institutions, and policy-makers value the approaches and institutionalize them with their own initiatives or internal resources. In its simplest meaning, good practices are practices that work towards the achievement of certain objectives under certain given conditions or a context (Sajise 2005). It can be a process, a method, an institutional arrangement or a combination of any of these. Under the framework of sustainable livelihoods, good practice works when a set of practices assembles together in a context.

This paper is based upon the several works and review studies reported by various authors during the project period (Gauchan *et al.* 2003; Jarvis and Hodgkin 1998; Jarvis *et al.* 2000b; Sthapit *et al*. 1999, 2003a, b, c). A set of good practices that are successful to achieve certain project objectives has been evaluated in the context of the definition of good practice and in the context in which the practices are applicable.

The paper is also based upon field observations, direct involvement, and other social analyses to verify the results. The good practices are assessed based on interactions with scientific communities, farmers, development workers and policy-makers to make sure the practices identified are good practices, or are valued by that group of stakeholders.

Results and discussion

Step 1: Understanding the local context

Farming communities have always nurtured substantial amounts of genetic diversity for food and agriculture. During the process of this step the focus group discussion (FGD) was organized to understand why some cultivars are grown in large areas by many farmers whereas some cultivars are grown in small areas by many farmers. There are also many cases in which large numbers of cultivars are maintained by few farmers in small areas. This extent and distribution of local diversity is influenced by a complex set of socioeconomic, cultural, environmental, biological, policy and market factors. There is a need to understand the rationale for taking such decisions and the associated local knowledge and culture. There are several ways to understand this rationale in different contexts (for details see Friis-Hansen and Sthapit 2000; Rana *et al.* 2005; Sthapit *et al.* 2003a, b, c).

Table 2. A set of good practices for implementing community-based on-farm management of agricultural biodiversity in Nepal.

Process of on-farm conservation of agricultural biodiversity and objective of the steps	Practices tested	References
1. Developing understanding of local context and local agrobiodiversity	Rapid rural assessment Four-cell method Social seed network Baseline survey	Rana *et al.* 2000 Subedi *et al.* 2003 Rana 2004 Rana *et al.* 2005
2. Sensitizing farming communities and key stakeholders	Village workshop Meetings Rural Poetry Journey Rural Drama Teej geet competition Song/poetry/essay/painting competition Diversity fairs Exchange visit Rural Radio Travelling seminar National workshop	Sthapit 1999a, b Rijal *et al*. 2000a, b Chaudhary *et al.* 2003 Rijal *et al*. 2003c Sthapit *et al.* 2003a, b, d Baral *et al.* 2005
3. Locating, characterizing and evaluating useful diversity	Intensive data plot Diversity fairs Diversity blocks Diversity kits Community biodiversity register	Sthapit *et al.* 1999 Rijal *et al.* 2000a, b Sthapit *et al.* 2003a, b, d Rana *et al.* 2003 Rijal *et al.* 2003a, b, c Subedi *et al.* (p. 41) †
4. Improving access to materials and knowledge	Diversity fairs Diversity blocks Diversity kits Promoting nodal farmers Community seed bank	Sthapit 1999a Rijal *et al*. 2000 Sthapit *et al.* 2003 Rijal *et al.* 2003 Shrestha *et al.* (p. 70) †
5. Managing community biodiversity information systems for empowering and monitoring local biodiversity	Community biodiversity register (CBR) Inventory/Catalogue Stamps Community biodiversity management (CBM)	Rijal *et al.* 2003b Subedi *et al.* (p. 41) † Joshi *et al.* 2005
6. Developing options for adding social, economic and environmental benefits to community	Value-addition programme Participatory variety selection Participatory plant breeding Landrace enhancement Community seed production	Sthapit and Jarvis 1999 Sthapit *et al.* 2001 Sthapit *et al.* 2003c Joshi *et al.* 1999 Rijal *et al.* 2000a, b Gyawali *et al.* (pp. 161, 189, 202)†
7. Influencing policy	Travelling seminar Diversity fairs Community biodiversity register Variety release of PPB and landrace enhancement Workshop/Meetings/Visits	Gauchan *et al.* 2003 Gauchan *et al.* 2004 Upadhyay *et al.* (p. 123)
8. Exit strategy and sustainability	CBM Micro-credit Linkages with other agencies	Sthapit and Eyzaguirre 2005 Subedi *et al.* (p. 41) †

† Refers to papers in this volume.

What basic information is needed to understand on-farm conservation?

- What is the amount and distribution of the genetic diversity maintained by farmers over space and time?
- What are the processes (conscious or unconscious) used to maintain the genetic diversity on-farm?
- Who maintains genetic diversity within a community and how?
- What factors influence farmers' decisions on maintaining traditional varieties?

Understanding the above-mentioned questions provides the knowledge needed not only to better manage plant genetic resources on-farm, but also to develop options for better livelihoods and enhancement of incomes (Jarvis *et al.* 2004).

Distribution of diversity patterns

The distribution of variety names within and among communities and regions may or may not indicate richness and evenness patterns of genetic diversity on-farm (Sadiki *et al.* 2005). Methods to characterize the amount and distribution of crop cultivars were developed in Nepal based on average area and number of households growing each cultivar (Sthapit *et al.* 2001; Rana 2004). Farmers' varieties (local and formally released cultivars) were categorized into groups of cultivars that occupied large or small areas (based on average area or perceived local knowledge of participating farmers), and those cultivars that were grown by many and few households (based on number of households). This method, known as Four-Cell Analysis (FCA), has been used in a variety of ways to understand the amount and distribution of local crop diversity in a village or landscape level. The FCA method takes a population genetics approach similar to that proposed and discussed by Marshall and Brown (1975) and Brown (1978) for sampling alleles during germplasm collecting. They described divergence among populations according to frequency and distribution of alleles, leading to four different types of alleles and suggested that populations with locally common alleles are thus primary targets for collecting and conservation. Common, widespread alleles are likely to be found wherever a crop is grown and rare alleles are seldom easy to capture. In the context of on-farm management of local crop diversity, it is difficult for farmers and communities to articulate this concept. Rana (2004) used FCA as a decision-making tool for on-farm conservation actions. Sthapit *et al.* (2002, 2003c) used this as a participatory method to understand farmer's rationale in allocating land area for each cultivar, identifying common and rare cultivars and monitoring local crop diversity for conservation actions in Nepal, Mozambique, Sri Lanka and Malaysia. Grum *et al.* (2003) used this method in Sub-Saharan Africa to discuss farmers' perceptions on the extent and distribution of rice, yam, sorghum, millet and cowpea diversity. In Uganda, it was used to identify rare banana landraces (Mulumba *et al.* 2004) whereas in Nepal and Malaysia the methodology required adjustment when it dealt with fruit tree species in home gardens (first author's observation). For perennial species, it was found to be more appropriate to use the number of trees instead of area under the variety.

What are the incentives to communities for an effective on-farm conservation programme?

In order for local crop diversity to be maintained by farmers, the resources must have some value and/or be competitive with other options a farmer might have. Benefits to farmers, communities and society may be in the form of economic, ecological and sociocultural gains. However, with changing socioeconomic conditions, this is not enough to sustain the conservation efforts by the custodians of diversity. The farmers and communities should be able to benefit more. To make the benefits more apparent and purposive, two options can be considered in adding benefits; the first through participatory plant breeding, and the second through public awareness, better marketing and policy incentives (Gauchan *et al.* 2003). The first option is to seek improved quality, disease resistance, high yield, better taste and other preferred traits through breeding, seed networks and modified farming systems. The second option includes adding value to local crop resources so that the demand for the material or one or more products derived from it may be increased. These diverse options will emerge when the community, researchers and developmental institutions are directly involved in analysis of livelihood assets and outcomes and management of traditional knowledge and genetic resources for biodiversity-based livelihood and income generation. This is only possible if the local capacity of farming communities and institutions is strengthened for making appropriate decisions and these partners also take up the responsibility of monitoring local crop diversity after developmental interventions.

Step 2: Sensitizing farming communities and key stakeholders

A range of practices has been tried to raise the awareness of farmers, local institutions, development workers and policy-makers. Table 2 lists a few of these good practices that were found to be useful in a rural setting. At the outset of project implementation, village workshop and meetings with key local leaders are critical for obtaining support from the local institutions and individuals. However, these methods do not necessarily reach all the public ranging from young students to elderly people. In Nepal, rural dramas on biodiversity issues were very popular in attracting a large population of the community from a range of ages, gender and ethnicity. We also found rural poetry journey, *Teej*[8] song competitions to be a crowd puller in the Nepalese context (Sthapit 1999a). They were used effectively not only for mass public awareness but also for documentation of traditional knowledge in the form of songs and poems. Exchange visits of farmers, travelling seminars, rural radio and diversity fairs are very farmer-friendly practices and have been found to be effective in different ways (see pp. 226 and 236, this volume).

Diversity fair has been found to be a multipurpose participatory tool that can be used not only for raising public awareness from farmers to policy-makers but also as a rapid way of locating and assessing diversity in a given village (Sthapit 1999b; Rijal *et al.* 2003c). The method encourages farmers to share traditional knowledge, skills and materials and strengthen social networks for future exchange. Local institutions have learned to organize diversity fairs, and in the process, they have developed the capacity to mobilize funds, groups and networks as a social learning method.

Step 3: Locating, characterizing and evaluating useful diversity

The least-cost conservation will occur in sites that are most highly ranked in terms of public benefits. Cost is also low where, because the private benefits that farmers obtain from growing genetically diverse varieties are the greatest, public interventions to encourage them to do so is minimal. The economic concept that farmers' varieties embody both (1) 'private' values in the harvest that the farmer enjoys, either directly as food or feed, or indirectly through the cash obtained by selling the seed/grain and purchasing other items, and (2) 'public' values in its contribution to the genetic diversity from which future generations of farmers and consumers will also benefit (Smale *et al.* 2004). Those crop genetic resources, which have both low farmer utility (current private value) and public value, will be difficult to conserve *in situ* unless public interventions are made for adding benefits. These are a few challenges that need demonstration of social, economic and environmental benefits to the communities. In order to establish the value of agrobiodiversity, characterization, and evaluation of traits for productivity and quality is an essential component. Often this is done in isolation in research stations by plant genetic resource specialists and the protocol for this is well established (Guarino *et al.* 1995). In Nepal, materials collected from farmers or diversity fairs were grown in unreplicated diversity block to characterize and evaluate materials. Farmers were invited to watch the diversity block in the field and determine

[8] This is a unique festival of Hindu women marked by fasting, folk songs and dancing.

whether the farmers are consistent in naming and describing varieties. CBOs often use these plots as demonstration blocks to sensitize a community, and multiply seed for further distribution.

Step 4: Improving access to materials and knowledge

Poor access to livelihood capitals is one of the constraints to developing better options for sustainable livelihoods. Once the agricultural biodiversity was assessed and characterized, simple methods were developed by the community to multiply useful and unique local cultivars in diversity block managed by either CBOs or schools or self-help groups or community seed banks/producers to test consistency in names and possible incidence of pest and diseases. These seeds are packed in small bags or envelopes (in the case of vegetable seeds) as diversity kits and distributed and/or sold to farmers to encourage them to select, maintain and exchange materials through their own social networks. This practice has been found very effective not only in the project but also in other projects in rice and other crops (Joshi and Sthapit 1992; Witcombe *et al.* 2003). One CBO in Bara *in situ* site in Nepal raised funds to build a community seed bank to keep records of local cultivars, multiply and store small amounts of unique and rare varieties to improve access to germplasm by needy people (Shrestha *et al.*, see p. 70, this volume). The local community of Bara has considered the community genebank to be one of the best things to happen to the community as the access to local seeds is ensured. These experiences have been used by community-based resource nurseries in home garden projects in Nepal and Vietnam to improve access to locally adapted germplasm and knowledge and to generate livelihood options for nursery-keepers. In Vietnam, such nursery-keepers displayed the saplings and seed of interesting local fruits and vegetable in diversity fairs to sell information and materials. Similar examples have been reported by Seed Saver Network in the Pacific Islands (Jansen 2002). The most important aspect of this practice is that communities began to appreciate the value of biodiversity as a natural asset that could be linked to local and national markets for generating income for household use. In Nepal, PPB products of on-farm conservation sites were deployed through nodal[9] farmers so that information and seed could be spread through social seed networks (Subedi *et al.* 2003). The stability and effectiveness of such networks is currently being studied by Subedi *et al.* (see p. 41, this volume).

Step 5: Managing community biodiversity information systems for empowering a community

Plant genetic resources and associated traditional knowledge[10] are increasingly appreciated and valued not only by those who are currently depend on them for daily subsistence but also by modern industry, health and agriculture. There have been increasing concerns of NGOs and Civil Societies that genetic resources and traditional knowledge are being misappropriated by multinationals for commercial interest. Community Biodiversity Register (CBR) [11] is a dynamic method developed by the project team to address a range of objectives, such as protection from bio-piracy, promoting bio-prospecting, monitoring genetic erosion, developing local ownership for development and conservation actions. A CBR process aims to encourage communities and local institutions to develop a better understanding of their own biodiversity assets and their value so that they develop research, development and conservation strategies at the local level. Through learning and doing

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9 Nodal farmers are those nodes of communication and material flow (farmers) who search, select, maintain and exchange genetic resources and associated knowledge (Subedi *et al.* 2003a).

10 Traditional knowledge refers to the body of wisdom, innovations and practices of indigenous peoples and local communities around the world (source: www.biodive.org).

11 CBR refers to "a record, kept in a book or electronic format by community members, of the genetic resources in a community, including information on their custodians, passport data, agro-ecology, cultural and use values" (Sthapit *et al.* 2001).

experiences, we found that farming communities and local institutions could be empowered to make their own developmental and conservation decisions if their capacity to document local biodiversity inventory and traditional knowledge, analyze and use information in way that farmers can understand was enhanced (Rijal *et al.* 2000a; Subedi *et al.*, p. 41, this volume). There are many efforts reported by MoFSC (2000) and People's Biodiversity Register in India (Utkarsh 1999) which focus on documentation of traditional knowledge and inventory of species and varieties as protection from bio-piracy. Subedi *et al.* reviewed the pros and cons of all the methods and then refined the CBR methodology in consultation with local communities. The method of CBR may differ according to the set objectives. In order to promote ownership of the biodiversity and community level awareness, it was realized that a set of activities (e.g. orientation meeting, diversity fair, inventorying, four-cell analysis, results sharing and developing conservation actions) can be considered good practice for CBR. Many groups have organized biodiversity fairs to raise awareness and promote exchange of materials and knowledge. These events could be used to document village-level biodiversity and provide their custodians with some level of preliminary training. These efforts are good enough to monitor common and rare types of species/cultivars and local diversity plots are useful to multiply rare types for grassroots breeding and conservation actions.

The most important lesson derived from this process is that farmers have realized that a large number of local cultivars are now conserved by few households and thus are highly vulnerable to genetic erosion and eventual loss. This realization has encouraged 22 farmer groups to form a nodal CBO, namely Agricultural Development and Conservation Society (ADCS), in Bara, one of the *in situ* sites in *terai* part of Nepal. ADCS established a community seed bank with seed money from local government and IPGRI to store unique landraces of rice, local crops and vegetables. The purpose of the community seed bank is to maintain the CBR, multiply local traditional seed for increased access and maintain a small quantity of seed in traditional storage for short-term purposes (Shrestha *et al.*, see p. 70, this volume). The ADCS has further created a community biodiversity management (CBM) committee to manage the community seed bank, formulate procedures for seed collecting and distribution. The committee has now requested the *in situ* team to train their staff in safe seed storage and movement of genetic materials and to develop an annual workplan that supports maintenance of agricultural biodiversity. This ADCS has developed the capacity to voice their needs and ability to source the funds (financial capital) from both local government and other developmental NGOs.

Step 6: Developing options for adding social, economic and environmental benefits to a community

Experience suggests that effective management and conservation of genetic resources on-farm takes places where the resources are valued and used to meet the needs of local communities. If crop genetic resources are going to be conserved on-farm, it must happen as a spin-off of farmer's production activities directed to his/her livelihood. This means on-farm conservation efforts must be carried out within the framework of farmer's livelihood[12] needs. So far, rich local crop diversity is maintained in those regions where the private value of local landraces and public value of genetic diversity are high (Smale *et al.* 2004). Given the current globalization trends and market environment it would be difficult to maintain local crop genetic resources if they are not made competitive in the market. The project has used multiple strategies to use local crop diversity and knowledge for generating social, economic

[12] A livelihood comprises capabilities, assets (including both material and social resources) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintains or enhance its capabilities and assets, both now and in the future, while not undermining the natural resource base (Chambers and Conway 1992).

and environmental benefits for the people. Local institutions were trained to analyze sustainable livelihood capitals and use key assets to develop livelihood outcomes. The following general strategy was used to raise the value of local crop diversity:

- increase value of local crop diversity by increasing access to information, knowledge and materials (e.g. nutritive value of specific crops or varieties)
- increase demand for local crop diversity by non-breeding approaches (e.g. value-addition of processed taro)
- improve the materials by participatory germplasm enhancement or participatory plant breeding.

It is important that the existing CBOs, women's groups, self-help groups and cooperatives be encouraged to understand the farmers' information database and identify appropriate strategies for the local conditions. In order to be able to do this their capacity to assess the locally available natural capital (e.g. biodiversity assets) along with other resources to capitalize the above-mentioned strategy, and the choice of such strategy which will vary according to local context, should be developed. The resources that communities need in order to maintain and manage agricultural biodiversity include (1) knowledge and skills of their biodiversity and associated landscapes (human capital), (2) systems for maintaining and exchanging their local materials (social capital), (3) local institutions that support and validate local management and access to agricultural biodiversity, (4) techniques and practices that add value and adaptive capacity to local materials (human capital), (5) local financial resources such as savings and credits to support local initiatives (financial capital) and (6) physical infrastructure such as road, communication and cooperatives (physical capital).

Table 3 illustrates the mobilization of key sustainable livelihood assets for implementing on-farm conservation experiences. Specifically, the project focuses on practices that will help farmers and communities to manage and utilize diversity sustainably. It is concerned particularly with determining the social processes that contribute to diversity maintenance and identifying ways that will strengthen these processes. The following good practices were found useful for enhancing economic benefits to the society:

Value-addition of local crop diversity

The first step of a value-addition programme is to raise consumer awareness on the value of local agricultural biodiversity and local products developed from it. We are fortunate in some way that there are a few private entrepreneurs who are interested in marketing local products and need a regular supply of quality products. The project played a key role in linking farmers and its cooperatives to the established local market outlets. The process has helped to make communities realize that local products prepared from the locally available biodiversity could be marketed for urban consumers and cash income could be ploughed back into the rural community. They also quickly realized the need for working together for mass production and a commodity chain approach to link the production chain from producers to processing, packaging, quality monitoring and marketing. This provides new impetus to the existing self-help (mostly women) groups and cooperatives to work together which brings in experiences of social learning and community cohesiveness. The project assisted in strengthening this social capital along with the skills and knowledge of women farmers in managing biodiversity assets (Table 3).

Table 3. A set of good practices employed in enhancing livelihood assets of on-farm conservation project sites in Kaski and Bara districts, Nepal for developing options of livelihood strategies, outcomes and impacts, grouped by vulnerability context (abiotic, biotic, social).

Good practices for enhancing livelihood assets	Livelihood strategies	Livelihood outcomes	Livelihood Impacts
Abiotic: Hailstorm, drought, cold, flood, climate change			
Enhancing social capital • Strengthening role of existing women groups/self-help groups/ cooperatives/clubs/CBOs • Identification of nodal farmers and seed networks through social network analysis • Empowering local institutions • Social inclusion through stakeholder analysis using power, interest and legitimacy (PIL) tool • Strengthening institutional linkages, partnership and networks • Target women groups	Use local skills and knowledge for value-addition of local products • *Masura* (taro) production, collection, packaging and marketing • Marketing Anadi rice (sticky and medicinal value) for local food culture • Finger millet flour link to supermarket, bakeries and cafés	• Group initiatives • Functional local institutions • Empowerment of women • Social networks and cultural importance recognized	• Increased self confidence in dealing with biodiversity and other local-level developmental issues • Communities highlighted and their voice heard in local and national planning
Biotic: Pests and diseases, Decrease of pollinators, Decrease of soil microorganisms			
Enhancing human capital • Public awareness of raising value of biodiversity • Exposure visits and interactions • Need-based training (group mobilization, account keeping, etc.) • Strengthening capacity of CBOs for developing own workplan and monitoring calendar • Identification of nodal CBOs for specialized activity; fair, value-addition, PPB, etc. • Training women for community video filming and crossing plants	Generate more rural employment and income generation opportunities • Specialized seed productions • Farmer-to-farmer training • Resource persons to other projects (e.g. World Vision) • Video filming	• Leadership development • Specialized CBOs/women groups formed and recognized • Public-Private partnership networks established	• Awareness of value of TK and biodiversity enhanced
Social: Political conflict, Market fluctuations, Law and order			
Enhancing natural capital • Assessment of local crop diversity using PRA, FCA, and TK • Analyze and understand value of farmers' varieties • Diversity fair, diversity block, diversity kits, CBR • Grassroots breeding and PPB	Improve access to materials and knowledge • Seed multiplication of Panchmukhe taro, aromatic sponge gourds, lalka basmati rice, bhatti, etc. and marketing • Distribution of diversity kits of vegetables, fruits, etc.	• Unique and economically valuable biodiversity identified and promoted • CBM plan implemented	• Rate of genetic erosion of mandate crops slowed down

Good practices for enhancing livelihood assets	Livelihood strategies	Livelihood outcomes	Livelihood Impacts
	• Improved traits of local varieties • PPB of Mansara x K-4 and other crosses • PLE of Jetho budho		
Enhancing financial capital • Link farmers to market channels • Revitalizing cooperatives for marketing of value-added products • Monthly saving and microcredits • Mobilizing Conservation Trust Fund • Link to donors and line agencies for supporting local development plans		• Enhanced capacity to source other funds	• Enhanced group work to mobilize funds • Increased community-based conservation/CBM funds
Enhancing physical capital • Community-level staff and offices for the project and CBOs • Supporting local initiatives to construct community seed bank in Bara • Strengthening cooperatives and processing units • Dirt road, boats, phone, rural radio and electricity line		• Community seed banks • Processing mills and dryers established	• Increased social cohesiveness

Compiled from FGD of livelihood analysis and synthesis from Subedi *et al*., p. 41, this volume.

The challenges were to standardize local products from diverse producers, organize small farmers into a group that produces the products in a marketable volume and quality and then ensure timely supply to local market outlets. This requires strategic alliance with NGOs and private sector in the process of establishing a commodity chain, which was not appreciated earlier by the government research and development institutions. Together with the project team members and private entrepreneurs, regular planning meetings were held to identify potential local crop diversity and their local products (based on traditional knowledge and food culture) to identify a few local products that may have urban market opportunities. The group-selected items were: *masura*[13], *gava*[14] and *tandra*[15] from taro, *anadi*[16] rice, *jetho budho* and *jhinuwa* rice landraces, *chuk*[17] and *duna tapari*[18] from *Shorea robusta* forest tree (Rijal *et al.* 2003a). The CBOs and women groups were encouraged to make their own annual workplans and assign specific roles and responsibilities for monitoring the progress

13 Dried nuggets made from chopped petiole of taro mixed with paste of black gram flour and sun-dried and used for *masaura* curry as a local delicacy.
14 Half portion of young taro leaf is rolled up and made into knots, boiled, dried and preserved for off-season green curry.
15 Taro petiole is cut vertically as noodle or threads and braided like women's hair and cut into small pieces before soaking in warm water and prepared as different kinds of curry.
16 Sticky rice, a culturally important food.
17 Concentrated citric acid made from citrus and used for pickle preparation.
18 Bowls and dinner plates made from broadleaved trees for holy use.

of activities. Activities that need knowledge generation, training, production and marketing were integrated into the group's workplans so that they develop ownership of the programme.

Linking farmers to market through value-addition of local products has been a good practice to increase community interest in conservation through use. Although the idea of value-addition of local products is very appealing to local communities and policy-makers, successful implementation requires a concerted and integrated long-term approach from multi-partners. Marketing local products is a specialized field and therefore needs special attention on skill enhancement of cooperatives, farmers and local entrepreneurs. Bhandari *et al.* (2005) reported that value-addition of finger millet and linking to market has increased the demand for finger millet flour and the area under millet in two villages. The team is studying the impact of such intervention on maintenance of other crop species and varieties. CBR information also revealed the area under taro varieties has steadily increased in Chaur village because of value-addition of taro products and marketing (Subedi *et al.*, see p. 41, this volume). The most important lesson derived from this process was that different partners have different expertise but key roles in the commodity chain and can develop a partnership to use the comparative advantages of each partner for mutual benefit.

Germplasm enhancement

Diversity assessments in various crops have shown that the amount and distribution of local crop diversity is rich and variable (Bajracharya 2003; Gauchan *et al.* 2004; Rana 2004). How such diversity could be efficiently used for the benefit of custodians was not often demonstrated in on-farm conservation projects. The challenge is to make the existing diversity useful and available to farmers willing to use it, rather than organizing rescue operations (Bellon *et al.* 2003). Gyawali *et al.* (see p. 161, this volume) demonstrated that the value of a local landrace (e.g. *Jetho budho* and *Lalkabasmati*) could be enhanced by enhancing the population for farmers' and consumers' preferred traits. These selected populations of landraces are now being multiplied by communities and extension people and the selected landrace population of *Jetho buddho* will be nationally released soon. There are many such crops with existing diversity that could be exploited to add value to specific traits followed by community seed production and marketing of quality seeds. Neglected species and marginalized farmers are almost always found in difficult areas comprising combinations of poor soils, unreliable rainfall, hilly topography and degraded vegetation. Often international and national research systems invest scarce resources in a high technology based approach to address farmers' daily needs. However, there is great opportunity to obtain genetic gain from simple assessment of existing diversity of neglected and underutilized crops for preferred traits, multiplication of planting materials and a large-scale participatory variety selection approach to reach a large number of farmers for testing and scaling up materials through farmer-to-farmer social seed networks.

Participatory plant breeding (PPB)

PPB has been identified as a good practice for managing agricultural biodiversity on-farm (Witcombe *et al.* 1996; Sthapit and Jarvis 1999; Friis-Hansen and Sthapit 2000; Sthapit *et al.* 2002, 2003c). PPB consolidates the role of farmers in plant breeding (Eyzaguirre and Iwanaga 1996). Many farmer's varieties or landraces are the products of on-farm conservation and they may contain co-adapted gene complexes that have evolved over the decades. Farmers who search, select and maintain seeds for exchange and own use play a key role in creating and deploying new diversity. The PPB process allows farmers to build capacity to understand existing local crop diversity and the underlying strengths and weaknesses of the available genetic resources, and to search for preferred traits. PPB also offers skills to farmers to select fixed or variable materials and maintain seed in traditional ways. PPB together with integrated pest and nutrient management empowers farmers to manage their genetic and natural resources under agroecosystems in a sustainable manner. The detailed process is described elsewhere (Sthapit and Jarvis 1999; Sthapit *et al.* 2003c). Gyawali *et al.* (see p. 202, this volume) demonstrated the value of using locally adapted landraces like *Mansara* (grown by poor farmers in low-input and rain-fed conditions but with no market value because of poor quality) in a PPB programme to improve quality and productivity of landraces for providing social, economic and environmental benefits to resource-poor rice growers. This work was initiated by the global on-farm project in Nepal in 1998. Twenty-three populations of *Mansara* that have the adaptive trait under low-input rain-fed conditions were selected by farmers for better grain and straw quality and productivity. This work has demonstrated that genetic resources conserved by poor farmers could be used as local parents for client-oriented (in this case the poor *Mansara*-growing farmers) plant breeding for developing livelihood options for poor farmers and also adding value in on-farm management of landraces.

Step 7: Influencing policy

Demonstrating real examples in the field not only helped farmers to understand the value of on-farm conservation but also influenced policy-makers in making on-farm conservation a priority in the national agenda (Gauchan *et al.* 2004; Upadhyay *et al.*, see p. 123). Understanding of key policy issues with appropriate research and development information and policy analysis will help decision-makers make the most informed choices that will have profound implications for ensuring food security and poverty reduction. Lessons learned from Nepal's *in situ* project are that policy-makers respond not only to empirical evidence from policy analysis but also to seeing the demonstrated impact of intervention at the project sites and being provided opportunities to interact with farmers and local institutions. For this purpose, diversity fairs and travelling seminars at the site are considered good practices for influencing policy-makers (Gauchan *et al.* 2002; Upadhyay *et al.* 2002; Upadhyay *et al.*, see p. 123). During this process, the *in situ* project team was able to integrate with another IPGRI project, "Genetic Resources Policy Initiative", to include agricultural biodiversity as a national priority issue in the 10th Five Year Plan of Nepal; they also provided intellectual input to formulate a national agricultural and agrobiodiversity policy and allocated government resources to mainstream some of the good practices (e.g. CBR and diversity fairs) developed by the project.

Step 8: Community-based biodiversity management as exit strategy and sustainability

The bulk of the world's agricultural biodiversity is under the stewardship and management of agrarian communities. Under their management, agricultural biodiversity evolved to meet the new challenges posed by changing needs and environments. Over the millennia, this biodiversity has moved to new environments, found new uses and acquired new traits. Even when other livelihood assets are few and inaccessible, agricultural biodiversity (basically local crop diversity or its close relatives in the vicinity) remains the basic resource that the poor can manage and depend upon for their livelihood. In order to maintain and enhance the value of agricultural biodiversity as a resource for the rural poor and for humanity as a whole, communities and institutions need to be supported, empowered and assisted in managing their agrobiodiversity assets, making them more accessible and valuable. This is one of the most important lessons learned from the project. It is important to focus not only on scientific understanding of on-farm management of agricultural biodiversity but also to develop institutional capacity to run internally driven on-farm conservation programmes.

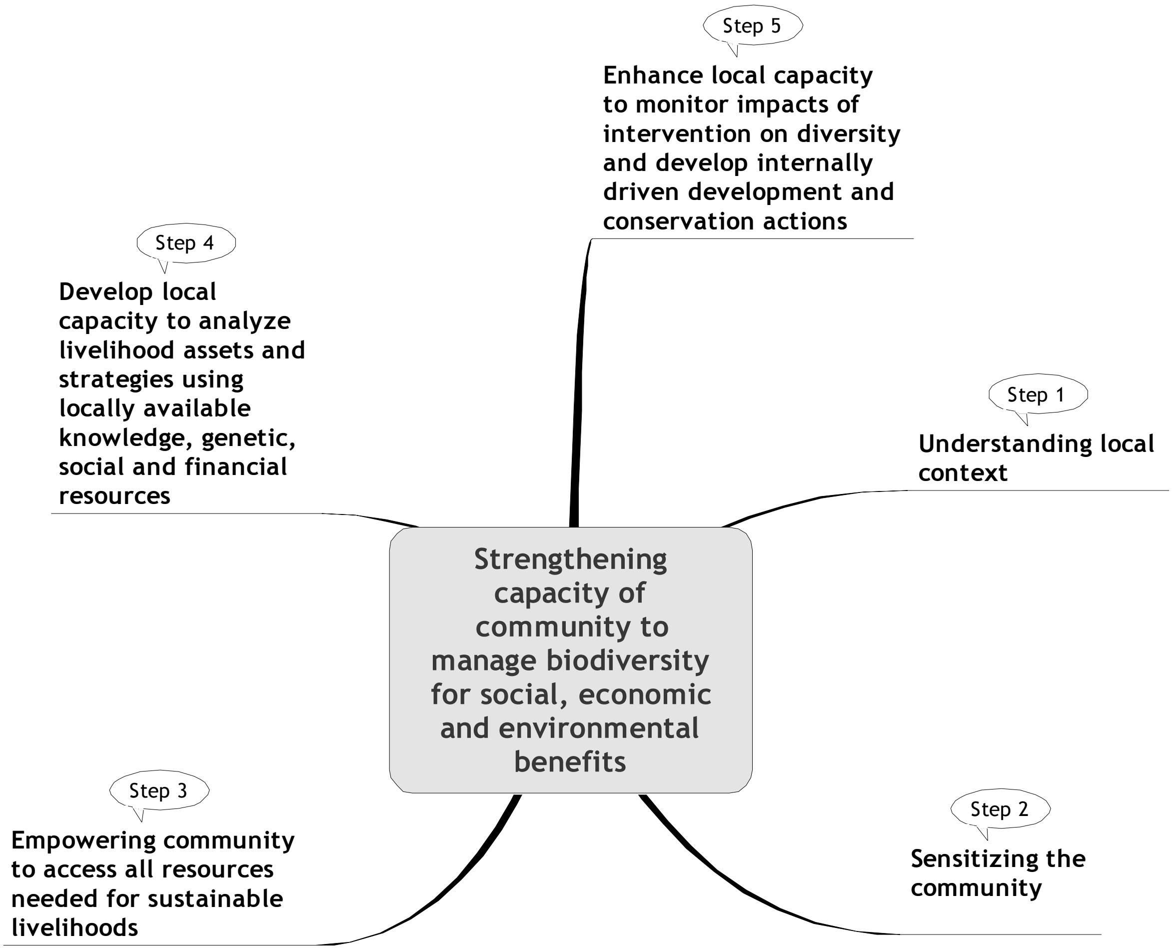

Figure 1. Steps of community biodiversity management of agricultural biodiversity on-farm.

It has been realized that local communities and village-level opinion leaders need to understand how they can use their own local biodiversity, and mobilize social and human capitals to generate financial resources for developing livelihood options and conservation actions. Communities that depend on biodiversity also need to partner with other agencies and receive new knowledge and materials from other institutions, stakeholders and communities involved in agricultural biodiversity management. The resources that communities need in order to maintain and manage agricultural biodiversity are (1) knowledge about biodiversity and associated landscapes, (2) social systems for keeping and exchanging their local materials, (3) local institutions that support and validate local management and access to biodiversity, (4) techniques and practices that add value and adaptive capacity to local materials, (5) local financial resources such as savings and credits, and (6) physical infrastructure such as road, communication and cooperatives. Together, these aspects of a community's culture, landscape and institutions constitute the basis of community-based biodiversity management (CBM). In order to achieve this, as illustrated in Figure 1, communities and local institutions need to develop better understanding of the sustainable livelihood framework, which helps them to analyze local context and comprehend why and how people do what they do to generate income, create livelihood options for food and nutritional security, and improve their well-being. This is only possible if local people are empowered to exercise their rights, knowledge and resources. The CBM approach encourages farmers to document, share and use local biodiversity knowledge to understand and enhance the amount and distribution of local biodiversity and its contribution to livelihoods.

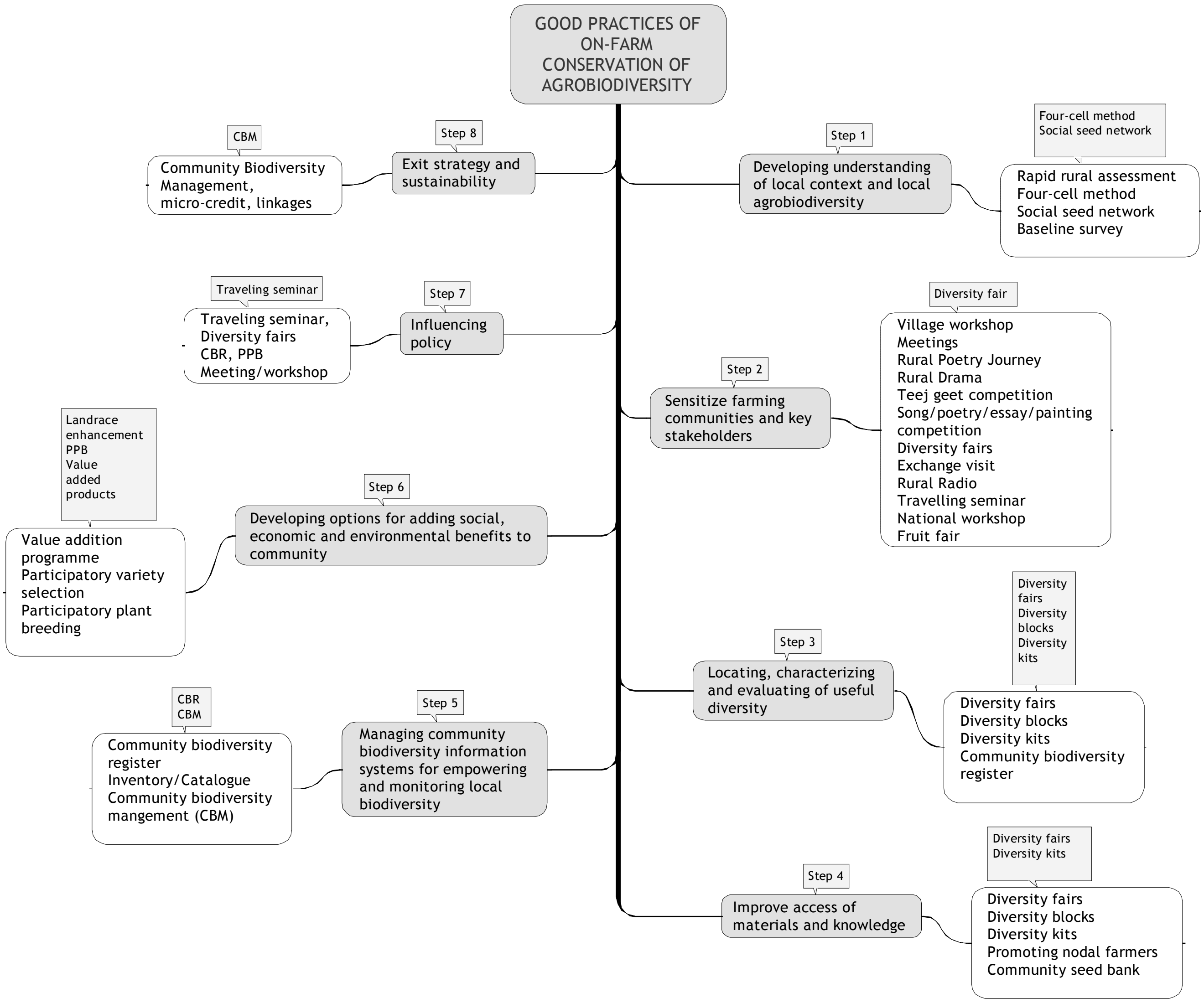

Figure 2. A set of good practices for community based on-farm conservation of agricultural biodiversity in Nepal. Legend: Steps 1 to 8 are the processes used in the project and callout practices are good practice identified for the given context.

Concluding remarks

Identification of target taxa, sites and collaborating partners are key steps for the success of good practices described in this paper and many studies have been reported (Guarino *et al.* 1995; Jarvis *et al.* 2000a, b; IPGRI 2001; Maxted *et al.* 2002; Ganeshaiah and Umashaanker 2003; Uma Shaanker *et al.* 2004). The good practices related to this area are not considered in this paper.

The project has developed a set of good practices to encourage farmers and communities to capitalize on traditional knowledge and skills, locally adapted unique genetic diversity, and social capital such as social seed networks and local institutions to substitute for more scarce resources such as financial as well as physical infrastructure. Figure 1 illustrates steps that worked in many communities to strengthen capacity of institutions for managing biodiversity for greater social, economic and environmental benefit. It addresses the local institutions, customs and practices for managing genetic resources. It recognizes and supports local institutions and communities as legitimate and crucial actors in the national plant genetic resource system, and its role in the wider context of biodiversity and development. Therefore, there are early indications that a community will continue the development and conservation action in a sustainable manner and this could be considered an exit strategy for any on-farm conservation initiative: let communities continue to shape and adapt that diversity to meet their needs and the changing environments.

Figure 2 illustrates good practices that have been assembled and adapted for the specific purpose and the same method could be applied to achieve objectives to suit the local context. When farmers become more conscious about own rights and value of knowledge and resources through steps 1 and 2, a practice like CBR will be much clearer when activities such as diversity fairs, diversity blocks, diversity kits, participatory variety selection and participatory plant breeding are integrated into community-based informal seed production and marketing of value-added products. These activities could be part of an annual workplan of local institutions. Assessment of local crop diversity and exploring opportunities to market value-added products to local and national markets will provide immediate benefits to people. However, the impacts of such an approach on genetic diversity need to be monitored using CBR, and continued research and development support is required for promoting diverse market products and strategies.

Participatory plant breeding and deployment of diversity kits will strengthen the capacity of farmers to search, select, maintain and exchange genetic resources for obtaining both genetic and socioeconomic benefits for farmers and society. This is a rather long-term approach which needs effective incentive mechanisms in place; however, the approach has been found to be an effective way to demonstrate the value of landrace conservation of many neglected and underutilized arable and home garden species. Interested farmers and local institutions can be strengthened for grassroots breeding, seed production and marketing to capitalize on local genetic resources and the community will benefit directly where modern agriculture has not yet penetrated.

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Role of home gardens in on-farm agrobiodiversity management and enhancing livelihoods of rural farmers of Nepal

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Abstract

Home gardens are an integral part of Nepalese farming systems. Despite the important roles of home gardens in on-farm management of plant genetic resources and their contribution to food and nutrient security, they have not been included in the national priority for research and development. There is no documentation of production data or, more importantly, the contribution of home gardens to nutrition and food security and other relevant information on national statistics. Studies were carried out in four different sites (Ilam, Jhapa, Rupandehi and Gulmi) with contrasting ecological and socioeconomic settings. Only 2–11% of the total agricultural land is under home gardens and the area of home gardens ranges from 0.0017 to 0.5 ha. The numbers of species grown in these small home gardens are, however, very high, reaching up to 87. Nepalese home gardens are predominantly vegetable-dominant (30–47% of total species in home gardens are grown for vegetable purposes). carefully and efficiently combined with fruits, fodders, medicinal herbs and ornamental plants. Home gardens are also the areas where farmers introduce new plant materials and or/species and experiment with them, and home gardens are the place for domesticating wild species. In the mountain region of Nepal, plant species with medicinal value are domesticated while in the plains (*terai*), vegetable and fruit species are found. Home gardens are the main sources of vegetables and fruits, accounting for about 60% of the total fruit and vegetable consumption of the households. Home gardens are the major source for the diversified diets required for family consumption. Introduction of plant genetic resources based on the assessment of household diets that are dependent on home gardens could serve as a scientific basis for enlarging the options of plant species to be planted in the home gardens and enhance social, economical and environmental benefits to farmers and other rural poor.
Key words: Home gardens, biodiversity management, dietary diversity

Introduction

Home garden refers to the traditional land use system around a homestead where several species of plants are grown and maintained by the household members and their products are primarily intended for family consumption and utilization (Shrestha *et al.* 2002). In Nepal, 72% of households have home gardens with areas of 2–11% of total land holdings (Gautam *et al.* 2005a). Home gardens are traditional sources of food and nutrition and therefore are important contributors to food security and livelihoods of farming communities in Nepal. They are typically cultivated with a mixture of annual and perennial plants that can be harvested on a daily or seasonal basis. Home gardens, with their intensive and multiple uses, provide a good safety net for these households during food-deficit periods. These gardens have been important sources of food, fodder, fuel, medicines, spices, herbs, flowers, construction materials and income in many countries and also are important means of on-farm conservation of a wide range of unique genetic resources for food and agriculture (Subedi *et al.* 2004). Many uncultivated as well as underutilized species are making an important contribution to dietary diversity of local community (Gautam *et al.* 2005b). Despite being an integral part of the Nepalese farming systems and playing an important role in the livelihood of the community, scientific investigations on the states, role, and dynamics of home gardens are severely lacking. This lack of information has led to home gardens not having been treated as important contributors to food security and the welfare of farming communities, or to on-farm management of genetic resources by the implementers and policy-makers of agricultural research and development.

Several studies were carried out in four different sites (Durbar Devisthan of Gulmi and Dudrakshya of Rupandehi and Gauriganj of Jhapa and Panchakanya of Ilam in the Western and Eastern regions of Nepal) under the project entitled "Enhancing the contribution of home gardens to on-farm management of plant genetic resources and to improve the livelihoods of Nepalese farmers" in close collaboration with different research and development organizations and farming communities. Details on the project sites are presented in Table 1. The project is part of IPGRI's global home garden project implemented in other countries (Cuba, Venezuela, Vietnam, Guatemala and Ghana) and is funded by the Swiss Agency for Development and Cooperation (SDC) during the year 2003/04 in order to study the importance of home gardens with respect to on-farm agrobiodiversity conservation and as a source of nutritional security and livelihoods.

Table 1. Main features of research sites.

Main features	Gauriganj-5, Jhapa	Panchkanya 4,5 and 6, Ilam	Dudrakshya 1,8 Rupandehi	Durbardevisthan 2,3 and 5-Gulmi
Ecozone	Eastern *terai*	Eastern high hill	Western Terai	Western mid-hill
Altitude range	80 m	1200–1640 m	100 m	800–1500 m
Ethnicity	Mixed: Subba, Brahmin, Chhetri, Giri, Rajbanshi/ Tajpuria	Mixed: Chhetri, Brahmin, Tamang, Rai	Mixed: Tharu, Newar, Chhetri Brahmin	Mixed: Brahmin, Chhetri, KDS
Occupation	Agriculture: 90 Other: 10	Agriculture: 84 Other: 16	Agriculture: 40 Other: 60	Agriculture:55 Othes: 45
Institutional setting†	ASC, LSC, Sub health post, Cooperatives, Youth club, Women's group	ASC, LSC, 5 farmers' groups, NARC outreach station	ASC, LSC, Women's group Subhealth post, RDC	ASC, LSC, LI-BIRD, Subhealth post, Krishi Samuha
Market access	Medium	Medium	High	Low

† ASC=Agriculture Service Centre, LSC=Livestock Service Centre, NARC=Nepal Agricultural Research Council, RDC=Rural Development Centre, KDS=Kami Damai Sarki groups.

Materials and methods

Household surveys were conducted to explore the benchmark information on home gardens with respect to the ecological zones and the different socioeconomic settings. Stratified random sampling was followed. For this, households (HH) were identified as a basic sampling unit for the survey. As major strata, three categories of economic endowment (resource rich, resource medium and resource poor) and two categories of ethnic composition (*Pahadi* and *Terain* in the *Terai* Region, *Brahmin/Chhetri* and *Newar/Magar/Rai/Limbu/Gurung/KDS* in the Hill region) were considered for the purpose. Wealth ranking was done prior to a baseline survey during the PRA studies of the selected sites. The sampling structure and sample size of different strata are presented in Table 2.

Besides the household survey, a focus group discussion was held to find out the species domestication in home gardens and to generate other relevant information for the study.

Table 2. Sample HHs selection from different categories in four sites of home garden project.

Wealth category	Ethnic † category	Gulmi		Rupandehi		Jhapa		Ilam	
		Total HH	Sampled HH	Total HH	Sampled HH	Total HH	Sampled HH	Total HH	Sampled HH
Rich	1	181	39	100	14	57	16	42	10
	2	4	1	14	2	32	8	42	11
Average	1	107	22	186	26	51	14	42	10
	2	10	3	69	10	25	6	65	16
Poor	1	87	19	230	32	30	8	30	8
	2	26	6	35	6	140	38	145	35
Total		415	90	634	90	335	90	366	90

† Ethnic categories:
For Rupandehi and Jhapa – 1 for hill migrants and 2 for *terai* community.
For Ilam and Gulmi – 1 for Brahmin/Chhetry and 2 for Rai/Magar/Limbu in Ilam and 2 for Kami/Damai/Sarki in Gulmi.

Results and discussion

Species diversity in home gardens

The total number of species in a single home garden was found to be a maximum of 87 with more than 80% of households having between 11 and 50 species (Table 3). Species in home gardens are generally affected by ecological factors, ethnic composition, migration, area of home gardens and wealth status (Shrestha *et al.* 2002). Typically home gardens are valued for the following specific uses: (1) food security, nutrition and cash income, (2) fodder, firewood and timber, (3) spices, herbs and medicinal plants, (4) green manures and pesticide crops, and (4) cultural and religious use (Shrestha *et al.* 2002). In the wetter parts of the mid-hills of Nepal (e.g. Illam), more than 75% of home gardens have 21–50 species per HH whereas in the drier parts (Gulmi) they had 11–40 species (Gautam *et al.* 2005b). Species diversity was comparatively higher in the eastern parts than in the western areas and higher in hills than in *terai* region. The association between total species diversity and ecological region was highly significant ($P<0.05$). The major ecological factors influencing the species diversity are temperature, soil type, stresses and other climatic parameters. Thus, the home gardens of Ilam were reported as having the richest species diversity, as more than 60% of the home gardens in this location had more than 30 species per home; at Rupandehi, the poorest community, over 60% of home gardens had less than 20 species (Table 3).

Table 3. Number of species found in home gardens across agroecosites.

Total no. of species	Gulmi (%)	Ilam (%)	Jhapa (%)	Rupandehi (%)
1–10	5.6	2.2	8.9	21.1
11–20	32.2	5.6	36.7	40.0
21–30	25.6	32.2	22.2	24.4
31–40	21.1	24.4	18.9	10.0
41–50	10.0	26.7	10.0	4.4
51–60	3.3	4.4	1.1	1.1
61–70	1.1	3.3	1.1	
71–80	1.1	1.1		
81–90		1.1		

Information on richness and dominances of home garden species in Nepal is presented in Table 4: they are vegetables, fruits, spices, fodder, medicinal, ornamentals and others in that order (Subedi *et al.* 2004).

Table 4. Richness and dominance of home garden species based on local use values.

Diversity indices†	Vegetables	Fruits	Spices	Fodders	Medicinal	Ornamental	Others
SWI (H')	1.3849	1.3606	1.3451	1.3020	1.2470	1.0869	1.2700
SI (λ)	0.7493	0.7366	0.7305	0.5911	0.6816	0.6816	0.6886

† SWI = Shannon Weaver Index, SI = Simpson's Index.

Although the correlation between home garden area, ethnic composition and wealth status, and total species diversity was found to be statistically non-significant (P>0.05), the general trend shows that there is higher species diversity in the home gardens of migrants than in indigenous communities (in case of *terai*), in resource-rich than resource poor and in large home gardens than in small gardens (Figure 1).

Plant species important for religious purposes like cotton (for making oil lamp wicks for home temples), *tulasi* (*Ocimum sanctum*), *bar* (*Ficus bengalensis*) and *peepal* (*F. religiosa*) regarded as holy plants in Hinduism, were found comparatively high (14%) in home gardens of Gulmi compared with other sites as there is dominance of *Brahmin/Chhetri* communities in the sampled households. Farmers of Ilam have maintained both the organic-based home garden for home consumption as well as high input-based commercial gardens for a few market-oriented crops. The association between home garden species and ethnicity was not significant as only a very few species were found linked with special culture and food habits. As a very high number of the species are maintained in the home gardens, a few species differences could not make statistically significant differences. However, a few species like *Pindar* (*Trewia nudiflora*), *Kundruk* (*Coccinea grandis*), *Lafa* (*Malva verticillata*) and *oal* (*Amorphophallus campanulatus*) are found in home gardens of the *terai* community in the *terai* area. These crops are grown for their special taste and are also required during special festivals of the people from that region.

The study showed that home gardens of Nepal are mostly vegetable based as vegetables occupied 30–47% of total species composition (Figure 2). The home gardens in eastern Nepal contain a comparatively higher number of ornamental species than in western regions. Numbers of fodder/forage species were higher in hills than in *terai* region. Fruit species were found to be comparatively low in home gardens of Ilam than at other sites.

Home garden species were found to be mostly annual (53–61%) and perennial (37–41%) types. The most common species in home gardens throughout the sites were radish, broadleaf mustard (BLM), pumpkin, beans and chili. However, site-specific common species varied in individual home garden (Table 5).

Besides direct use values, farmers' maintain rich local crop diversity in home gardens for the following reasons: (1) to meet household needs and preferences, (2) to meet the specific need of local ethnic food culture, (3) to increase the options of availability of fresh leafy vegetables, herbs, species, fruits etc. at the household level, (4) easy access to fresh food as the use of refrigerators is not common, (5) to save money by reducing expenses on daily needs, (6) to improve self-reliance as access to markets is difficult in remote areas, (7) to improve access to the source of low cost vitamins and minerals, (8) to increase the variety of vegetables, fruits, etc. for ensuring nutrition, functional/health value, viz. antioxidant, hypoglycemic, carotenoids, phenolics, dietary fibers, etc. (Sthapit *et al.* 2004).

It was found that considerable numbers of species (Rupanedi-11, Jhapa and Gulmi 16 each and Ilam-31) are either already domesticated or in the process of domestication in home gardens for home consumption These species were collected from forest and waste lands and conserved on-farm for their specific values. The study was limited to identifying the sources of seed and their use values only. Mostly, the species having medicinal and cultural/religious value are domesticated in the home gardens of hill area and plant species used for vegetable and fruit purposes are domesticated in the home gardens of *terai* area.

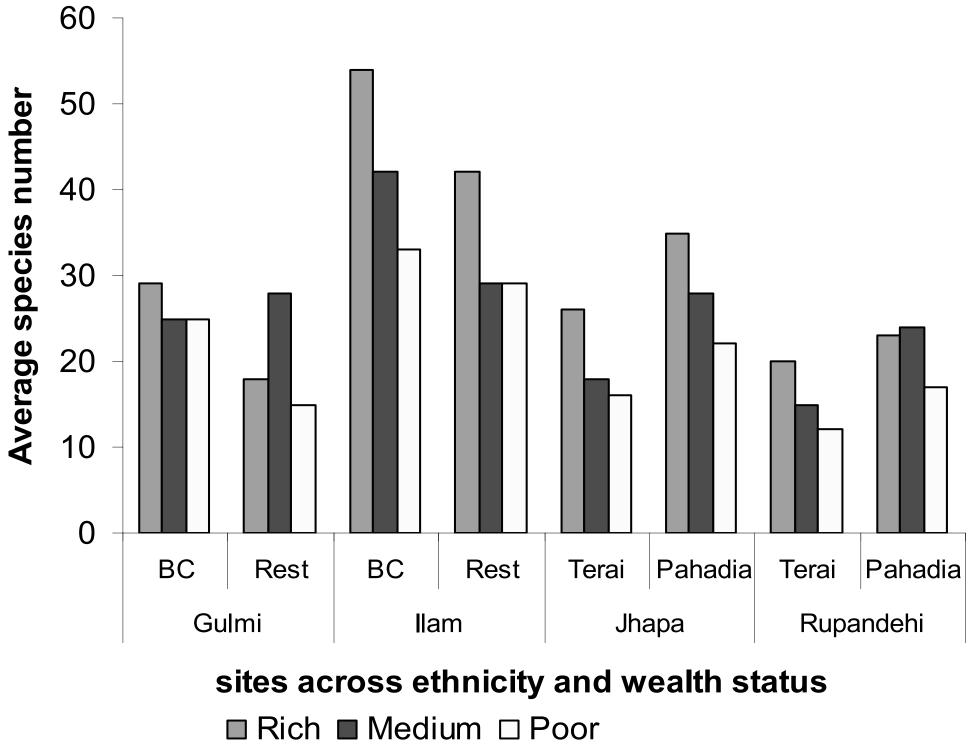

Figure 1. Species diversity in home gardens by ethnic groups and endowment categories.

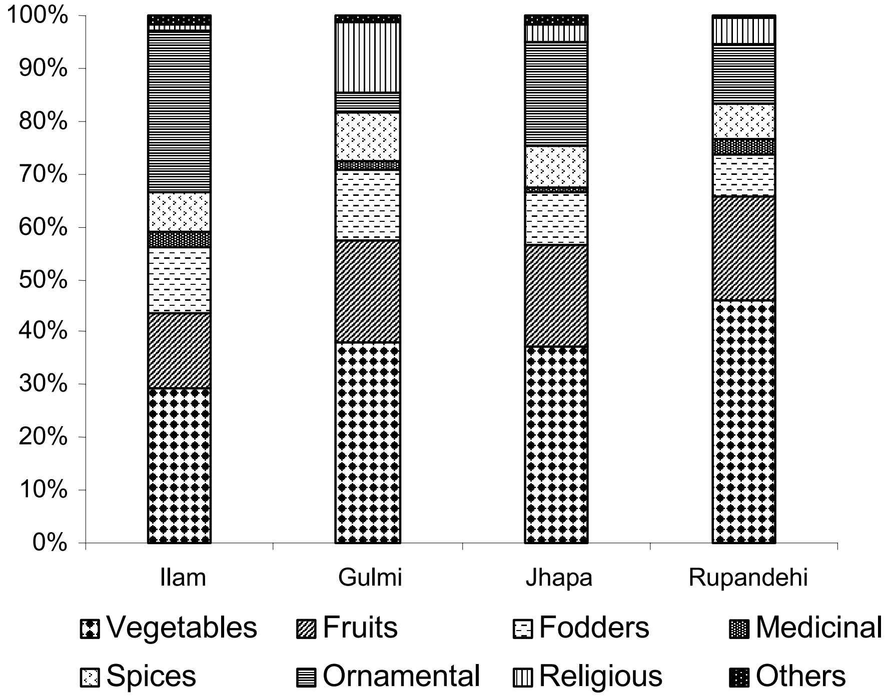

Figure 2. Home garden species by use type.

Table 5. Ten most common species found in home gardens of different sites

Gulmi		Ilam		Jhapa		Rupandehi	
Species†	**Freq.**	**Species†**	**Freq.**	**Species†**	**Freq.**	**Species†**	**Freq.**
Potato	67	Chayote	86	Mango	75	Spongegourd	73
BLM	66	Cucumber	81	Spongegourd	74	Cowpea	57
Radish	62	Radish	74	Kadam†	69	Mango	53
Chili	56	Dudhilo†	66	BLM	68	Papaya	52
Banana	53	Taro	62	Potato	64	Ridge gourd	52
Beans	49	Binyee†	62	Bakaino†	64	Okra	50
Chayote	48	Akabare†	55	Banana	59	Tulasi	49
Peach	46	Pumpkin	54	Radish	59	Chilli	47
Nimaro	43	Tree tomato	54	Garlic	56	Egg plant	45
Pumpkin	39	Nimaro	53	Tulasi	53	Bittergourd	45

† Nimaro (*Ficus roxburghii*), Dudhilo (*F. nemoralis*), Binyee (*Solanum anguivi*), Akabare (*Capsicum* spp.), Kadam (*Anthocephalus cadamba*), Bakaino (*Melia azadiracht*).

Species details are provided in Table 6. As home gardens offer increased availability of water, production systems are mostly organic-based, which provides easier protection against predators (Harlan 1975) and allows close monitoring by the household members. Experimentation with growing new species and varieties is a well-known aspect of home gardens and is in fact an important contribution to crop improvement and evolution (Engels 2002; Shrestha *et al.* 2002). However, a detailed study on the status of domestication and process followed by the farmers during domestication needs to be carried out.

Food security and livelihoods

The contribution of home gardens to the household food supply is significant in rural and peri-urban areas of Nepal. A baseline study done in the four home garden project sites in Nepal revealed that the contribution of fruits and vegetables to the total meal of a household was up to 44% (based on total intake of the food). Home gardens provide 60% of the household's total fruit and vegetable consumption (Gautam *et al.* 2005a). A survey conducted in the Philippines revealed that 20% of the foods consumed by families were produced in home gardens (IPGRI 2004) while in Vietnam it was 51% (Trinh *et al.* 2003). In Bangladesh, UBINIG (Policy Research for Development Alternative=Unnayan Bikalper Nitinirdharoni Gobeshona), a community-based NGO, has noted that uncultivated food items such as leafy greens, fish and tubers collected from ponds, farmers' fields, roadsides and common lands comprise a large proportion of the daily diets of the rural poor, accounting for at least 40% of the food they consume (IPGRI 2004).

The following additional new information for a better understanding of the role of home gardens in Nepalese life was presented during a recent workshop on home gardens organized by LI-BIRD and IPGRI in Pokhara, Nepal (Sunwar 2003; Gautam *et al.* 2005a; Subedi *et al.* 2004).

- Home gardens, although occupying a very small proportion of the total land holdings of the family (2–11%), are rich in biodiversity (up to 87 species recorded from the home gardens).
- Home gardens are a major source of family vegetable and fruit supplies (60% of the requirements fulfilled by home gardens).
- Nepalese home gardens are largely vegetable based (vegetable species accounting for 37–48% of total species planted), followed by fruits, fodders, medicinal and ornamental plants, in that order of numbers planted.
- Home garden have their own management systems and mostly are an organic-based production system with maximum utilization of locally available resources.

- Home gardens are where many important plant species (11–31 species in studied sites) are domesticated for their various uses. Mostly plant species having medicinal values are domesticated in the hills and mountains whereas in the *terai,* fruits and vegetable species are predominant.

Table 1. Domestication of wild species in home gardens.

Nepali name	Common name	Botanical name	Use value	Parts used	Propa-gation†	Plant type‡
1. Durbar Devisthan, Gulmi						
Marhathi		*Spilanthes clava*	spice, medicine	root, branch	V	H
Timoor		*Xanthoxylum armatum*	spice	fruit	S	Sh
Barma Dhaniya	Wild coriander		vegetable, salad	leaf	S	H
Pudina	Mints	*Mentha* spp.	pickle, medicine	leaf	S	H
Bael	Wood apple	*Aegle marmelos*	religious, medicine	leaf, fruit	S	T
Ghiu kumari	Indian aloe	*Aloe barbadensis*	medicine	stem	S	H
Tarwale			medicine	leaf	V/S	H
Ban Tarul	Wild yam	*Dioscorea* spp.	vegetable	corm	V	H
Pipla	Long pepper	*Piper longum*	medicine	fruit	V	H
Siplican	Crateva	*Crateva unilocularis*	vegetable, pickle	leaf	S	T
Kimbu	Mulberry	*Morus alba*	fodder, fruit	leaf, fruit	V	T
Githi	Boehmeria	*Boehmeria rugulosa*	forage, fuel wood	leaf, branch	S	T
Bojho		*Acorus calamus*	medicine	stem	V	H
Guransh	Rhododendron	*Rhododendron* spp.	medicine, decoration	flower, whole plant	S	T
Pipal		*Ficus religiosa*	religious	whole plant	S	T
Chakamake			vegetable, pickle	fruit	S	Sh
2. Dudrakshya, Rupandehi						
Bael	Wood apple	*Aegle marmelos*	religious, fruit	leaf, fruit, stem	S	T
Pipla	Long pepper	*Piper longum*	medicine, spice	fruit	S/V	H
Khanyu		*Ficus cunia*	fodder	branch, fruit, timber	S	T
Chattel		*Momordica cochinchinensis*	vegetable	fruit	V	Cr
Kewa			vegetable	stem	V	H
Pidar		*Trewia nudiflora*	vegetable, medicine	fruit	S	T
Bayer	Jujube	*Ziziphus* spp.	fruit, medicine	fruit	S	T
Kurilo	Asparagus	*Asparagus* spp.	vegetable, medicine	root	S/V	H
Amrishu	Broom grass	*Thysanolaens maxima*	forage	leaf		H
Koiralo/Tanki		*Bauhinia* spp.	forage, vegetable	branch	S	T
Jangali parwar	Wild pointed gourd		vegetable	fruit	V	Cr
Kusum	Ceylon tree	*Schleichera oleosa*	forage, fruit	leaf, fruit	S	T

Nepali name	Common name	Botanical name	Use value	Parts used	Propa-gation†	Plant type‡
Amaro	Golden apple	*Spondias pinnata*	fruit, fuel wood	fruit	S	T
Amala		*Emblica officinalis*	fruit	fruit	S	T
Jamun	Surinam cherry	*Eugenia jambolana*	fruit, fodder/fuelwood	fruit, stem, branch	S	T
Siplikan	Crateva	*Crateva unilocularis*	vegetable, forage	soft branch, leaf	S	T
3. Gauriganj, Jhapa						
Pidar		*Trewia nudiflora*	vegetable	fruit	S	T
Chattel		*Momordica cochinchinensis*	vegetable	fruit	V/S	Cr
Bankhira	Wild cucumber	*Solena heterophylla*	vegetable, pickle	fruit	S	Cr
Badhar		*Artocarpus lakoocha*	fruit, pickle	fruit	S	T
Kabro		*Ficus lacor*	pickle	fruit	S	T
Mishrikan		*Pachyrhizus erosus*	fruit	corm	V	Cr
Jamun	Surinam cherry	*Eugenia jambolana*	fruit	fruit	S	T
Ban Dhaniya	Wild coriander		spice	leaf	S	H
Kacchu	Taro	*Colocasia* spp.	vegetable, pickle	corm, leaf	V	H
Pudina	Mint	*Mentha* spp.	pickle	leaf	V	H
Rukh alu		*Dioscorea* spp.	vegetable	fruit	S	Cr
4. Panchakanya, Ilam						
Pakhanbed	Rockfoil	*Berginia ciliate*	medicine	root	V	H
Jaringo	Sweet belladonna	*Phytolacca acinosa*	vegetable	leaf, stem	S	H
Simrayo	Watercress	*Nasturtium officinale*	vegetable	leaf, tendril	V	Cr
Kurilo	Asparagus	*Asparagus* spp.	medicine	root	V	H
Chinde sag			vegetable	tendril	S	T
Bojho		*Acorus calamus*	medicine	root	V	Sh
Pudina	Mint	*Mentha* spp.	medicine, vegetable	leaf	V	H
Dungdunge sag		*Allium* spp.	vegetable	leaf	V	H
Iekako jara			medicine	root	V	Sh
Timoor		*Xanthoxylum armatum*	medicine	fruit/seed	S	T
Punarnama		*Boerhaavia diffusa*	medicine	root, leaf, stem	V	H
Jatamashi	Spikenard	*Nardostachys jatamansi*	medicine	root, leaf, stem	S/V	Sh
Tune hadchur		*Viscum* spp.	medicine	pod/fruit	V	Sh
Rukha hadchur		*Viscum* spp.	medicine	leaf/skin	V	Sh
Hardjoda		*Vanda* spp.	medicine	leaf, root	V	Cr
Phachayang			medicine	corm	V	H
Khareto jhar			medicine	leaf	S	Sh
Shikari lahara			medicine	leaf, stem	S	Cr
Chiraito	Chiretta	*Swertia chirata*	medicine	leaf, root, stem	S	T

Nepali name	Common name	Botanical name	Use value	Parts used	Propa-gation[†]	Plant type[‡]
Madaure aaru			fruit, medicine	fruit, leaf	S	T
	Persimmon	*Diospyros virginiana*	fruit	fruit	S	T
Lahare anp	Passion fruit	*Passiflora edulis*	fruit	fruit	S	Cr
Jyamire		*Citrus* spp.	fruit	fruit	S	T
Bimero		*Citrus* spp.	fruit	fruit	S	T
Amarbeli	Dodder	*Cuscuta reflexa*	medicine	creeper	V	Cr
Dudhilo		*Ficus memoralis*	forage	leaf/stem	V	T
Amrishu	Broom grass	*Thysanolaens maxima*	forage	leaf/stem	V	H
Alainchi	Cardamom	*Amomum subulatum*	spice	fruit	V/S	H
Betlauri	Costus	*Costus specious*	medicine	corm	V	H
Ghiukumari	Indian Aloe	*Aloe barbadensis*	medicine	leaf	V	H
Kafal		*Myrica esculenta*	medicine	fruit, skin	V	T

[†] S=Seed; V=Vegetative.
[‡] Cr=Creeper; H=Herb; Sh=Shrub; T=Tree.

Farmers were found using several uncultivated species (species naturally grown around the home gardens of which seed are not maintained by the farmers but intercultural management is done) for the food supply (Table 7). Most of those species were used for vegetable purposes. *Poi sag* (*Basella rubra*), *Karmisag* (*Ipomoea* spp.), *Bethe* (*Chenopodium* spp.), Amaranthus, *Jaluka* (wild taro), *Kholesag* (*Rorippa nasturtium*) and *Niuro* (*Diplazium* spp.) are a few examples of uncultivated species in home gardens fulfilling the vegetable demands. The survey found that uncultivated species contribute about 4% (in Gulmi) and 8% (in Rupandehi) of total vegetable supply.

Table 7. Number of uncultivated species used for consumption in different sites.

	Ilam	Gulmi	Jhapa	Rupandehi
Vegetable species	11	32	25	14
Fruit species	1	4	0	0
Total	12	36	25	14

Dietary diversity and health value

More than 85% of the total dietary intake by Nepali is based on cereals, which is more than double the intake of people from developed countries (Johns and Sthapit 2004). In Nepal, diet supply from animal sources is very poor (only about 5%). In addition, only 2–3% of the diet is vegetable based. Therefore, by improving the quantity and diversity of the food from home gardens, the constitution of Nepali diet be improved, by making it less cereal-based. Diets poor in leafy vegetables, fruits and animal proteins in particular may lead to xerophthalmia (a form of blindness) associated with vitamin A deficiency and are linked to poverty. It is also recognized that a diet rich in energy but lacking other essential components can lead to heart disease, diabetes, cancer and obesity. These conditions are no longer associated with affluence; they are on the increase among poor people from urban areas in developing countries. A diverse diet offers nutritional buffers and there should be a key policy reform to combat this unhealthy trend (Johns and Sthapit 2004). In this context, the value of home gardens for family health is paramount as they harbour a wide range of genetic diversity that increases economic options, dietary variety and nutritional levels for low-income households in both rural and urban communities. However, a basis for systematic introduction of plant species with different nutrient/dietary value is severely lacking.

Figure 2 contains an example from which the current gaps with regards to both availability and distribution of different diet-rich plant species could be determined. The example is from Jhapa site where the monsoon is both earlier and heavier in the eastern region than in the western region in Nepal. Monsoon begins in late *Jyestha* (i.e. early May) in the eastern region, which causes problems in planting many seasonal vegetables. Heavy rain also affects vegetable farming by creating waterlogged conditions for a considerable period of the time. Therefore, it has a direct effect on the availability of vegetables in the home garden. As Jhapa is flat and more prone to flooding and water stagnation, most of the field remains submerged during the monsoon season. Almost no vegetable species is available during *Srawan* to *Aswin*, i.e. July to September (see Figure 3).

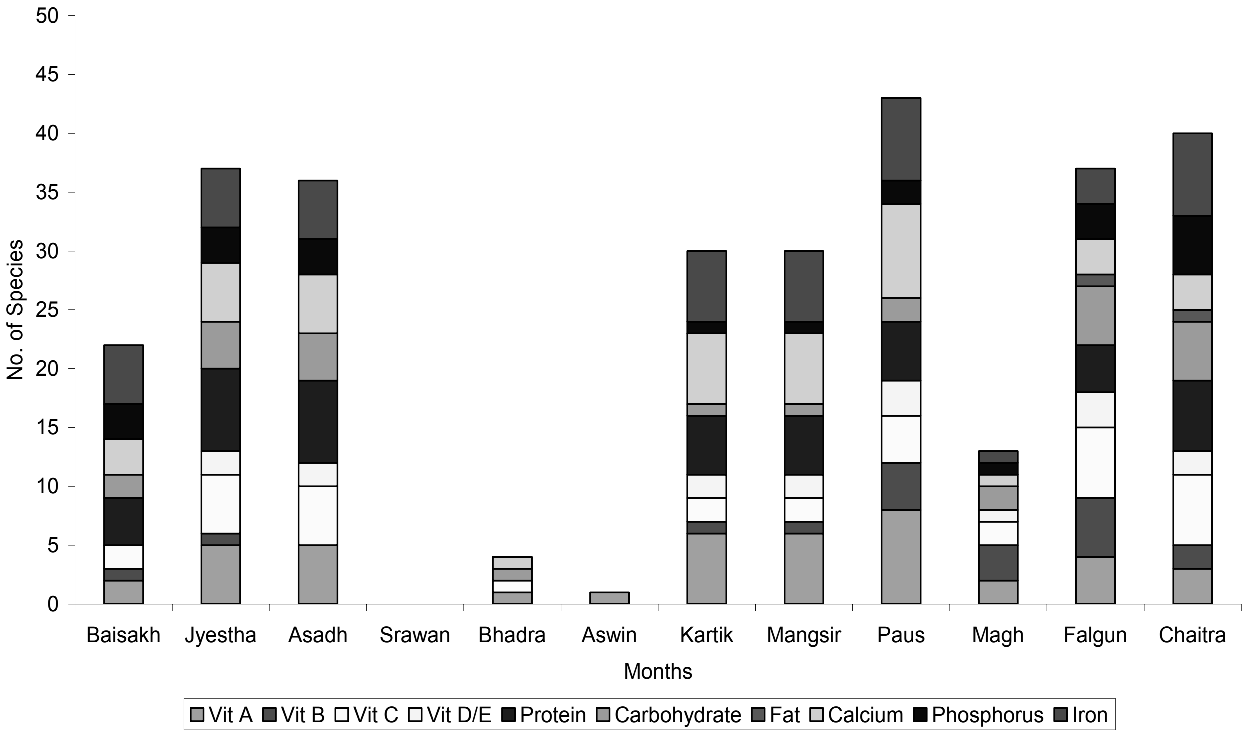

Figure 3. Nutrient supply from home gardens, Jhapa, Nepal.

Conclusions

Genetic diversity valued by resource-poor farmers is often maintained in their available lands around the homestead, selected over generations and the materials and knowledge exchanged through his/her social seed networks. A home garden is an important source of food security and livelihoods as it supplies diversified vegetables and fruits rich in micronutrients, provides spices and herbs to meet culinary and cultural requirements, provides medicines for relief, provides ecosystem services and also provides income. Despite its small area, a home garden is a biodiversity-rich production system and should be considered as a viable unit of on-farm biodiversity conservation. However, the home garden is yet to be recognized as an important source of unique plant species, nutrition and food security, and livelihoods. The home garden's contribution has not been reflected in national priority, programme and national statistics. Resource-poor farmers consider agrobiodiversity of the home garden production system to be an important livelihood asset to manage their natural and socioeconomic circumstances and therefore, access to and control over such resources are a critical policy issue. In addition, there is large potential for further enriching the home gardens with plant species that can help resource-poor people to acquire increasingly balanced diets and lead a healthy life.

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Institutionalization process of *in situ* conservation programmes and policies of agrobiodiversity in Nepal through scientific capacity-building, representative partnerships and influence

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Abstract

Agrobiodiversity is a crucial natural asset available to resource-poor farmers for managing sustainable production systems, and therefore access to and control over such genetic resources are a critical policy issue. Today the agrobiodiversity of the earth's plant life is under threat as never before. Nepal is one of the 180 countries to ratify the Convention on Biological Diversity (CBD) which aims for conservation (*in situ* and *ex situ*) of biodiversity, its sustainable use and the equitable distribution of benefits arising from its use. The purpose of this paper is to document methods and participatory approaches used for institutionalizing good practices of *in situ* conservation programmes and policies in Nepal. The broad methods used were: (1) building scientific capacity of farmers, research and development institutions, (2) forming representative partnerships of GO and NGO sectors, and (3) enlightening policy-makers by demonstrating empirical data and results. Organizing national sharing and learning workshops, as well as travelling seminars for policy-makers, provided them with opportunities to interact with farmers and become aware of their situations. Capacity-building at various levels, specifically those of farmers at community level for the management of agrobiodiversity, requires a continued and long-term commitment from national and international partners. Capacity-building of local institutions in establishing effective links to formal research and extension institutions, as well as to market intermediaries, is an area where inputs from the project will be focused. The project has taken significant strides in 'mainstreaming' *in situ* conservation by highlighting it at national debates. Continuous engagement in dialogue with policy-makers and planners to inform them of the findings from the field has yielded positive results. For the first time, the government's Five-Year Development Plan makes specific reference to the conservation of agrobiodiversity within the text. This has positively influenced the policy-makers' perception on the issues of agrobiodiversity conservation. His Majesty's Government of Nepal (HMGN) has commissioned the *in situ* policy formulation team and Genetic Resource Policy Initiatives (GRPI) project task force members in Nepal to draft a national policy on agricultural biodiversity. The policy has been drafted successfully, incorporating policy issues, experiences and lessons learned. Despite these successes, the institutionalization of methods and practices within government institutions on natural resources is limited and requires a continued effort to enlighten research managers and policy-makers with further evidence and in-depth case studies.

Key words: Agrobiodiversity, policy, institutionalisation, conservation, use, Nepal

Introduction

Conservation and sustainable utilization of agrobiodiversity play vital roles in promoting poverty alleviation, ensuring food security and enhancing livelihood measures in developing countries rich in diversity. *In situ* conservation of agricultural biodiversity on-farm deals with conservation, use and management of genetic variation in farmers' fields that supports continuity of the dynamic evolutionary processes of genetic resources and ecological services, provides indigenous communities with ownership of and access to genetic resources, and delivers options for improving livelihood measures specifically to resource-poor farmers (Bragdon and Jarvis 2003). Recognizing these benefits, a global project on "Strengthening the Scientific Basis of *In situ* Conservation of Agricultural Biodiversity on-farm" was launched in Nepal in 1997.

A significant amount of technical information, methods, tools and models was developed during the first phase (1997–2002) of the project to assess local crop diversity and understand processes/factors that influence farmers' decision-making in managing the diversity on-farm (Bajracharya *et al*. 2003; Baniya *et al*. 2003; Gauchan *et al*. 2003; Rana *et al*. 2003; Subedi *et al.* 2003). Studies on the policy status in conservation and utilization of plant genetic resources revealed the realization of the significance of *in situ* conservation among policy-makers, key officials of government (GO) and non-government (NGO) organizations, and farming communities. Suggestions were also made for advocacy roles, formulating favourable policies and capacity-building by the project for conservation, sustainable use and management of plant genetic resources (Gauchan *et al*. 1999; Sapkota *et al*. 2003). It was obvious that the outputs of the first phase might remain only in papers without their adoption in the national research and development system if adequate initiatives were not carried out for sustaining the good practices developed by the project. Therefore, the second phase (2002–2004) of the project strongly visualized the need for institutionalization of agrobiodiversity conservation on-farm in the national research and development system. This study aims to document the lessons learned during the institutionalization process of *in situ* conservation of agrobiodiversity on-farm in Nepal and also identifies some problems and barriers in achieving this.

Materials and methods

Nepal Agricultural Research Council (NARC), Local Initiatives for Biodiversity Research and Development (LI-BIRD) and International Plant Genetic Resources Institute (IPGRI) joined hands in 1997 to implement the "Strengthening the Scientific Basis of *In situ* Conservation of Agricultural Biodiversity on-farm" project by creating a framework for implementation and management of the project (Figure 1) in a multidisciplinary and multi-institutional approach involving formal and informal institutions from grassroot to policy-making levels (Upadhyay and Subedi 1999). The strategy employed ranged from involvement of farming communities in field activities to decision-making at policy level. Methods to accomplish the specific activities incorporated in the annual programmes to ensure active participation and ownership of institutions involved in a three-tier management system of the project are outlined below.

Identification of the problem and need for institutionalization of *in situ* conservation programmes

Intensive review of national policy documents, proceedings of *in situ* conservation project and articles published in the government and non-government sectors on conservation and sustainable use of agrobiodiversities was made (Box 1). The review was supplemented with informal interaction with key policy-makers, civil societies and farming communities. National project management teams and the policy research team analyzed and synthesized the findings of such initiatives and later were included in annual activities of the second phase of the *in situ* conservation project.

Methods used in capacity-building for institutionalization

National project management and local project management teams identified needs for capacity-building through collective learning in brainstorming sessions. A competitive project proposal developed by each thematic/activity leader was evaluated and successful candidates were selected for PhD studies in diversity assessment, economics, social science and ecology. Accordingly, short-term training courses were identified and the activity leaders were trained at national and international levels. At the grassroot level, leader farmers were identified and provided with orientation training, skill development training and management of CBOs, cooperatives, CBR, diversity fair, etc.

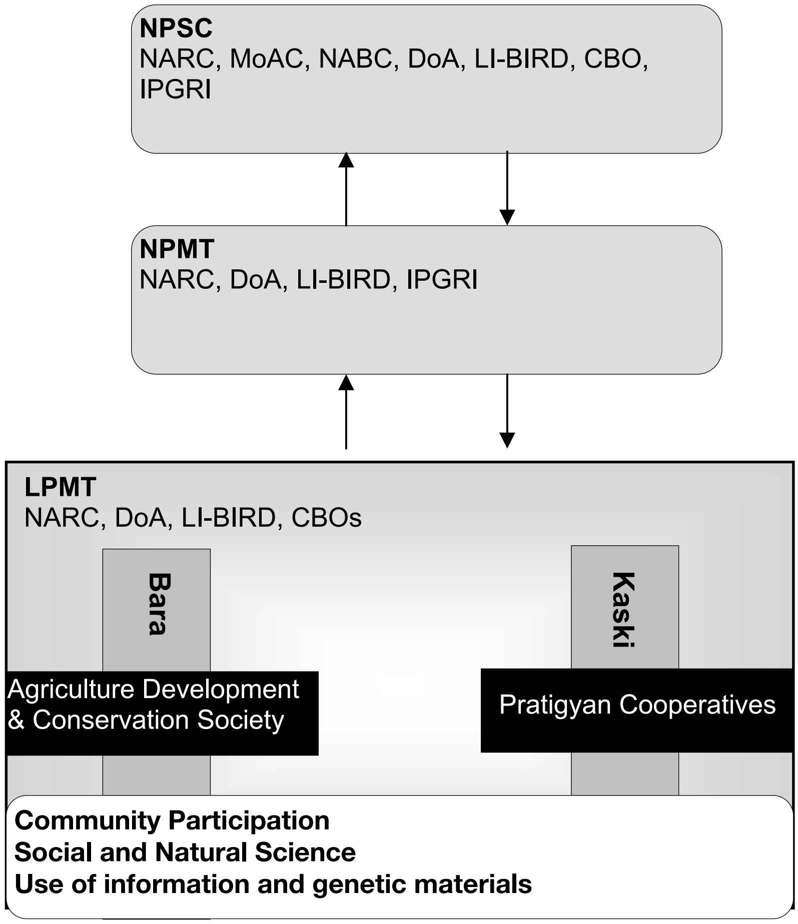

Figure 1. Management structure of the project.

Box 1. National policy and legislation application for PGRFA in Nepal.

- Long-term Agricultural Perspective Plan (1995-2015)
- Ninth Five Year Plan (1997-2002)
- Forestry Master Plan (1988) and Revised (2000)
- Seed Policy (2000), Seed Act (1988), Seed Regulations (1997)
- Environmental Action Plan (1992)
- Local Governance Act (1998)
- Forest Regulations (1997) and Forest Act (1993)
- Primitive Patents, Designs and Trademark Act (1965)
- Food Act (1966) and Food Rules (1972)
- Plant Protection Act (1972), Pesticide Act (1991)
- National Park and Wildlife Conservation Act (1973)
- King Mahendra Trust for Nature Conservation (1982)
- National Biodiversity Strategy (2002)
- National Biodiversity Action Plan (Under approval)
- Access and Benefit Sharing Legislation (Being drafted)
- Biodiversity Trust Fund Legislation (Being drafted)

Methods used in developing representative partnership

Primary stakeholders involved in undertaking field activities and advocacy roles were identified by a national multidisciplinary group and the policy research team in brainstorming sessions to broaden the collaborative mode with a multisectoral, multi-institutional and multidisciplinary approach. Closer partnership with various stakeholders has opened up new avenues for collaboration and resource mobilization. Emphasis was given to generating a bilateral funding base for implementing good practices of the project at the national level. Realizing the expertise developed in on-farm conservation of agrobiodiversity in Nepal, the thematic experts also explored the plausible roles that the Nepal team could play at the international level.

Methods used in policy influence

The Nepal project has used three types of policy influence: (1) expanding policy capacities, (2) broadening policy horizons, and (3) affecting policy regimes as a framework of policy influence (Glover 2002; Lindquist 2001). The policy research team interacted with key officials from MoAC and NPC to indicate policy needs in Nepal for fulfilling the commitment made in the CBD 1992 and the Global Plan of Action 1996. Officials were provided with hard copies of national proceedings, reports and articles dealing with national and international issues. At the grassroot level the *in situ* staff and local project management team (LPMT) interacted with farming communities in Kaski and Bara ecosites for creating awareness in the community. Mass media was regularly used and experts were made available for interaction in radio and television programmes. Articles were published in local languages in daily newspapers and a bimonthly agricultural magazine. Leader farmers, community mobilizers and technical experts were jointly used for creating awareness. A team of experts is available at *in situ* ecosites for the purpose. Systematic steps used for policy influence in government sectors and mobilizing grassroot level communities are described below.

Inclusion of conservation and sustainable use of agrobiodiversity in the 10th Five Year Plan

The following steps were used by the team to incorporate conservation and sustainable use of agricultural biodiversity agenda in the 10th Five Year Plan:

- Identify legitimate key official (resource person) in MoAC and NPC.
- Provide opportunity for interaction with farming communities at grassroot level in *in situ* project ecosites.
- Share knowledge products (national proceedings and articles, CBD documents, decisions of conference of the parties of the CBD).
- Direct interview with key policy-makers in MoAC and NPC to identify policy gaps in implementation of programmes related to agrobiodiversity.
- Repeated internal consultation among technical experts from MoAC, NABC, NARC, DoA and DLS for continued advocacy roles by *in situ* policy team.
- Member secretary of NABC takes lead for group interaction with wider stakeholders/partners and shares reports with MoAC.
- Draft of agrobiodiversity-related information submitted to NPC by MoAC for inclusion in the 10th Five Year Plan.
- A key official from NPC interacts, modifies the draft and includes agrobiodiversity in the 10th Five Year Plan.

Process used for formulating draft national agrobiodiversity policy

The team also reviewed the steps followed in the successful formulation of a national agrobiodiversity policy in Nepal (Box 2).

- Identify legitimate resource persons from MoAC and NABC.
- Invite the resource persons to meetings, workshops and field visits for sensitization and enlightenment on issues related to conservation and sustainable utilization of agrobiodiversity.
- Motivate member secretary of NABC to invite *in situ* team and participate in regular meetings of NABC to brief and update on findings of the project, need for national agrobiodiversity policy and benefits of agrobiodiversity conservation and sustainable use in national development agenda.
- MoAC/NABC commissioned *in situ*/Genetic Resources Policy Initiative (GRPI) Nepal team to draft national policy on agrobiodiversity.
- *In situ*/GRPI policy team forms a core team of experts from NARC/LI-BIRD/IPGRI and invites thematic experts from horticulture, livestock, fisheries, seed, biotechnology, insects, microorganisms and food processing/food technology sectors and prepares preliminary draft.
- *In situ* GRPI policy team organizes three meetings for interaction, review and finalization of draft policy:
- Meeting with experts from departments under MoAC and NARC.
- Meeting with national project steering committee of *in situ* conservation project.
- One-day 3M stakeholders workshop facilitated by GRPI project.
- The *in situ*/GRPI policy team synthesizes the outputs of the meetings and submits to NARC.
- NARC forwards the draft policy to Gender Equity and Environment Division, MoAC.

Process used in involving farming communities in decision-making process

Farming communities from *in situ* ecosites were included in the national project steering committee. They were also invited to participate in national meetings/workshops, and leader farmers are the task force and working team member in GRPI Nepal project.

Strengthening or creating community-based organization

Community-based organizations at *in situ* ecosites were either revitalized by orientation training, exposure visits and strengthening market linkages of local produce or mobilized to establish a new organization. Participatory tools to mobilize communities have been discussed, for example, a regular participatory planning and review process, revitalizing women's groups and cooperatives, diversity fairs, etc. (Rijal *et al.* 1999).

Findings of institutionalization initiatives

Scientific capacity-building

A core team of research scientists capable of providing leadership and technical feedback to a national and international research and development system in the field of conservation and sustainable utilization of agrobiodiversity (Table 1) has been developed in major thematic areas: crop biology, seed supply system, policy research, ecology, social science, participatory plant breeding, genetic resource economics and data integration. The technical team has developed skills of collective learning action in the meetings of national project management team. Scientists from laboratories and social scientists had an opportunity to interact with each other and work as a team.

Box 2. National Agrobiodiversity Policy.

Goal

The main aim of the National Agrobiodiversity Policy is the conservation and sustainable utilization of agrogenetic resources, materials and traditional knowledge, skill, etc. for present and future generations with the collaboration of people concerned with agrobiodiversity. In national and international levels, effort has been made to conserve biological diversity. The policy aims to put the agrobiodiversity within the boundary of efforts to gain economic success and maintain ecological equilibrium, which corresponds to the aim of sustainable development in agriculture.

Strategy

- Encourage creation of public awareness at local and central levels for conservation, promotion and sustainable utilization of agrobiodiversity.
- Priority shall be given to benefit from a programme that is in favour of working with public participation-based local farming communities.
- The use of scientific technique and traditional knowledge of farming community shall be encouraged and facilitated.
- Effective management, implementation and evaluation agroecosystem-based approaches.
- The cooperation and coordination among the governmental, non-governmental, private sector and international units that are interrelated with agrobiodiversity shall be strengthened.
- For the conservation, promotion and utilization of agrobiodiversity in local, regional and national levels, basic physical structures and manpower shall be prepared.
- Collect internal and external economic aid to conduct programmes of National Agrobiodiversity.
- Manage fair and equitable sharing of the benefits arising from the access and use of agro-genetic resources and materials or local traditional knowledge and skills.
- Management to evaluate the environmental effect according to the law as exercised in agricultural programmes shall be followed.

A set of protocols has been developed for carrying out major activities incorporated in annual programmes. IPGRI was active in locating institutions for providing short- and long-term training to the *in situ* project team. A PhD fellowship was provided to four scientists from NARC and LI-BIRD to carry out some in-depth research on problems. Two candidates from NARC have completed the PhD courses and currently are contributing in the field of crop genetic resources and the supplementary *in situ* project. The PhD fellowship has significantly increased national capabilities in the sector.

A Biotechnology Unit was established under the aegis of Agriculture Botany Division to assess diversity using isozyme analysis, Random Amplified Polymorphic DNA (RAPD) and Microsatellite DNA markers. Collaboration with National Institution of Agrobiological Resources (NIAR), Tsukuba, Japan to analyze genetic variation of wild buckwheat in Nepal strengthened the biotechnology laboratory. Four scientists currently work in the laboratory, which has an independent status and receives national funding from NARC's regular fund.

At the grassroot level in Bara and Kaski ecosites, farming communities were motivated and enlightened to strengthen local capacity in the field of research management, policy influence and CBO management. Both communities have been managing field-based research and participatory plant breeding plots. With continued interaction and technical support, the farming communities have developed a capacity to manage the agrobiodiversity at the community level to enhance livelihood measures. The Agriculture Development and Conservation Society (ADCS) in Bara was established to enhance farmers' capacity to manage crop genetic resources. In Kaski, a *Pratigyan* (community-initiated cooperative from Begnas village) was revitalized to undertake management of the cooperative and link with urban markets for the promotion of crop genetic resources.

Table 1. Capacity-building of national partners.

Course	Name of Trainee	Affiliated Institution	Year
PhD in Social Science, UK	R.B. Rana	LI-BIRD	2000–2004
PhD in Economics, UK	D. Gauchan	NARC	2000–2004
PhD in Crop Biology, UK	J. Bajracharya	NARC	2000–2003
PhD in Ecology, Norway	D.K. Rijal	LI-BIRD	Continuing
MSc in PBG, India	S.R. Gupta	NARC	2001–2003
MSc (Partial), USA	P. Chaudhary	LI-BIRD	2003
MSc in PGR, India	D.N. Mandal	NARC	2000
Short course in GRP, Sweden	M.P. Upadhyay	NARC	2003
Training in genetic resources database management, Nairobi	S.K. Shrestha P.R. Biswakarma	NARC LI-BIRD	2000
Training in socioeconomic aspects of conservation and use of native tropical fruit genetic resources, Sri Lanka	H.R. Regmi	NARC	2002
Short course in genetic diversity, China	K.K. Sherchand J. Bajracharya R. B. Rana D.K. Rijal	NARC NARC LI-BIRD LI-BIRD	1999
Short course in agroecology, USA	P.R. Tiwari	LI-BIRD	1999
Training on ethnobotany and genetic diversity of Asian taro, China	Y.R. Pandey	NARC	1999
Training on participatory rural appraisal (PRA), Nepal	NMDG members	NARC, LI-BIRD	1999
Training on isozyme analysis, Nepal	J. Bajracharya H.P. Bimb N.R. Dungel J. Shrestha and G.B. Bajracharya	NARC	1999
Training on basic statistics and multivariate analysis, Nepal	NMDG members	NARC, LI-BIRD	1998
Training in genetic diversity of rice, Japan	R. Shrestha N.P. Adhikari	NARC	1997
Training on PGR documentation using GMS software, Nepal	S.R. Gupta T.B.Ghimire D.B. Thapa J. Bajracharya D.M. Dongol	NARC	1997
Training on GIS, Nepal	B.K. Joshi H.B. KC A. Subedi	NARC NARC LI-BIRD	2003
Exposure visit of farmers	M.P.Yadav R.P. Yadav J.B.R. Yadav S.D. Jaiswal R.D. Jaiswal S.S. Teli S.L. Yadav K.D.D. Tatma	Farmers of Kachorwa, Bara	2003

Capacity-building initiatives continued at domestic and international levels as well as in collaboration with stakeholders. The *in situ* project team contributed to initiatives of IUCN, Action Aid, PROPUBLIC, UMN, etc. in sensitizing and popularizing the output of the project to government/non-government officials, civil societies, CBOs and farming communities. Sensitization of judges, police officers, custom officers and civil engineers was a unique effort in creating awareness of national roles and responsibilities in biodiversity issues. Enlightening of policy-makers on agrobiodiversity issues was critical in generating support for institutionalization of the good practices of the project. A travelling seminar organized for key officials from MoAC, MoFSC and NPC to interact with farming communities at Kaski ecosite created momentum to popularize CBR for genetic resources/traditional knowledge documentation and inclusion of agrobiodiversity in the 10th Five Year Plan. A gap still exists in enlightening members of parliaments. Similarly, IPGRI was crucial in disseminating the achievements of the Nepalese *in situ* team at the global level.

Advances in agricultural sciences and technologies gained momentum and priority in the national research and development agenda. Since the inception of periodical plans to the 9th Five Year Plan and recent 20 Year Agriculture Perspective Plan, the national roles and responsibilities for conservation and sustainable utilization of agrobiodiversity have not been reflected. Now, with consistent efforts from the *in situ* research team in sensitizing and providing technical and critical information from national and international sources to major stakeholders and developing partnerships with them, the earlier scenario seems to be changing. The directives for implementing activities on agrobiodiversity have been included in the 10th Five Year Plan and a National Agrobiodiversity policy is on the verge of finalization.

Broadening the bilateral funding base and collaborative mode

Partnership development is effective for addressing the complex issues of agrobiodiversity. Since plant genetic resources are the basic raw material required for participatory crop improvement, several efforts were made to link and coordinate stakeholders for realizing the synergies of joint ventures in addressing poverty and livelihood concerns. The outcomes of these initiatives are projects generated for scaling-up the good practices of the *in situ* project.

The Genetic Resources Policy Initiative (GRPI) project was initiated by NARC and IPGRI to strengthen capacity to develop national options for policy framework. The complexity of the issues arising from international conventions and agreements—access to genetic resources, benefit-sharing, genetically modified organisms, biosafety and intellectual property rights, etc.—prompted the *in situ* project team to generate support for multistakeholder, cross-sectoral and multidisciplinary policy initiatives. It is expected that the GRPI's modus operandi will result in developing a comprehensive report of gaps in policy research and their prioritization, a policy information brokerage service, training materials, policy framework and capacity-building in the national system. One member of NPMT (Dr Anil Subedi) has been nominated by the CGIAR Secretariat to represent the CGIAR Genetic Resource Policy Committee member as well.

The Western Terai Landscape Complex Project situated at mid-western and far-western development regions focuses on conservation and sustainable utilization of biological diversity in a landscape approach involving community people in the mainstream. The Ministry of Forest and Soil Conservation (MoFSC) implemented the project in collaboration with MoAC, NARC, LI-BIRD and IPGRI for agrobiodiversity component. Scaling-up of good practices identified by the *in situ* project and capacity-building of extension agents from the Department of Agriculture have been identified as the major activities in the regions.

The Community Biodiversity Register Project is a GEF/UNDP small grant project implemented by LI-BIRD in the periphery of *in situ* conservation at Kaski ecosite. LI-BIRD supported the community to establish a conservation trust fund, link biodiversity with market and document valuable resources.

The Ministry of Forestry and Soil Conservation (MoFSC) has developed a Biodiversity Registration format in collaboration with multi-institutional experts to document and register biological resources, their use values and associated indigenous knowledge. A travelling seminar organized by the *in situ* project for key officials from the government ministries and national planning commission provided impetus to development and testing of the format. The contribution of farming communities from Kaski ecosite in the process has been duly recognized by MoFSC.

IUCN, Nepal has recently launched a project on "Building capacity to protect biodiversity and indigenous rights through documentation and registration of traditional knowledge in Nepal". The project is divided into two phases: learning and testing/development of the traditional knowledge (TK) documentation. A total of 28 districts and 35 ethnic communities have been considered for TK documentation. Resource persons from the *in situ* project have been involved since the formulation of the project and mutually benefited by sharing of information and knowledge.

Similarly, the Gender Equity and Environment Division (GEED) under MoAC has developed a proposal in collaboration with the *in situ* project for 2004/05 to carry out activities on creating awareness at the central, district and national levels, organizing an agrobiodiversity fair at the district level and documenting the information. An amount of NR1.4 million has been proposed for the purpose to His Majesty's Government of Nepal. The GEED has assigned responsibility to the project team for assistance in implementing the activities mentioned in the annual programme.

The proposal development for establishing a Centre of Excellence (CoE) in Nepal is underway through a NARC/IPGRI/ICRA initiative using a multistakeholder approach. Based on the capacity-building strategy of the *in situ* project, NARC/LI-BIRD have developed the capacity to organize a short-term regional training course on *in situ* conservation of agrobiodiversity on farm.

At the community level, the Agriculture Development and Conservation Society (ADCS), a community-based organization, was established in Bara ecosite. The society is actively involved in the management of local genetic resources and income-generation activities for the community. At Kaski ecosite, the *Pratigyan* Cooperative has been strengthened and supported by making market links. Exposure visits, formal/informal training and other community awareness tools have increased the confidence level of the farmers to participate in National Project Steering Committee of the project, Task force and working team of the Genetic Resources Policy Initiative (Multi-stakeholder initiatives) Project, National workshops and policy meetings. These farmers are making a significant impact at the meeting by raising various pertinent issues.

The policy influence

The visit of executives/policy-makers to the *in situ* Kaski site and interaction with farming communities and *Pratigyan* Cooperative members was a turning point from general discussion to implementation of agrobiodiversity in a national perspective. Positive responses from the high-level team members were finally expressed in the 10th Five Year Plan (Box 3). This greatly recognized the contribution of the *in situ* project team as well as various other partners in the MoAC, NABC, DoA and NPC. The National Project Coordinator and IPGRI–APO scientist were invited as special guests to discuss the achievements of the *in situ* conservation project. This led to the formulation of a draft national agrobiodiversity policy by an *in situ*/GRPI policy team and inclusion of good practices of the *in situ* project in the national programme under MoAC (Box 2). The MoAC has allocated NR1.4 million to undertake biodiversity fair, awareness programme and Community Biodiversity Registration at central, district and community levels. A training center under DoA will carry out training activities for officials from MoAC, DoA and NARC and the expertise will be provided from the project. Similarly, the Gender Equity and Environment Division of MoAC will implement district- and community-level programmes in cooperation with the project team and district officials.

Box 3. Agrobiodiversity in the 10th Five Year Plan.

Objective:

- To conserve and use agrobiodiversity for sustainable development

Strategy:

- Develop and implement national agrobiodiversity policy
- Assess agrobiodiversity and adopt agroecosystem
- Initiate registration of genetic and traditional knowledge
- Encourage stakeholders including private sectors in research/bioprospecting and value-addition in the fields of agrobiodiversity conservation and application of biotechnology
- Create ownership over genetic resources.

Lessons learned from the project

One of the major strengths of the project has been the capacity-building of professionals in different disciplines, thus contributing intellectual inputs in planning and drafting national policy work and ensuring agrobiodiversity initiatives beyond the project phase. The project has taken significant strides in mainstreaming *in situ* conservation by highlighting the issue at the national debates. Continuous engagement in dialogue with policy-makers and planners through meetings and policy workshops, informing them of the findings from the field, have yielded positive results. For the first time, the government's Five-Year Development Plan makes specific reference to the conservation of agrobiodiversity within the text (NPC 2003). Organizing travelling seminars for policy-makers provided them with opportunities to interact with farmers and apprise them of situations on the ground. This has positively influenced the policy-makers' perception on the issues of agrobiodiversity conservation. His Majesty's Government of Nepal (HMGN) has commissioned the *in situ* policy team and GRPI project task force members in Nepal to draft a national policy on agricultural biodiversity. The policy has been drafted successfully, incorporating policy issues, experiences and lessons learned.

Despite these successes, the institutionalization of methods and practices within the government institutions on natural resources is limited and requires a continued effort to enlighten research managers and policy-makers with further evidence and in-depth case studies. Nepal Agricultural Research Council (NARC) will continue to play an important role in this process. In contrast, an NGO partner has been able to integrate some of the good practices into the existing projects of agricultural biodiversity and attract funds from external sources such as the home gardens project in Nepal from SDC, value-addition of local biodiversity from Development Fund Norway and Community Biodiversity Register from SGP/GEF.

Capacity-building at various levels, specifically those of farmers at community level for the management of agrobiodiversity, requires a continued and long-term commitment from national and international partners. Capacity-building of local institutions in establishing effective links to formal research and extension institutions, as well as to market intermediaries, is an area where inputs from the project will be focused. Institutionalization of methods and practices within NARC and the government institutions will require time, and the need for continued lobbying for policy changes/reforms will require further evidence and case studies.

Discussion

One significant outcome is that the committed *in situ* policy team and the Genetic Resources Policy Initiatives (GRPI) Projects reinforced each other in Nepal, leading to official requests to IPGRI for related taskforces to prepare a national agricultural biodiversity policy as the Government has recognized the group as human capital in this area.

Institutionalization, a complex phenomenon, may take a longer time to be included in the newly developed methods and tools in regular programmes (Rogers 1995). The *in situ* project was the pioneer in introducing conservation and sustainable utilization of agrobiodiversity into the national system and has the advantage of working with the governance structure of MoAC and NARC, which have authority to influence policy. The arrangement made in the project for inclusion of policy-makers/executive leaders from MoAC, DoA, NPC, MoFSC and NABC in various events is quite effective in policy influence, as was also suggested by Senge (1990). He said that the inclusion of executive leaders and policy-makers in a team is fruitful in creative thinking and articulating the case studies for change in terms of observable results.

Advances in agricultural sciences and technologies have gained momentum and priority in national research and development agenda. Since the inception of periodic plans (9th Five Year Plan and recent 20 Year Agriculture Perspective Plan), the national roles and responsibilities for conservation and sustainable utilization of agrobiodiversity have not been reflected. Now, with the consistent efforts from the *in situ* research team in sensitizing and providing technical as well as critical information from national and international sources to major stakeholders and developing partnerships with them, the earlier scenario seems to be changing. The directives for implementing activities on agrobiodiversity have been included in the 10th Five Year Plan and a National Agrobiodiversity policy is on the verge of finalization.

His Majesty's Government of Nepal is currently facing challenging issues such as complex international agreements/conventions dealing with the globalization and liberalization of economy, climate changes, global concerns for biodiversity conservation, and biosafety regulations. A national commitment to conservation and sustainable utilization of PGRFA is apparently visible in the national biodiversity strategy and 10th Five Year Plan that assigned high priority to agrobiodiversity. Recognizing the significance of valuable genetic resource and harmonious implementation of international agreements and conventions, institutionalization of good practices to conserve, use and manage PGRFA is imperative in the national perspective. Experiences indicate that the institutionalization of PGRFA activities in the national system requires the following enabling initiatives:

- Sensitization of stakeholders
- Generation of information
- Strengthening national capacity at GO/NGO/Private/Community levels
- Partnership development among stakeholders
- Efficacy of change agent in identifying legitimate power group.

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Supportive policies

Policy incentives for conservation and the sustainable use of crop genetic resources in Nepal

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Abstract

Policy environment and incentives play critical roles in the conservation and sustainable use of crop genetic resources by farmers, plant breeders and other stakeholders. Using a case study of crop genetic resources in Nepal, this study aims to analyze the effects of policy, legal and local institutional incentives on the maintenance and use of local crop genetic diversity. Analysis of current policies and institutional environments and their likely and actual influence on conservation and sustainable use of crop genetic resources in Nepal are reported based on the participatory assessment of the perception of stakeholders and a review of the relevant policies and laws. The analysis shows that the current policy, laws and local institutional environment that prevail in the country are either inadequate or inappropriate for the conservation and sustainable use of crop genetic resources on-farm. A comprehensive policy for conservation and sustainable use of crop biodiversity in harmony with international agreements and national needs of the country is presently lacking. Finally, the paper suggests the review of present agricultural and economic development strategy and a re-assessment of current policies and regulations to creating incentives for conservation and sustainable use of crop genetic resources in Nepal.

Key words: Crop genetic resources, genetic erosion, incentives, on-farm conservation, policy threat, sustainable use

Introduction

Crop genetic resources (CGR) in the form locally adapted crops and ancestral varieties are crucial to local food and livelihood security in traditional farming systems in developing countries. As crucial to food production as CGR are, they have been eroding at an unprecedented rate throughout the last century as a result of introduction and promotion of modern varieties (MVs) and cash crops in developing countries. Along with these important resources of mankind, the traditional knowledge of cultivation, management and use associated with them are also in serious threat of extinction (Shiva 1991; FAO 1998; Thrupp 2000). Concerns for genetic erosions of crops in the centres of diversity in developing countries and genetic vulnerability of modern food production systems worldwide have raised important awareness and policy development on conservation of genetic resources in recent years. This issue got special momentum after the historic signing of the Convention on Biological Diversity (CBD) in 1992 in Rio de Janeiro. The CBD led to a change in the perception of genetic resources as 'common heritage' of mankind to one that acknowledges national sovereignty (CBD 2001). Recent developments in biotrade and intellectual property rights (IPR) systems with the establishment of the World Trade Organisation (WTO) agreements on Trade Related Aspects of Intellectual Property Rights (TRIPS) have further stimulated the debates and concerns for conservation and sustainable use of genetic resources. In the changing context of economic liberalization and globalization, conservation and sustainable use of CGR will depend on the availability of incentives for farmers and plant breeders to continue selecting, maintaining and making available these resources (Hawtin and Hodgkin 1997).

Nepal is rich in crop genetic diversity as a result of its diverse farming systems, extreme variation in micro-agroecological niches and varied sociocultural settings. Recently, however, concerns have been raised in scientific and development circles about the rapid loss of farmers' traditional varieties and their associated indigenous knowledge (Shahi 1995; Joshi *et al.* 1998; Sthapit and Joshi 1998; Upadhyay 1998; HMGN/MFSC 2002). Addressing the concerns of the loss of diversity requires innovative public policies that create and maintain incentives for individuals and communities to invest in and benefit from conservation and sustainable use of agrobiodiversity (Halewood and Mugabe 2002). There is a noteworthy number of studies on the various socioeconomic and agroecological factors that influence households' decision to maintain genetic diversity in the centres of crop diversity (Brush *et al.* 1992; Bellon and Taylor 1993; Meng 1997; VanDusen 2000; Smale *et al.* 2001). However, little is known about policy incentives on conservation of local crop diversity on-farm (Collins and Petit 1998; Maxted *et al.* 2002; Bragdon and Jarvis 2003).

The challenges for the governments of developing countries are therefore twofold. The first challenge is to understand policy mechanisms that influence use and management of local genetic resources and to create the right incentive mechanisms for their continued use and maintenance by farmers, plant breeders and other stakeholders. The second challenge is to ensure that national policies and institutions in agricultural and other related sectors support these goals. The study presented here is based on a participatory policy case study conducted in Nepal, a centre of diversity and domestication for rice (Vaughan and Chang 1992) and other important crops such as buckwheat, barley, finger millet, pigeon pea, cucumber and sponge guard, to name a few. This study aims to identify the key policy and institutional incentives at national, local and international levels that affect conservation and sustainable use of diverse crop genetic resources for informed decision-making. Only with a thorough understanding of the policies and institutions related to genetic resources can the policy-makers make the most informed choices that will have profound implications on sustainable conservation and long-term economic development. The next section presents the research methods employed followed by the findings, with special reference to the influence of national, international and local policies/institutions on the conservation of genetic resources. These findings are the result of an analysis based on information derived from several years of interactive participatory research with farmers, plant breeders and other key stakeholders of the crop genetic resources system. The last section provides conclusions, including implications of the findings of the study.

Materials and methods

The study uses information from a recent case study supplemented by information from several years of participatory policy research that has been conducted since the implementation of the *in situ* conservation of agrobiodiversity project in Nepal. It employs participatory research tools (Kaplowitz and Hoehn 2001; Robb 2002; Kumar and Chambers 2002) in combination with stakeholder analysis (Grimble and Wellard 1997) and an institutional approach (De Marchi *et al.* 2000; Hodgson 2000) for information collection and analysis. The specific methods are outlined below:

Stakeholder identification and key informant survey

Relevant stakeholders of crop genetic resource systems were identified through literature review, prior experience on the project activities, in house discussion of policy research team and informal consultations with some of the relevant stakeholders. The stakeholder groups that were chosen include: (1) key decision-makers in public sectors representing different government ministries and institutions, (2) private seed entrepreneurs and traders, (3) non-governmental organizations, (4) related donor-funded projects, (5) plant breeders and conservationists, and (6) farming communities and grassroots institutions. Three to five key informant interviews were conducted for each representative stakeholder group using semi-structured stakeholder-specific guided checklists and questionnaires. All together, 22 interactive, open-ended interviews were conducted at informants' work places.

Consultation meeting of relevant stakeholders

Consultation meetings for specific national-level stakeholder groups were organized to triangulate the findings of the interview process by presenting and discussing with them and accordingly updating with the new information. A face-to-face interaction meeting of the local community representatives with key government officials was organized to explore farmers' and local communities' perceived policy constraints and to assess their potential interest in conservation of crop genetic resources. In addition, the information drawn from these meetings was supplemented with the regular project planning and review meetings held in the project ecosites (Bara and Kaski).

Focus group discussions, direct observation and periodic monitoring

The information collection and validation process also included direct field- and farm-level observations, focus group discussions and key informant interviews of the local communities and project field staff in the project ecosites using guided checklists for regular project monitoring activities. Field monitoring of the project activities provided significant insights and evidence of the policy and institutional incentives at the local level. During the field visits, the researchers interacted with and elicited relevant information from community leaders, community-based organizations, men and women farmer's groups, market agents and local field staff, as well as representatives of the local extension offices and other line agencies of crop genetic resource conservation programmes.

Analysis and synthesis of the findings

A desk study was carried out for situation analysis of policy, laws and local institutions and their actual and likely influences on conservation and sustainable use of local crop diversity. This analysis was based on the information generated from the above-mentioned research tools in combination with a review of relevant policy documents and findings of earlier policy research case studies (Gauchan *et al.* 2000a, 2000b, 2002; Gauchan 2004). The study used a diagrammatic form and several matrices to analyze and synthesize collected information from various sources. Matrix formats were used for mapping and analyzing key policies, laws and local informal institutions and their actual and potential influences. Quantification of the impacts of policies was, however, not possible owing to the difficulty and complexity of collecting quantifiable data on policy perceptions from the diverse set of stakeholders.

Findings

Influence of policies at different hierarchical levels

Sustainable conservation and use of plant genetic resources on-farm are influenced by the decisions made at the international, national and local community levels by the relevant stakeholders and decision-makers (Gauchan 2004). These decisions either directly or indirectly influence farmers' choice and maintenance of genetic diversity through the policy and institutional systems they form and incentives or restrictions they generate. Policies are designed and implemented at different levels: international, national and local. Figure 1 presents the general conceptual framework of the policies at the international, national and local levels and their direct or indirect influences on the *in situ* conservation and sustainable use of crop genetic resources.

International policies, agreements and legal frameworks to which the country is a party, guide the development and enforcement of national policies and laws at the national level. National policies and laws have direct impact on conservation of genetic resources through related product and input markets, prices, information and regulations (indicated by dark lines). The regulations of national laws (e.g. Seed Act, Plant Protection Act) impose restrictions on the access, use and exchange of genetic resources in the communities, regions and beyond the national boundary. International policies have less direct influences on local level policies and institutions (indicated by thin or dotted arrows). However, national policies have more direct influences on the operation of local community rules, norms and practices, though in some cases it may be indirect, as shown by the thin arrows. The local policies and informal institutions at the community level directly influence on-farm conservation through affecting farmers' choice, use, exchange and management of local genetic resources in the community.

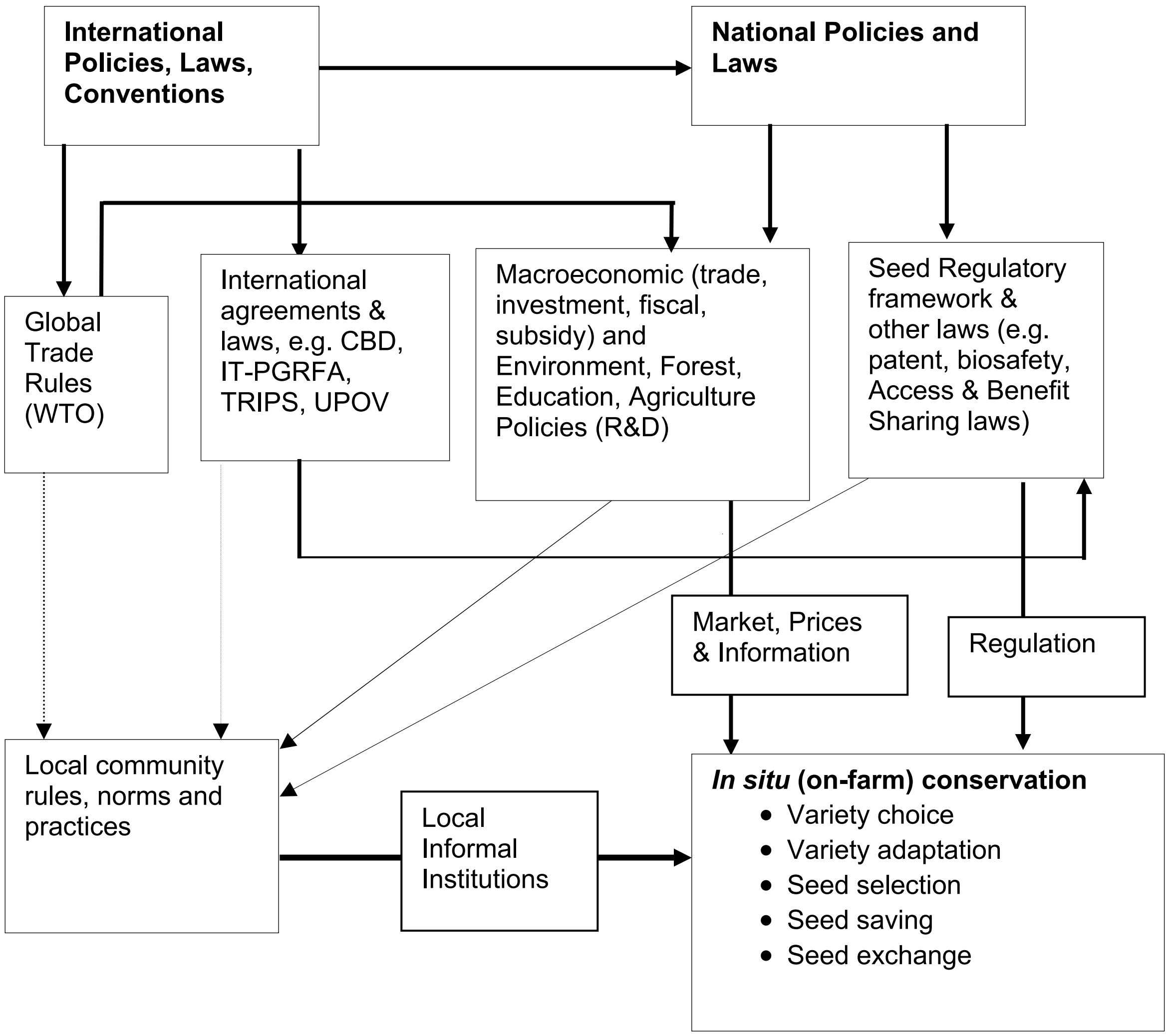

Figure 1. Influence of policies (national, international and local) on *in situ* (on-farm) conservation of crop genetic diversity (Dark lines indicate direct influence; thin lines indicate direct but less influence and dotted lines indicate indirect influence).

International policies and their expected influence

Table 1 provides the list of various international policies and their perceived impacts (actual and potential) on local crop diversity in Nepal. The most important international policy agreement that has been perceived to have a direct positive impact on the maintenance of local diversity is the Convention on Biological Diversity (CBD) which was signed in 1992 and ratified by Nepal in 1993 (HMGN/MFSC 2002). To meet the obligations of CBD, recently some initiatives have been made by the Ministry of Forest and Soil Conservation (MFSC) by developing relevant policies, action plans and programmes such as national biodiversity strategy (2002), Access and Benefit Sharing legislation (under approval), Biodiversity Trust Fund and the proposal for landscape approach to biodiversity conservation (HMGN/MFSC 2002). The influence of the WTO on the agricultural sector is mainly through agreement in agriculture (AoA), Sanitary and Phytosanitary Measures (SPS) and TRIPS. For Nepal's about 20 million farmers, accession to WTO have posed great challenges and opportunities. Despite Nepal's recent accession to WTO, adequate preparation has not been made to develop an appropriate *sui generis* legislation. to meet the requirement of TRIPS in WTO. One option is use of the International Union of New Plant Varieties (UPOV) model (1991) which has a provision for Plant Breeders' Rights (PBR). Adoption of the UPOV 1991 model as such and use of patent system in developing *sui generis* legislation are expected to have negative impacts for a country like Nepal (Adhikari *et al.* 2000; Gauchan *et al.* 2002). This is because above 90% seed supply in Nepal comes from farmers' own saving and local exchange of seed (Sthapit and Shah 2001; Baniya *et al.* 2003)**.** Adoption of strong IPRs that are presently available in the form of seed patents and PBRs may, therefore, function as a disincentive for *in situ* conservation of crop genetic resources in the country.

Table 1. Relevant international policies and their likely impacts on CGR conservation and farmers' livelihood in Nepal.

International Policies	Specific features	Influence on local diversity
Convention on Biological Diversity (1992): Nepal signed it in 1992 and ratified in 1993.	-Sovereign rights to nations -Conservation and utilisation -Access and Benefit Sharing -Prior informed consent	Positive influence on *in situ* conservation and use due to provisions of incentives for the nations and local communities.
WTO (1995): Nepal got accession in September 2003.	-Plant Variety Protection -Agreement on Agriculture -Sanitary and Phytosanitary (SPS) Measures	Poses both challenges and opportunities-without adequate preparation, may reduce diversity.
International Treaty for Plant Genetic Resources for Food and Agriculture (2001): Nepal is in the process of signing /accession.	-Sustainable Conservation, Use and Benefit Sharing -Multilateral Systems of Access -Farmers' Rights	Expected to have positive effects on crop diversity through easy access of seeds, Benefit Sharing, and Farmers' Rights provisions.
Global Plan of Action (1997): Nepal was a party to Global Technical Conference	-Conservation through use -Technical support for the countries in the south	Expected to have positive influence due to provisions for technical and funding support.
UPOV (1991): Nepal is not yet a member.	- Plant breeders' Rights - Patents	Reduced incentives for farmers' to use local crop genetic diversity

Nepal has yet to sign and ratify the recent FAO-International Treaty for Plant Genetic Resources for Food and Agriculture (IT-PGRFA), which is a legally binding international agreement approved by the FAO conference on 3 November 2001 (FAO 2001). This treaty highlights the unique future and public good nature of crop genetic resources and recognizes the present and past contribution of farmers in developing and making availability of crop genetic resources (Gauchan 2003). The treaty therefore is likely to provide incentives to farmers and small-scale public plant breeders in creating variability and farm-level breeding through the provisions of Multilateral Systems of Access and Benefit Sharing. However, as a non-member of IT-PGRFA, these provisions may not provide adequate incentives for *in situ* conservation in Nepal. Nepal was a party to the Global Plan of Action (GPA) in 1997, developed under the auspices of FAO at an international technical conference on Plant Genetic Resources held at Liepzig, Germany in 1996. This GPA represents the most comprehensive strategy for the conservation and sustainable use of crop genetic resources of the world (FAO 1997; Swaminathan 2002). Since it emphasizes both *in situ* and *ex situ* conservation and support to developing countries through technology transfer provisions, it is expected to have a positive influence on conservation and sustainable use of local crop diversity.

National policies and their influence

Table 2 presents some of the important national policies that have perceived influences on the conservation and sustainable utilization of local crop genetic diversity. These are macroeconomic policies (trade, investment, fiscal, monetary, etc.), as well as sectoral policies on the environment, forestry, agriculture, commerce and education, which are guided by the Tenth Development Plan (HMG/NPC 2002). The liberal economic policies initiated since the mid-1980s, which are being implemented rigorously since the advent of multiparty democracy after 1992, have favoured the promotion of industrial and service goods including import of cheaper agricultural products across the borders. As a result, there is free unrestricted import of cheaper subsidized agricultural goods, which is discouraging local production. The relative yield and price advantages of imported rice products including aromatic fine rice varieties have reduced the competitive ability of locally marketed popular aromatic Nepalese traditional rice varieties, such as *Pokhareli masino*, *Jhinuwa*, *Kalanamak*, *Chananchur*, *Basmati*, *Jethobudho*, *Krishna bhog* and *Biramphul*, to name a few.

Table 2. National policies and practices that have influences on conservation and sustainable use of crop genetic resources in Nepal.

Existing policies	Specific features	Influence on local diversity
Macroeconomic policies: Trade, Investment, Fiscal and Monetary	Liberal, open and import oriented with low or no tariff on imported primary agricultural products	Reduced incentives to local producers due to decreased agricultural prices as a result of flow of cheaper imported products
Agri-development policy: Agricultural Perspective Plan (APP)	Focus on irrigated, market accessible areas with support for few major crops and MVs	Farmers growing minor crops and landraces in rainfed risk-prone areas lack support
National Biodiversity Strategy (2002) of Ministry of Forest and Soil Conservation	Dominated by natural biodiversity despite the huge potential of CGRs for Nepal's agrobased economy	Limited influence on local diversity due to lack of specific integrated action plans and programs
Credit policies and practices	Credit supply for economic crops / MVs in irrigated areas	Landraces and minor crops do not qualify for subsidised credit
Educational policies and practices	Curriculum and text books concentrate on the promotion of major food, cash crops and MVs	Diversity is in decline due to lack of appreciation for local knowledge and practices
Research and Extension policies and practices	Research and extension promotes MVs and cash crops	Declining diversity of landraces and minor crops
Food supply and distribution policies	Supply of subsidized food in remote mountain areas	Reduced incentives for cultivation of local crops

Since the start of the agricultural development programs in Nepal, government policies have focused on promotion of MVs and associated imported technologies without recognising the role of traditional varieties in local livelihoods. Production programs, various donor-funded projects supplied subsidies and support on the introduced exotic MVs and external inputs. The Agricultural Perspective Plan (1997-2016), which is the key guiding policy framework for agriculture, has also focused in favourable areas with packages of MV technology and inputs for major crops and commodities (APROSC/JMA 1995). The pocket package strategy (PPS) of APP envisages that about 60% of the resources of the district agricultural development offices (DADO) need to be allotted to favourable irrigated and market-accessible areas for the promotion of MVs of major food crops and associated packages (DOA 2000). Farmers cultivating landraces and minor crops are increasingly disadvantaged, particularly those residing in inaccessible areas and those cultivating rain-fed farms. In addition, agricultural credit policies often require farmers to purchase and use MVs and agricultural chemicals in order to qualify for loans. Agricultural research, education, information environment and technical support services are also in favour of MVs and major crops, thereby creating disincentives for cultivation of local minor crops and landraces. Supply of subsidized main food crops (e.g. rice) by Nepal Food Corporation in the remote marginal mountain regions has increased dependency of local people on externally supplied cheaper foods, thus reducing local incentives for production and maintenance of native crops. Farmers lack timely and easy access to seeds of diverse local crop varieties, which are crucial to increasing local production and productivity (Joshi 2000; Gauchan *et al.* 2000a; Sthapit and Shah 2001). Though a recently developed (2000) Seed Policy has addressed some recent concerns of seed production and delivery through private sector participation, it still lacks recent concerns on recognition of farmers' traditional knowledge, innovation and sharing of benefits arising out of the genetic resources.

Present policies and programmes on biodiversity focus more on forest, wildlife resources and nature conservation without adequate recognition and emphasis on the overall genetic diversity encompassing agricultural crops important to food security (Gauchan *et al.* 2000b; Upadhyay *et al.* 2003). Despite the recognition of agrobiodiversity in a recently formulated national biodiversity strategy (2002) and also in the Tenth Plan (2003–2007), government lacks appropriate action plans and adequate coordination within the sectors and institutions.

National laws and regulations and their influence

Table 3 presents important legal policies that are relevant to conservation and sustainable use of crop genetic resources in Nepal. Currently Nepal lacks appropriate national legislation and institutional framework for conservation, utilization, access and benefit-sharing, including biosafety and legal protection of crop genetic diversity (Gautam *et al.* 1999; Gauchan *et al.* 2000a; Upadhyay *et al.* 2003). While there is no legislation directed solely at CGRs, there is a Seed Act (1988) and several other laws including the Forest Act (1993) and Plant Protection Act (1972) that have impacts on CGR (Gauchan *et al.* 2002). The available seed legislation (Seed Act 1988) is primarily geared towards the promotion of modern varieties and has no provision to recognize farmers' role in local crop development, informal seed systems and conservation of on-farm diversity. The country also lacks domestic safety regulations and arrangements, such as a biosafety law to guarantee safety, protect foreign investment, and promote international cooperation on local research. Nepal presently does not have a plant variety protection law but a related law, which is developed for industrial or non-agricultural purpose, that can be applied to the agricultural sector is found under the Primitive Patents, Designs and Trademark Act (1965). Recently Local Governance Act (1998) has been promulgated empowering local people in decentralized, local-level planning and management of natural resources, but the full implementation of this law has not yet been observed.

Table 3. Current legal policies that have influences on the conservation and sustainable use of local crop genetic diversity in Nepal.

Legislation	Specific features	Influence on local diversity
Seed Act (1998)	Focus on certification, quality control and testing of MVs of major crops with DUS † system	Reduced diversity due to absence of provisions for the promotion of farmers' varieties (landraces)
Forest Act (1993) and Forest Regulations (1997)	Focus on conservation and use of community forestry for timber, fodder, herbs and firewood trees	Erosion of native, minor and under-utilised crops since crop cultivation is not possible in community forest area
Access and Benefit Sharing Legislation under Approval	Focus on forest genetic resources and lacks recent concerns of FAO's-ITPGRFA (2001)	Less expected impact on local crop diversity since specific features of CGRs are not recognized
Food Act (1966) and Food Rules (1972)	Provisions for food quality testing but overlooks recent biosafety concerns	Poor food quality testing, unrestricted flow of imported food /plant materials have negative impact on diversity
Local Governance Act (1999)	Focus on local decision-making in management and use of resources	Expected to have positive impact but yet to be implemented fully
Plant Protection Act (1972)	Import of foreign genetic materials with quarantine testing but no provisions for monitoring and post-entry testing of materials	Implementation and enforcement of law is presently weak due to lack of adequate laboratory facilities and long open border with India

† Distinct, uniform and stable.

State of informal local institutions and their influence

The important informal community institutions operating in the project ecosites that have influences in maintaining local crop diversity include traditional rules, norms, customs and common practices. Informal community institutions guide the operations of local seed exchange networks, natural resource management groups, market and labour networks and local religious and cultural groups (Table 4). These informal institutions have historically played critical roles in the maintenance of crop diversity in the study sites. Informal networks of farmers such as nodal farmers (Subedi *et al.* 2003) in the community enhance farmer-to-farmer dissemination of genetic materials, particularly of landrace seeds. However, traditional rules and practices that have been sustaining such networks over many generations are declining, especially in market-integrated areas in Bara, where use of MVs has been accelerating. This is due to easy access to formal seeds and inputs at the local markets and presence of formal market institutions such as seed dealers (*Sajhas*) and Agrovets, which supply seeds of only MVs and other external inputs. As a result, unavailability of local landrace seeds is one of the key constraints to the conservation and maintenance of local diversity (Gauchan 1999; Chaudhary *et al.* 2001). Similarly, the practice of traditional reciprocal labour exchange (*Perma*) system among communities in the study sites has historically been important in sustaining agricultural production in general and maintenance of crop diversity in particular. However, this form of informal labour institution has been rapidly eroding by the use of hired labour, off-farm labour market integration and adoption of tractors and threshing machines in farming (Gauchan 2004). The influence of off-farm employment on crop genetic diversity appears to be strong, since local seed selection, saving and exchange are all labour-intensive activities, which compete with off-farm activities.

Table 4. Status of traditional, local, informal institutions and their influences on the conservation and sustainable use of local crop genetic diversity in Nepal

Local institutions	Status and specific features	Influence on local diversity
Local informal seed exchange and networks	Declining status of informal farmers' groups tied with local trust and kinship due to easy access of MV seeds from markets and local agri-extension office	Reduced flow of local genetic materials and information on local genetic resources in the community
Local informal labour institutions (*Perma* systems)	Reduced reciprocal labour exchange due to increased use of hired labour and machinery	Increase adoption of MVs that are suitable for machine cultivation and harvesting
Traditional informal market institutions and exchange systems	Replacement of informal traders, (e.g. *Kutuwa, Paldars)* and local trading systems (e.g. *Hats)*, by large traders (e.g. G*olas /Mills*)	Reduced marketing and exchange opportunities for landrace seeds and grains and thus reduced local diversity
Local, religious and cultural institutions that sustain food cultures and rituals	Declining trend of rituals and food traditions where landraces are used, (e.g. *Sathi* rice for worshipping goddess *Chath Mai)*	Declining values of local culture and hence reduced cultivation of local seeds
Natural resource use community groups	Rules of traditional management of irrigation and forest resources disappearing as a result of state regulations and interventions	Reduction in traditional natural resource management practices that have originally sustained high levels of diversity

Over the years with the increase of market integration, adoption, large-scale production and marketing of modern varieties especially in the market-integrated areas has resulted in increasing replacement of small-scale informal traders (*Bania, Kutuwa, Paldar*, etc.) by large-scale traders (*Golas*) and rice-processing mills that are specialized in MVs. This replacement process has reduced the transaction of landraces seeds as these small-scale traders were mainly facilitating traditional local trading and exchange practices of landrace grains and seeds. Similarly, small-scale, traditional home and community processing practices and grain mills, parboiling and other processing structures (used for parboiled rice, *bhuja, Chiura* making) and their local knowledge have been lost with the introduction and increased use of commercial processing mills. This process has been observed to have a negative effect on the marketing and local processing of minor crops and landraces. Coarse rice landraces, whose superior agronomic attributes are not reflected in their market price, are increasingly under threat from such market pressure (Gauchan *et al.* 2001).

Many cultural institutions that exist in the form of rituals, food traditions and religious practices such as *Chath* festivals in *terai* communities (Bara) including other cultural norms provide incentives for maintenance of local traditional crop diversity. For example, some culturally valued rice landraces such as *Sathi* are maintained for worshipping the goddess *Chathmai* during *Chath* festivals, which is a popular cultural practice of people living in the *terai* (lowland) of Nepal. Aromatic rice landraces, such as *Basmati* in Bara and *Jethobudho, Jhinuwa,* and *Panhele* in Kaski, are maintained because of their higher cultural and social values during specific feasts, festivals and local rituals. These landraces are preferred for serving guests during special family gatherings, weddings and religious feasts. Similarly, *Anadi*, a local rice variety, is especially demanded for preparation of snacks, such as *Latte and Khatte*, etc. for household and communal food traditions and household local medicinal purposes in Kaski (Rijal *et al.* 2001; Pant *et al.* 2003). However, such cultural institutions that are supported through indigenous food cultures, religious practices and customs are declining. As a result, conservation, use and maintenance of these local varieties and their associated knowledge are eroding in the local communities.

Conclusions and implications

The country presently lacks comprehensive policies to address overall conservation and sustainable use of crop genetic resources, even though there exist some policies in specific sectors for conservation of other forms of biodiversity. Present biodiversity policy and programmes are focused more on forest, wildlife and protected areas. Support measures in the form of direct and indirect subsidies and information to promote the intensification of agriculture are mainly creating an 'artificial' advantage for modern varieties. The formal education system in agriculture is primarily geared towards imparting knowledge, skills and attitudes on the cultivation and promotion of modern varieties and technologies. The notion that "economic benefits can be derived only from the promotion of modern varieties /technologies" is still the guiding philosophy in policy formulation (Gauchan *et al.* 2000a). Currently, international (TRIPS, UPOV) and national policies provide incentives to professional breeders, but no mechanisms exist to provide incentives for farmers and local communities. Public policies, mechanisms and commitments for enhancement of effective participation of farmers and private sectors in development of farmer-preferred varieties are limited. At the local level, local indigenous institutions and systems of genetic resource management are under threat by the recent changes brought about by market pressure, modernization and creation of some new institutions of credit, market and technology transfer by the state. The traditional community-level institutions of seed exchange, labour exchange (*perma*), product markets and customary rules that were historically maintaining local diversity, have been threatened and replaced by increasing off-farm labour migration and product market integration. Consequently, farmers lack adequate incentives to conserve and maintain a diverse genetic resource base for future livelihoods and sustainability of the agricultural systems in the country.

A wide gap exists between international policy development and local level understanding and capacity development. Rapidly changing markets and policy environment at both national and international levels make genetic resource policy-making more complex and therefore there is a need for sound understanding of the policy issues by developing national capacity to analyze and develop the right policy options. Predominance of farming communities in the rural areas and dependence of economy on traditional agriculture in Nepal require identification and formulation of relevant policies that protect interests of farming communities and of the nation, while making Nepalese agricultural products competitive in the global market. This requires strengthening of national research and development capacity in understanding, monitoring and analyzing changing markets and policy issues. Similarly, investment in training and empowering of farmers and communities in different regions, ecosystems and socioeconomic contexts is essential to enhancement of local efforts for on-farm conservation, breeding and seed maintenance. Ongoing field experience of the *in situ* project activities in Nepal have shown that technical skill enhancement of farmers' group, bottom-up programme planning, and regular sharing of information with local institutions have illustrated the ownership of programmes and increased mobilization of communities on local conservation programmes (Rana *et al.* 2001).

The findings of this analysis imply that present economic and agricultural development policies that focus on favourable areas need to be re-assessed and re-balanced with specific emphasis on marginal areas for both the equity and conservation reasons. The negative effects of liberal economic policies on local crop diversity have to be carefully studied and addressed with specific targeted measures on local food production, value-addition and marketing. Direct subsidies (e.g. cash payment) are not tenable, however, indirect subsidies for local crops and landraces may be an option depending on the amount of genetic diversity maintained by the communities and farming systems. Decentralized public research, seed testing and rapid release of varieties through biodiversity-friendly plant breeding in the location-specific agroecologies will provide greater farmers' choices, utilization and conservation of diverse local genetic resources (Sthapit *et al.* 1996; Witcombe *et al.* 1996;

Sperling and Ashby 1997; Joshi 2000; Cooper *et al.* 2001). This approach could be effective, particularly in market-accessible and high-production environments where threat of genetic erosion is high. In order to address the loss of crop diversity and strengthen informal local institutions for managing crop genetic resources, there is a need to increase capacity-building of local communities in local seed selection and crop breeding through seed fairs, community seedbank management, use and exchange. Participatory plant breeding (PPB) is one of the options to strengthen local seed networks, informal seed systems and grassroots institutions that can also be linked with formal seed systems and national institutions managing genetic resources. Some initiatives in this regard have already been made by the *in situ* project in Bara and Kaski ecosites in Nepal (Jarvis *et al.* 2000; Sthapit and Jarvis 2003), which need to be further tested and replicated in similar areas throughout the country.

There is a need to change national agricultural policies to incorporate superior landraces in local extension programmes and mainstream them into agricultural development packages, and to support the use of crop diversity to manage risk and uncertainty about social and environmental changes (IPGRI 2001). Concerns have been raised in recent years that the seed regulatory system must be flexible to allow PPB products, such as farmers' varieties or landraces, to be recognized for further dissemination (Sthapit and Joshi 1998; Sthapit and Shah 2001). The recent initiatives to draft new seed legislation and a plant variety protection (PVP) law in Nepal will fulfil the needed gaps and provide flexibility in certification and marketing of seeds. Similarly, the new legislation on *sui generis* systems, bioaccess and biosafety laws that accommodate both the concerns of international policies and national and local needs of the country need to be developed. Existing legislation such as the Seed Act (1988), Plant Protection Act (1972) and Access and Benefit Sharing law (under approval) and other related crop genetic resources laws and policies need to be reviewed, adapted and harmonized in accordance with the national needs and the requirements of international policies. Therefore, adequate preparation on the development of policies and legal infrastructure is immediately needed to meet the PVP requirements of TRIPS/WTO membership (Gauchan *et al.* 2002).

Further research is needed to carry out specific quantitative assessment and measurement of the impact of the various policy options on local crop genetic diversity, ecosystem health and human well-being at different hierarchical levels. Policy, legal and institutional responses must be monitored over time for their genetic, ecological and economic impacts on farming systems to see if they do indeed fulfil the goal of maintaining high levels of diversity on-farm, as well as supporting agroecosystem health and improving farmers' livelihoods in different contexts (Bragdon and Jarvis 2003). Much more effort is required to develop adequate analytical tools to enable policy-makers to explicitly address the trade-offs and consequences of particular decisions (Tripp and Heide 1996). However, the identification of an optimum mix of development and conservation initiatives is one of the most difficult tasks that conservationists and policy-makers face in the coming years and the necessity to develop location-specific policies and strategies adds to the complexity of the challenge.

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Conservation of crop genetic resources in community genebank: farmers' willingness to pay for conservation of rice landraces in Kaski, Nepal

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Abstract
A community genebank has been recognized as one of the practical approaches of strengthening on-farm conservation of crop genetic resources. This approach includes networks of local people sharing local crop resources for their local use and market purposes. The community seed bank approach enables: (1) maintaining genetic diversity on-farm, (2) updating the status of landraces, (3) providing reasons if extinct, (4) maintaining a database for local crop diversity and knowledge, (5) improving farmers' access to seed and knowledge resources, and (6) supplying seeds through regeneration as per local demand. The researchers provide technical assistance. The partnership between farmers and researchers offers a rationalized option for conservation. Therefore, this research assesses people's 'willingness to pay' for conservation of crop genetic resources in a community genebank using contingent valuation method. The rice crop as a model species was used. A total of 107 households were surveyed in Begnas village of Kaski District of Nepal. All the surveyed farmers were ready to contribute/invest for conservation. Compared with *ex situ* conservation, farmers showed their willingness to pay either in kind (land for seed regeneration and man-days for seed management) or cash or both to operate a community genebank. The mean willingness to pay was USD 16.75 per annum. In other words, farmers are ready to invest USD 17 every year if a community genebank is established. The variables such as landholding size, household size, socioeconomic status, sex of respondent as well as the number of crop landraces grown influenced households' willingness to pay for conservation. The study revealed that farmers give value to crop genetic resources and therefore pay considerable attention to conservation. The finding of the study provides the basis for planners in formulating appropriate policies regarding the conservation and use of local crop diversity.
Key words: Community genebank, crop genetic resource, conservation, landrace, willingness to pay

Introduction
The Convention on Biological Diversity (CBD) has raised awareness about the importance of biodiversity for sustainable development, and for maintaining ecological balance. Conservation of biodiversity either through *ex situ* or *in situ* means has increasingly been advocated in many fields including crop genetic resources (UNEP 1994). The crop genetic resources (CGRs) are also important assets of the farmers, which contribute food security (Rana *et al*. 2000) and livelihood directly to the farmers and indirectly to all humankind. Conservation of such CGRs is essential for the future generation. Understanding of the farmers' knowledge and their contribution in management of biodiversity can help in initiating *in situ* conservation of genetic resources, which complements the *ex situ* conservation already in existence. A partnership of conservationists and indigenous people offers the best option for achieving conservation (Alcorn 1993; Berkes 1999). Considering this, many efforts have been made to conserve these CGRs either *in situ* or *ex situ*. The conservation of biodiversity—particularly crop genetic resources—could be possible with different approaches such as *ex situ*, *in situ*[19], on-farm and an *in situ* community genebank

[19] Conservation of the plant genetic resources in the place where they originated, and variation was created and developed, is *in situ* conservation (Brush 1995). Here, '*In situ* on-farm' means conservation of genetic resources at household level whereas an *in situ* community genebank means conservation through the community-managed approach to *in situ*.

(see Worede 1992; Brush 1995; UNEP 1995; Rijal 2002; Hammer *et al.* 2003; Rana *et al.* 2003; Sthapit and Jarvis 2003; Sthapit *et al.* 2003).

The most common methods of conservation *ex situ* have been complemented through *in situ* conservation at household level in recent decades. However, the introduction of exotic and modern crop varieties is causing problems in conservation of CGRs *in situ* at household level (on-farm). Therefore, community gene (seed) banking is one of the emerging and suitable alternative methods for *in situ* crop conservation. A community genebank consists of the network of the local people, organized for the purpose of seed production, use and marketing of the local genetic resource for conservation (Rijal 2002). This is an method of *in situ* conservation of crop genetic resources where people maintain the genetic diversity on-farm by cooperating to establish the seed network. Establishment of demonstration block, seed production block and ensuring seed availability according to the demand of the public is the major activity in community gene-banking (UNEP 1995; Rijal 2002).

The Community Gene Banking identifies reasons for extinction, maintains a Community Biodiversity Register (see Rijal *et al.* 2003), regenerates them in the community farm based on the priority of PGR conservation (Rijal 2002) and creates awareness for benefits of individual farms. This approach complements on-farm growing of landraces or genetic resources by the individual farmers. The community prioritizes the landraces or CGRs, grows them as needed or may grow the in a few alternate years, saves the seed and reduces the seed quality losses and the drudgery of the seed retention at household level for conservation purposes. In this case the opportunity cost of conservation is lower than on-farm or household-level conservation by individual farmers. Moreover, this approach also conserves the traditional knowledge together with such resources.

Peoples' participation in conservation of genetic resources on a community farm or the community genebank would be higher because such genetic resources are the public goods (Braeur 2003) and the liability of conserving them abides with the society rather than the individual farmer. Also, the positive externality of conservation to society (Correa 2000) reduces the willingness of individual households to conserve on-farm.

Assessment of people's willingness to pay (WTP) for conservation of genetic resources is useful to generate information and knowledge for resource allocation in appropriate decision-making and identify least cost strategy to conserve CGRs (Gauchan 2000). The value that individuals and societies place on the conservation is measured by their willingness to forego the benefits of the alternative uses of the same resources. This can be reflected by a measure of their willingness to pay to acquire a benefit or satisfaction over the resources (UNEP 1995). The willingness to pay for conservation is a function of total economic value (TEV)[20] of the crop genetic resources (CGRs) for the society.

The purpose of the study is to assess people's willingness to pay for value of crop genetic resources such as rice landraces in monetary terms through contribution in conservation. Furthermore, it analyzes the possibility of using the community conservation approach for genetic resources. The contingent valuation method (CVM), an environmental economics technique, provides one way of doing this by quantifying public willingness to pay for a conservation approach (Loomis and White 1996). Among the various methods available for the valuation of genetic resources, contingent valuation is the only one that incorporates non-use values directly (UNEP 1995; White *et al.* 2001; Bräeur 2003) and is suitable to elicit the people's willingness to pay for genetic resources that are public goods with no market price. This has been widely used to value environmental and natural resources in developing countries (Navrud and Mungatana 1994; Mbelwa 2002).

[20] The total economic value of crop genetic resources is the direct use value, ecological function value, option value, existence value, bequest value (see Young 1992; Edwards and Abivardi 1998).

Materials and methods

The contingent valuation method

This method involves setting up a hypothetical market, obtaining bids, estimating mean WTP, constructing bid curves, aggregating data and evaluating the CVM exercise (Hanley and Spash 1993).

In setting the hypothetical market for CVM, the evaluated programme is clear in its aims and consequences and the valued goods (CGRs) are well known and of interest to the people (Bräuer 2003). Although the current trend in CV survey is towards the referendum formats using a dichotomous choice method (Arrow *et al.* 1993; Whittington 2002), a bidding game approach is also used for bid collection (Mitchell and Carson 1989; Hanley and Spash 1993; Dong *et al*. 2003). This study used the open-ended bidding game approach to elicit willingness to contribute. Two main reasons for using the open-ended question are: first, the dichotomous choice question tends to give higher estimates than the open-ended approach (Bateman *et al.* 1995, White and Lovett 1999) especially for studies conducted in low-income countries. Second, the sample required for the dichotomous choice type, to be statistically reliable, is higher (Mitchell and Carson 1989; White and Lovett 1999; OECD 2002), which was restricted in the present study due to time and resource constraints. The form and frequency of payment (Mitchell and Carson 1989) were clearly explained to the respondents. The payment vehicle in the study was the annual contribution of land, labour, cash or all inputs for a conservation programme in the community genebank for *in situ* conservation of their landraces.

As the CVM is always accompanied with doubts about its viability because of various potential biases such as hypothetical bias, information bias, strategic bias, design bias as well as embedding biases (Mitchell and Carson 1989; Hanley and Spash 1993; Hausman 1993; Navrud and Mungatana 1994), this study was designed to minimize such potential biases as far as possible. Efforts were made to deliver clear and equal information to all the respondents, the payment vehicle was clear, we used a pre-tested questionnaire, and four different local enumerators were used to reduce the strategic bias. To test the response validity, the questionnaire contained questions about the demographic and social background (Bräuer 2003) and embedded biodiversity knowledge of the respondents.

The study area

The study area is Kaski district in mid-hill region (800–1500 m asl) of Nepal, where a national NGO, Local Initiatives for Biodiversity, Research and Development (LI-BIRD) and Nepal Agriculture Research Council (NARC) have been working since 1997. The topography of the region is ancient lake and river terraces in moderate to steep slopes. It experiences high rainfall (>3900 mm/annum) with a warm temperate to subtropical climate. Mean daily minimum temperature of the coldest month is 7°C and the mean daily maximum of the hottest month is 30.5°C with monthly mean of 20.9°C (Sthapit *et al.* 1999, Rana *et al*. 2000).

The area is reported to be a hot spot in terms of crop diversity (Rijal *et al.* 1998). A total of 32 crops were reported as being grown. The major crops are rice, maize and finger millet. Rice being the major staple crop, it is grown in different growing environments (lowland, irrigated land, partially irrigated land, rain-fed and upland). The total rice varieties maintained by the local farmers are 69 (Rijal *et al.* 1998), 63 of them local landraces (Rana *et al.* 1999). Therefore, the study was done using rice landraces as a model species.

Population, sample and sampling

The study was conducted in the '*In situ* Conservation Project' of NARC, LI-BIRD and IPGRI in Kaski District, Nepal (Rana *et al.* 2000). The population was selected from 12 hamlets (*Tol*) stratified in different socioeconomic strata (Table 1). Proportionate random sampling technique (Nichols 2000) was used to select the sample for survey. The socioeconomic categories were identified by the project using farmers' own criteria (Rijal 1999). The main parameters for the categorization were the household's food sufficiency, size of landholdings, government services, business, house and homestead properties, ownership of house and/or land in major cities (Rijal 1999; Pant 2002; Rana *et al.* 2000). The study sample constituted 20% of the total households (515), which consisted of 107 households drawn proportionally from three socioeconomic strata (rich, medium and poor) of all 12 hamlets in the project area. As each household represented a sampling unit, one of the household members taking the decisions in agriculture was selected for survey.

Table 1. Population and sample size of the study.

Hamlet	No. of households by socioeconomic strata†			Total households
	Rich	Medium	Poor	
Archalthar	19(4)	13(3)	19(4)	51(11)
Majhthar	14(3)	13(3)	18(4)	45(10)
Adhikarithar	6(1)	18(4)	4(1)	28(6)
Chour	15(3)	5(1)	13(3)	33(7)
Pourakhe	24(5)	12(2)	5(1)	41(8)
Sundaridanda	14(3)	42(8)	8(2)	64(13)
Unnatsil	14(3)	20(4)	4(1)	38(8)
Jamunkuna	5(1)	9(2)	5(1)	19(4)
Rupashirjana	42(8)	25(5)	6(1)	73(14)
Danda thar	16(5)	15(3)	17(3)	58(11)
Poudelthar	13(3)	18(4)	13(3)	44(10)
Bisaunathar	8(2)	5(1)	8(2)	21(5)
Total	200(41)	194(40)	120(26)	515(107)

† Numbers in parenthesis are sampled (20%) households.

The survey and the questionnaire

The instrument used for the study was a questionnaire. Local experienced enumerators were employed to conduct the household survey to increase the trust and truthfulness. They were trained prior to conducting survey. The open-ended structured questionnaire was pre-tested with 8 respondents out of the sample frame and revised before being administered. The questionnaire consisted of three sections. The first section elicited the household and the respondents' demographic and socioeconomic information, which included variables such as sex, age, education, household size, food sufficiency and household income. The second section elicited information regarding the resources (land, genetic diversity), and the perception towards general knowledge on biodiversity and particularly on agrobiodiversity and rice landraces. The third section consisted of the explanation of the study hypothesis and elicited the willingness to pay (WTP) for landrace conservation. The explanation of the subject matter was done before asking WTP questions. The respondents were briefed on the need for conservation using hypothetical market value of the landraces and asked whether they were willing to contribute to landrace conservation. Different methods of conservation (*in situ* and *ex situ*) were presented and discussed. Then, household's willingness to contribute was elicited by asking how much different input (resources) they would be willing to contribute for the conservation of said landraces in an *in situ* community genebank (seed bank). They were asked to contribute land, labour (man-days), chemical fertilizers (kg), pesticides (Rs), manure (*Doko*[21]) and others).

[21] A basket-like structure, which is locally used to carry manure from the farm to the field. One *doko* costs about Rs 20 (USD 1 = Rs 73).

Question: Are you willing to contribute in cash or kind for conservation of landraces in a community seed bank or genebank? If yes, state the amount of labour (man-days), area (*ropani*[22]), and inputs (chemical fertilizers, pesticides, manure or seed).

The data were entered in an Excel worksheet and individual's WTP bids were then calculated from the willingness for contribution using the following equation.

$$WTP = \Sigma\,[L*Pl + A*Pa + F + P + M*Pm + S*Ps] \quad (1)$$

where L= Labour contribution in man-days, A= Area contribution in hectares, F= Chemical fertilizer contribution in cash, P= Chemical pesticides contribution in cash, M= manure contribution (*doko*), S= Seed contribution in kg, Pl= Labour price, Pa= price of renting land, Pm= Price of Manure, and Ps = Price of seed.

Data analysis and model specification

The WTP bids were transferred to Minitab statistical software for analysis (MINITAB 2000). Mean willingness to pay (WTP), standard deviation, and the relationship between WTP and categorical variables were analyzed using descriptive statistics, 2-sample t-test and ANOVA. The WTP bids were also regressed with various explanatory variables. The bid function was arrived at using general regression analysis, starting from the all-potential explanatory variables, removing the non-significant, re-estimating the model and so on until all remaining variables were significant at 95% level (for example, see Horton *et al.* 2003).
The valuation function is:

$$WTP = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \ldots + \beta_n X_n + \varepsilon_i \quad (2)$$

where WTP =Farmer's willingness to contribute to landrace conservation, β_0 = Constant, β_{1}- β_n= Coefficients, X_1 - X_n = Variables contributing in WTP, and ε_i = Random error ~N (0, 1).

Results

Sample characteristics

The demographic data obtained from the 107 households were proportionately stratified within socioeconomic status and randomized for sampling. The mean age of the respondents was 46 years. The respondents were nearly equally represented by males and females. Of the respondents, 15% were illiterate and <5% had university-level education. The average household size was 6.5 people, which is higher than national average of 5.44 (CBS 2003) but exactly similar to that reported by Rana *et al.* (2000). The mean household income was USD1153 in the study area, which is slightly lower than the national level (CBS 2003). The total land capital of the respondents was 0.8926 ha which is almost equal to the national average of 0.96 ha (P>0.05) (CBS 1998; Rana *et al.* 2000). The average number of land parcels was 7.75 in the study area, which is very high compared with the national average of 4.0 (P<0.01) (CBS 1998; Rana *et al.* 2000). The average food self-sufficiency was 9.95 months, which shows the majority of the people are relatively better off in terms of food production. It was found that 25% of the households are producing food for ≤6 months whereas 25% produce food sufficient for ≥12 months. The average number of landraces (excluding MVs) grown was 3.2 (Table 2).

[22] A local unit for area measurement (20 *ropani* = 1 hectare).

The sampling data are almost representative of the study area with the gender, household size, educational status of people, annual income and landholdings of the people, although the average diversity of landraces is higher than in *terai* and high hills of the country (see Paudel *et al.* 1999; Rana *et al.* 1999). Therefore, the study is representative of similar agroecological conditions in the country.

Table 2. Characteristics of sample (n=107).

Category	Number
Age (years; mean, SD)	45 (11.78)
Gender (n,%)	
Female	53 (49.5)
Male	54 (50.5)
Education of the respondents (n, %)	
Illiterates	16 (15)
Literates	33 (31)
Primary	16 (15)
Secondary	28 (26)
Higher secondary	10 (9)
University education	4 (4)
Socioeconomic status (n,%)	
Rich	41 (38.3)
Medium	40 (37.4)
Poor	26 (24.3)
Household size (mean, SD)	6.5(2.9)
Household income USD (mean, SD)	1153 (1647)
Landholdings (ha) (mean, SD)	0.90 (0.66)
Parcel of land (mean, SD)	7.75 (5.1)
Food self-sufficiency months (mean, SD)	9.95 (4.46)
Number of varieties grown (mean, SD)	3.2 (1.9)
Knowledge on agrobiodiversity (n, %)	
Yes	72 (67.3)
No	35 (32.7)

n= Number, SD= Standard Deviation

Farmers' knowledge on biodiversity

As the study was done as part of the '*In situ* conservation' project of NARC, LI-BIRD and IPGRI, the farmers of the study area have been very much informed by the project on the need for conservation. They were familiar with the term 'agrobiodiversity' and different methods of biodiversity conservation. The majority (67%) of farmers were familiar with the concept of agrobiodiversity. Most of the farmers explained the use value of the rice landraces relating to conservation. Although a few farmers (12%) perceived that landraces must be conserved for the needs of future generations (intrinsic value), most of them acknowledged the need for conservation because of the ecological, direct use and option use values of landraces. This resembles the findings of Rana *et al.* (2000) regarding the factors influencing the conservation and maintenance of landraces on-farm. Farmers have been very enthusiastic about explaining the need for landrace conservation and all the respondents participated in explaining why the local rice landraces should be conserved. The farmers' perceived knowledge on the 'need for rice landraces conservation' is presented in Table 3.

Table 3. Farmers' reason for conservation of landraces.

Need for landrace conservation	Responses (n = 107)	
	n	%
Possibility of extinction from the habitat	33	30.8
Medicinal values	27	25.2
Local varieties have diverse taste, use, straw need and importance	57	53.3
Diverse adaptability	64	59.8
Possesses cultural value	23	21.5
For improvement of new varieties	6	5.6
Security for future	12	11.2
Local landraces are suitable in adverse climatic conditions such as disease epidemics, etc.	8	7.5
Need for choice in seed in future	7	6.5
These have yield stability over years	13	12.1
Improved varieties have no guarantee of yield	10	9.3
The basis for subsistence is landraces	2	1.8
These should be conserved because of international or global importance	1	0. 9
These have been grown since ancient times	1	0. 9

Farmers' contribution to conservation

Form of contribution

All the surveyed farmers were willing to contribute to conservation of landraces *in situ* through a community genebank. Farmers had provided inputs as kind or cash in different forms. The majority of farmers were willing to contribute man-days for the community conservation (97%), provide land area (74%), contribute manure (86%), and chemical fertilizer (58%). However, many farmers were sceptical about providing pesticides, as they were not using them themselves, although they are eager to provide if needed. Some of the farmers were ready to contribute as equally as their neighbours do. The mean willingness for contribution was 3.9 man-days of labour, 0.018 ha of land, 5.6 *doko* of manure (value equal to USD 1.5), and one USD for chemicals for the conservation activities for one year (Table 4).

Table 4. Farmers' willingness to contribute to conservation by different means.

Form of contribution	Contribution (mean, SD)†	n (%)†
Labour (man days)	3.9 (2.8)	104 (97.2)
Manure (*doko*)	5.56 (7.35)	92 (86.0)
Land area (ha)	0.0186 (0.0188)	79 (73.8)
Cash for chemicals (USD)	0.56	62 (57.9)
Cash for pesticides (USD)	0.51	37 (34.5)

† n= respondent number, SD= standard deviation.

The contribution bids such as labour (man-days), land (ha) and manure contribution were analyzed using ANOVA and multiple linear regressions. The responses for a large number of hypothesized variables for the willingness to participate in the conservation activities were insignificant (Table 5). People having knowledge on agrobiodiversity, and food self-sufficient were interested in contributing more man-days than those who are not (P<0.05), but farmers who were growing a large number of landraces in their own farm were less willing to contribute man-days to community conservation (P<0.05). Similarly, the contribution of 'area for conservation' was also insignificant with most of the variables (Table 5). Mainly, the farmers having smaller family size, elderly decision-makers, and those with higher landholdings were willing to contribute land for conservation (P<0.05). Contribution of manure was not associated with any factors of contribution (Table 5) but seems to be highly affected by factors outside of the model. Similarly, other chemical inputs were not associated with any of the factors for contribution (not shown).

Table 5. Coefficients of the full and best-fitting models of explanatory variables in determining the willingness to contribute labour, land and manure.

Explanatory variable	Contribution of land		Contribution of labour		Contribution of manure	
	All variables included in model	Best-fitting model	All variables included in model	Best-fitting model	All variables included in model	Best-fitting model
Constant	–0.0139	–0.0089	3.7**	3.48***	3.57	–
Household size	–0.0014	–0.0017**		–	–0.112	–
Age of respondent	$5.3x10^{-4}$ ***	0.0005***	–0.0006	–	–0.012	–
Education level	0.0027*	–	–0.099	–	–0.053	–
Household income ($)	$1.3x10^{-6}$	–	–0.0002	–	–0.0004	–
Food sufficiency	$6.6x10^{-5}$	–	0.193*	0.173**	0.209	–
Landholdings	0.0105**	0.010***	0.23	–	–0.039	–
Land parcels	0.0003	–	–0.022	–	0.127	–
Number of landraces grown	0.0019*	0.0020*	0.379**	–0.399**	0.0455	–
R^2	0.30	0.25	0.10	0.08	0.03	0.02
N	79	79	104	104	92	92

* *P*< 0.10, ** *P*<0.05 and *** *P*<0.01.

Mean WTP per annum

The mean willingness for contribution of conservation of agrobiodiversity in a community genebank was equivalent to USD16.75±15.65 per annum, when converting all forms of resource contribution into monetary terms. The aggregated WTP for such a 'community based conservation scheme' is USD 8626 from the study area.

Factors influencing WTP

The variables hypothesized to affect the farmers' willingness for contribution of agrobiodiversity *in situ* through community banking were regressed with WTP bids using multiple linear regression. Most of the variables were insignificant (Table 6). However, respondent's age and landholding affect positively and household size negatively in contribution. Higher WTP bids were associated with the lower household sizes, elderly decision-makers and the larger landholdings. The low R^2 value (0.26) indicates that there are factors external to the regression models that influence the willingness to pay (WTP) of the farmers. However, Mitchell and Carson (1989) mentioned that the CV study showing R^2 more than 0.15 using few key variables is acceptable.

Apart from these explanatory variables, other categorical variables such as gender, socioeconomic status, and knowledge on diversity were tested using ANOVA. The effect of the gender and socioeconomic status was significant at 0.05 and 0.01 respectively. However, the effect of knowledge on diversity was insignificant on WTP.

Discussion

The majority of the people showed their willingness to contribute in the form of man-days and manure rather than land and cash for pesticides and insecticides. The farmers having less land area were not very enthusiastic about providing land. However, participation as a labourer and providing manure was high because most of the farmers had manpower to work on the farm and kept at least a few livestock. Most farmers were sceptical about providing chemicals as they were not using them themselves or lacked the cash to buy them. There was a trade-off on contribution of labour and land for the conservation of landraces. Those contributing higher man-days were contributing lower land and vice versa.

Table 6. The full model and the best-fitting model of explanatory variables in determining WTP.

Explanatory variables	All variables included in model		Best Fitting model	
	Coefficient	T-values	Coefficient	T-values
Constant	–5.26	–0.73	2.203	0.40
Household size	–0.924	–1.65	–1.17**	–2.25
Age of respondent	0.324**	2.56	0.256**	2.14
Education level	1.337	1.18	–	–
Household income (USD)	$6.4x10^{-4}$	–0.67	–	–
Food sufficiency	0.395	0.80	–	–
Landholdings	10.4***	3.08	11.73***	5.61
Land parcels	–0.416	–1.18	–	–
Number of landraces grown	1.337	0.52	–	–
R^2	0.29		0.26	
N	107		107	

** *P*<0.05 and *** *P*<0.01.

An association of WTP bids was found with household size, age of the respondents, and size of landholdings. Larger households had reduced WTP, which is theoretically unexpected. But the reason could be that the large households need more cultivated land and contribution of land is low which in turn reduces the total individual's WTP for conservation (see Table 5). Most of the older respondents are male, and males are willing to pay more than females (*P*<0.05); this is the reason that older people are willing to pay more than younger ones. Similarly, the reason for women's lower willingness to pay might be that they are not the decision-maker or the household head although they are respondents. It is also obvious that males have a higher WTP due to income and education effects, in the case of developing countries (Horton *et al*. 2003).

The farmers with large landholdings are willing to contribute more to the community genebank for the purpose of conservation of landraces or other genetic resources than farmers with smaller landholdings. This might be because they need a large number of landraces for their diverse land. However, it is also possible that the people with larger landholdings are willing to contribute more because of the social prestige of doing so and also due to their food preferences.

The richer people could provide more land to the community for conservation purposes. They are also the custodian farmers, so they manage more landraces and have greater diversity (Rana *et al.* 2000) and also are willing to contribute for such diversity.

Household income, and the food sufficiency status of the household were not significantly associated with WTP bids. People with high incomes are reluctant to provide either man-days or land, which is inconsistent with the economic theory. However, the empirical results reported by the World Bank (1993) on WTP for quality water supply also do not depend on income. Similarly it has been found by Aldy *et al.* (1999) that the low-income population disproportionately has higher environmental risk than the wealthy or high-income population. The conservation of landraces is therefore more important for those who depend on agriculture and have low income. This might be why income and food sufficiency have no effect on the WTP for landrace conservation.

The farmers' willingness to pay for conservation of landraces is one of the indicators that the community gene-banking approach to conservation is acceptable for *in situ* conservation and there is considerable support from the farmers for such a crop-conservation project managed and implemented through a community. The mean willingness to contribute for conservation of biodiversity in a community genebank (USD 16.75) is higher than for *in situ* conservation at household level (USD 4.18) and *ex situ* conservation (USD 2.20) obtained in the same study by Poudel (2004). This difference could be due to the external nature of the conservation and public access to landraces (no rivalry in consumption nor exclusions), which reduces the WTP for contribution to both *in situ* and *ex situ* conservation. However, it is also possible to overestimate the willingness to pay (Neil *et al.* 1994; Loomis and White 1996; White *et al*. 2001) to continue the '*in situ* conservation project'. There were no protests or zero response although variation of payments range was huge. We assume that the positive response is because of the respondents' familiarity with the project activities and their involvement. If such suspected biases appear in the study, there is future scope to conduct studies taking these issues into consideration.

This study revealed some empirical evidence useful for developing conservation strategies. This is one of the conservation approaches where farmers are willing to contribute more resources compared with other approaches. Design and implementation of an *in situ* community conservation project might reduce the cost of conservation of the local crop genetic diversity.

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Enhancing local germplasm

Jethobudho landrace enhancement I: a participatory method for on-farm management of agrobiodiversity

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Abstract
Participatory landrace enhancement and selection is one of the on-farm management strategies for searching, selecting, maintaining and exchanging economically valued rice varieties. The paper describes an on-farm conservation method used with the locally popular rice landrace *Jethobudho* from middle hills of Nepal. The study aims to find out whether some farmer-preferred economic traits of *Jethobudho* landrace population could be enhanced and also to see whether landraces of economic value could be conserved per se by enhancing some economic traits, and whether community-based seed production system can integrate incentive mechanisms for custodian farmers or a farming community for promoting on-farm conservation. The paper reports the first two research questions whereas the answer to the final question will take more years to verify the hypothesis. The 338 accessions (subpopulations) collected in 1999 from seven popular geographic regions of the *Jethobudho* landrace were screened in on-farm and on-station nurseries and trials in subsequent years. In 2001, 183 accessions were selected but, following screening for postharvest grain quality traits, they were reduced to 46 accessions. A market survey was carried out to establish the most preferred consumer traits of *Jethobudho* and these traits were used for the screening the materials. The major screening criteria used in the germplasm-enhancement programme are for blast disease and lodging tolerance in the field whereas milling, organoleptic and physiochemical analysis are completed in the laboratory. Selection, in the presence of the disease, for relatively shorter plants and better postharvest traits will give a genetic gain for improved *Jethobudho* populations. An incentive mechanism for conservation and exchange of selected population is currently being researched.
Key words: Landraces, farmer participation, on-farm conservation, rice

Introduction
The Convention on Biological Diversity (CBD) has recognized the continued maintenance of traditional varieties *in situ* as an essential component of sustainable agricultural development (FAO 1998). Landraces or farmers' traditional cultivars are important biological resources for resource-poor farmers to ensure sustainable production and improve livelihood options. This is the foundation upon which plant breeding depends for the creation of new varieties and, therefore, landraces have a critical public value for global food security. Farmers' varieties or landraces may contain co-adapted gene complexes that have evolved over decades and are the most valued genetic resources because they provide optional choices for a range of climatic and edaphic stresses (Rao and Sthapit 2002). Agricultural biodiversity is disappearing at an alarming rate owing to the lack of adequate incentives to continue developing and conserving local crop varieties. It is argued that in most developing countries farmers practise *de facto* conservation of landraces as an integral part of their traditional farming systems and have done so for centuries. If landraces are going to be conserved on-farm, it has to happen as a spin-off of farmers' development activities or provide economic incentives for continued cultivation. This means on-farm conservation must be put into a context of farmers' livelihood needs and income (Sthapit and Jarvis 2003).

Landrace enhancement is one of the practical strategies for on-farm management of agricultural biodiversity *in situ* (Worede and Hailu 1993; Bellon *et al.* 2003) and the project aims to investigate: (1) whether landraces of economic value could be conserved per se by enhancing some economic traits, (2) whether genetic gain of some economic traits add value to the landraces and provide economic incentive for farmers, and (3) whether a community-based seed production system can integrate incentive mechanisms for custodian farmers or the farming community for promoting on-farm conservation of landraces.

Materials and methods

Study sites

The study site, Begnas village (600–1250 masl) is situated in the Pokhara valley of the Kaski district, and represents the middle mountain ecosystem of Nepal. It is characterized by a number of lakes, broad alluvial valleys, isolated hills, terraced farming and meandering streams. Farming systems are either rice-based or maize relayed by finger millet systems according to land types and water availability.

The annual rainfall recorded is 3500–4000 mm. A total of 759 households (6070 population) live on about 363 cultivated areas. Surveys indicated that the sample site is deficient in food production and is self-sufficient for only 8 months of the year (Rana 2004).

Baseline survey for understanding varietal richness and distribution

The study site is rich in diversity of rice varieties (Table 1). However, 48 of 69 cultivars are endangered as only a few households are growing them on small areas (Sthapit *et al.* 2001) and have been conserving them *ex situ*. There are nine locally common cultivars in Begnas village and most of them are local except *mansuli* (59 of 206 households). Of 206 sample households (HHs), 43 grow the *Jethobudho* variety, covering about 8.6% of rice area. This variety is being maintained by farmers for its better postharvest quality and relatively competitive straw and paddy yields. In 2004, we administered to 176 households the same rice-related questionnaires used in the baseline study. We analyzed the responses on various parameters recorded in 1999 and 2004 (Table 1).

The comparison of different socioeconomic parameters revealed that 86% of farmers used local rice landraces but the number of landraces decreased by 15 during 1999 to 2004 (Table 1). We found that mostly the upland (*Ghaiya*) landraces have been lost from the sampled households. We observed that the number of common landraces/cultivars has increased from 9 to 15. Interestingly, we found that the area under landraces also increased in 2004; however, the total and mean areas under *Jethobudho* decreased in 2004. Also the number of farmers growing this landrace decreased by 2%. The comparison of the productivity of the enhanced *Jethobudho* shows that enhanced accessions had higher grain yields compared with the highest range of productivity of this landrace in 1999 (Table 1). This indicated that there has been significant genetic gain in the grain yield per unit area in enhanced *Jethobudho*.

We also analyzed the socioeconomic parameters within social strata in the community based on well-being ranking (Table 2). The results suggested that the rich farmers (73% in 1999 and 64% in 2004) mainly grew *Jethobudho* landraces because this landrace requires a regular water supply, highly fertile land and has market potential. In 2004, we noticed that a few more farmers from the poor category also started growing *Jethobudho.* Overall, the mean area of *Jethobudho* decreased in 2004 but the range increased, indicating that a few farmers have increased the area of *Jethobudho* in project villages.

Table 1. Socioeconomic parameters of the study site Begnas village measured in a baseline study in 1999 and compared for 2004.

Socioeconomic parameters for *Jethobudho* rice	Begnas village (baseline year 1999†)	Begnas village (2004‡)
Total number of HHs	941	–
Sample HHs	206	176
Average of all types of cultivable farm (ha)	0.65	–
Average rice farm size (ha)	0.51± 0.3	0.51±02
Average area under landrace (ha)	0.36± 0.02	0.40±0.02
No. of farmers growing landraces (n)	–	152 (86%)
Average area under modern variety (ha)	–	0.25±0.02
No. of farmers growing modern varieties (n)	–	73 (41%)
Average family size (n/HH)	6.5±0.02	–
Farmer-named rice cultivars (n)	63	51
Modern variety (n)	6	15
Total number of rice cultivars (n)	69	65
No. of common cultivars (n)	9	15
No. of rare cultivars (n)	48	50
Productivity of landraces (t/ha)	2.04±0.04	–
Productivity of modern variety (t/ha)	2.75±0.24	–
Productivity of *Jethobudho* (t/ha)	2.4–2.59±0.1	2.83–3.35±0.23 §
Productivity of Mansuli (t/ha)	3.11–3.37±0.2	–
Range of *Jethobudho* area/HH (ha)	0.01–0.24	0.00–.038
Total area of *Jethobudho* (ha)	3.21	1.70
Mean area of *Jethobudho* (ha)	0.11	0.08
Number of farmers growing *Jethobudho* (n)	30 (15%)	22 (13%)

Source: data for 1999 adapted from Rana (2004).
† Number of samples =206.
‡ Number of samples = 176.
§ Productivity of enhanced *Jethobudho* in 2004.
HH = Household.

Table 2. Comparison of socioeconomic parameters for *Jethobudho* between social strata: rich, medium and poor categories in 1999 and 2004.

Socioeconomic parameters for *Jethobudho* (JB) rice	Rich		Medium		Poor	
	1999†	2004‡	1999	2004	1999	2004
No. of farmers growing JB (n)	22 (73%)	14 (64%)	7 (23%)	5 (23%)	1(3%)	3 (14%)
Total area under JB (ha)	2.36	1.24	0.66	0.33	0.24	0.13
Mean area under JB (ha)	0.1	0.09	0.09	0.07	0.24	0.04
Range (ha)	0.01–0.23	0.38–.01	0.02–0.18	0.0–0.18	–	0.01–0.08

Source: data for 1999 adapted from Rana (2004).
† Number of samples =206.
‡ Number of samples = 176.

Rijal *et al.* (2000) reported that rice landraces such as *Bayerni* and *Biramphul*, which are not competitive with either landraces or modern varieties, are grown by a few, richer, resource-endowed households for their high quality. Landraces that are highly competitive with other landraces in terms of yield and postharvest quality traits are reported to be grown by many households in a larger area. Sthapit *et al.* (2001) found that resource-poor farmers in Begnas have allocated a large portion of their rice fields to *Jethobudho* (0.24 ha ±0.11). *Jethobudho* is mostly grown to meet market demand. This landrace is basically sold at the farm gate because of the high market price, which is based on its good cooking qualities.

The understanding of local landrace diversity was accomplished using four-cell analysis where *Jethobudho* landraces (along with others) were identified as high quality and valued landraces for marketing. The positive and negative traits of each of the landraces falling into all four cells were discussed with the farmers and understood. The community interests in improving the landraces were explored and breeding goals were set according to the positive and negative traits analysis.

Setting goals for landrace enhancement

We used four-cell analysis of rice landrace to assess the rice landrace diversity in Kaski valley and also for setting the breeding goals for landrace improvement. The *Jethobudho* landrace is known for its quality and consumers pay a premium price at the farm gate. However, consumers complained about the variability in cooking quality and farmers were not benefitting from growing the quality *Jethobudho* rice. It also has been reported that mill-owners pay a variable price to the *Jethobudho* paddy according to geographic area of cultivation, source of water and use of organic fertilizers. Besides GxE interaction, *Jethobudho* is severely attacked by blast caused by *Pyricularia grisea* both pre- and post-anthesis and is highly prone to lodging (Sthapit *et al.* 2001; Gyawali *et al.* 2003). These biotic and abiotic factors cause low grain yield and poor postharvest qualities in *Jethobudho* landraces. Therefore, farmers consider *Jethobudho* to be niche-specific to Pame, Biruwa and Kundahar and less competitive than modern varieties in other rice-growing *Phants* of the valley. The goal for *Jethobudho* landrace enhancement, therefore, was set by farmers and researchers jointly in 1999 as: blast tolerance, lodging tolerance and superior postharvest quality grain traits.

The technical feasibility of *Jethobudho* landrace enhancement was discussed within the PPB thematic group and at a NMDG meeting. A protocol of *Jethobudho* landrace was developed by the team of breeders.

Collection of *Jethobudho* rice diversity

We collected 338 *Jethobudho* accessions from seven *Phants* of Pokhara valley (Gyawali *et al.* 2003) at the time of maturity. The PPB thematic group consulted expert farmers, consumers and agricultural officers in order to locate habitats or target agroecosystems of *Jethobudho* landraces for collection of accessions in the valley. Seven *Phants* were identified and 338 accessions were collected (Table 3).

Table 3. Collecting sites of *Jethobudho* subpopulation in Kaski in 1999.

Phant **(geographic area and elevation)**	**No. of farmers' plots**	**Perceived value of JB rice based upon consumer demand and price by consumers, miller and rice merchants**
Satmuhane and Malmul (600 m)	50	Average
Sisuwa and Maidi (675 m)	50	Average
Khaste (700 m)	35	Average
Arghun and Rithepani (700 m)	50	Average
Kundhar (775 m), Arba (800 m) and Kamal pokhari (800 m)	50	Good
Buruwa (850 m)	51	Very good
Fewa (900 m)	52	Excellent

Local knowledgeable persons or custodians of *Jethobudho* were involved in accession collection during transact sampling. To capture distinct variation, we used client-preferred traits—aroma, more effective tillers, longer panicle length, dense grain-setting, free from leaf and neck blast, and non-lodging. We randomly selected five panicles each from *Jethobudho* populations of 338 farmers' fields in seven *Phants* (rice production area) (Figure 1). We threshed five panicles from any one household and bulked the seed together and marked it as an accession. Each accession was divided into three bulks and numbered. From each bulk, the blast screening and observation nurseries were established in ARS *Malepatan* (850 m asl) whereas on-farm trials were conducted in *Malmul* (600 m) and *Fewa Phant* (900 m) in 2000.

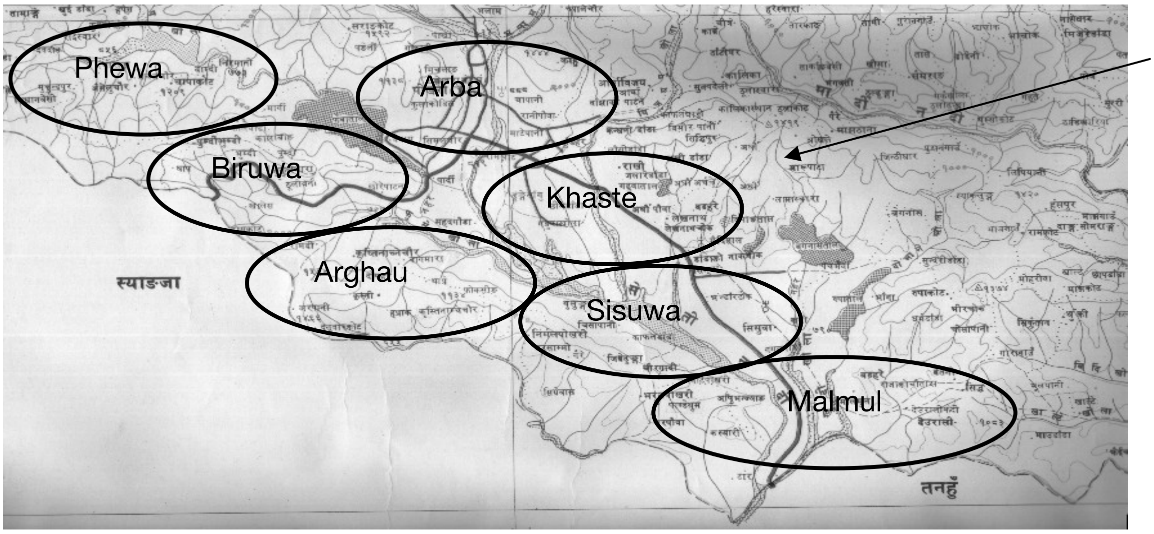

Figure 1. Metapopulation of *Jethobudho* landraces collected from seven *Phants* of Kaski valley in Nepal for landrace enhancement activity in 1999.

Diversity assessment of *Jethobudho* accessions

On-farm observation nurseries were established to assess the diversity of *Jethobudho* accessions for various agronomic and postharvest quality traits. Gyawali *et al.* 2003 explained the process of diversity assessment of *Jethobudho* landrace accessions for enhancement. We observed higher variation in terms of disease (blast) and lodging tolerance, tillering capacity (see p. 172) and various postharvest quality traits (see p. 179). The results of diversity assessment suggested potential traits where breeders can make progress during enhancement.

Understanding quality traits of *Jethobudho* from market survey

Postharvest quality of rice is a complex trait and before screening of germplasm, an understanding of the postharvest quality traits was extremely important in *Jethobudho* landrace enhancement since these traits were used as criteria for screening accessions. We conducted a survey to understand the most important quality traits of *Jethobudho* rice perceived by 60 respondent including farmers, housewives, cooks from hotels, and rice millers in the valley. The analysis of postharvest quality traits using diverse clients helped scientists set the criteria for screening a very large number of accessions. Very interestingly, softness was found to be the most important quality trait in *Jethobudho* as perceived by the respondents, followed by taste, separateness and aroma (see p. 179). Once the postharvest quality traits (micromilling and organoleptic characters) were understood, these traits were used for screening and selection of desired accessions.

Evaluation and screening of *Jethobudho* accessions disease and lodging tolerance

The *Jethobudho* accessions were rigorously screened for leaf and neck blast and lodging tolerance (see p. 172). The accessions were exposed to the natural inoculum pressure of blast caused by *Pyricularia grisea* in the field since 2000. The blast infection was scored on a 0 to 5 scale for leaf and neck blast (Table 4) using the Standard Evaluation System for Rice (IRRI 1996). Accessions scoring more than 2 were rejected for further evaluation.

Table 4. Resistance and susceptibility class based on disease severity or incidence (IRRI 1996).

Disease index value	Severity or incidence	Resistance/susceptible class
0	Immune reaction	Highly resistant
1	Less than 1%	Resistant
2	2–5%	Moderately resistant
3	6–25%	Moderately susceptible
4	26–50%	Susceptible
5	51–100%	Highly susceptible

Similarly we used a lodging tolerance index to screen collected accessions. The trials were conducted under farmers' management conditions and in lodging-prone areas. We also tested the materials under a high-fertility condition to screen the lodging tolerance where farmers experienced lodging of *Jethobudho* every year. Lodging tolerance was assessed on a 0 to 5 scale, depending upon the severity of lodged plants in the plot (Table 5). The lodging tolerance was also verified by the culm strength measured qualitatively.

Table 5. Tolerance to lodging class based on lodging severity adopted for evaluation of *Jethobudho* accessions (IRRI 1996).

Lodging index value	Severity of lodging	Resistance/susceptible class
0	Highly resistant to lodge	Highly resistant to lodging
1	Less than 1% lodged	Resistant
2	2–5% lodged	Tolerant to lodging
3	6–25% lodged	Moderately lodging prone
4	26–50% lodged	Lodging prone
5	51–100% lodged	Highly lodging prone

Participatory on-farm agronomic evaluation

On-farm agronomic evaluations of *Jethobudho* accessions were conducted in both farmers' fields in Malmul and Pame, and on-station at the Agricultural Research Station (ARS), Malepatan during 2001–2004 (see p. 172). Various agronomic traits such as yield and yield components, disease, aroma and grain characters were studied. We selected for shorter plant height, higher effective tillering, longer panicle length, higher test weight and grain yield. The aroma and other grain characters were evaluated and best accessions were selected for these farmers' preferred traits. During the process of selection in the field, farmers were invited to the on-farm trials during maturity to identify the preferred accessions especially based on panicle types and grain characters. We measured the qualitative and quantitative traits of various agronomic traits, analyzed the data using statistical tools and selected the best accessions for further evaluation for quality traits (see p. 179).

Evaluation of postharvest quality traits

Since the value of *Jethobudho* rice is primarily determined by the quality trait, we used postharvest quality traits to screen the large number of *Jethobudho* accessions (see p. 179). Among postharvest quality traits, physical appearances (grain type and colour), milling traits (milling recovery, head rice recovery, broken rice) and organoleptic test (aroma, cooking and eating qualities) were used as criteria for screening the material. We developed a laboratory method for screening a large number of *Jethobudho* accessions using physical, milling and organoleptic tests for postharvest quality traits. These accessions also were screened based on the standard physiochemical analysis (gel consistency, volume expansion, water absorptions and amylase contents). The selected accessions were further evaluated for farmers' acceptance on postharvest quality traits in participatory variety selection. We analyzed farmers' perception using household-level questionnaires. We found that the enhanced *Jethobudho* accessions were highly accepted for various quality traits by >80% of farmers (see p. 179) against farmers' own saved *Jethobudho* grain and culinary traits.

Participatory variety selection

We conducted participatory variety selection (PVS) of enhanced *Jethobudho* accessions involving farmers from the valley in 2003 and 2004. The feedback from PVS of *Jethobudho* revealed that the enhanced materials were accepted by the collaborative farmers. The seed-saving and sharing of seed with neighbouring farmers in 2003 indicated that the enhanced materials were perceived to be superior to the farmers' own saved seed. We found a greater interest of the District Agriculture Development Office (DADO), Kaski in scaling-up of enhanced *Jethobudho* through PVS. Therefore, in 2004, DADO and its network in the district were involved in the PVS process right from planning and implementation through to evaluation.

Community-based variety production

Farmers' access to seed, especially of landraces, is considered the major constraint in landrace enhancement and scaling-up. It is important to understand the ways in which farmers produce, select, save and acquire seeds and the properties of a healthy seed system (Hodgkin 2004). In Nepal, the formal seed sector contributes less than 1% of the total demand for rice seed (Singh 2003). Therefore, community-based seed production of enhanced *Jethobudho* accession was initiated in the valley to provide a regular supply of seed in future. The custodian farmers were involved in production of the first generation (foundation seed), following enhancement of their skills in panicle selection, purity and germination testing.

Thereafter, farmer-breeders will be responsible for supplying breeder seed to Community Based Seed Production (CBSP) groups and will be linked to the District Seed Self-sufficiency Program (DISSPRO) of DADO, Kaski. The custodian farmers (farmer-breeders) initiated the breeder seed production in 2004 with technical support from the PPB thematic group of the *in situ* conservation project. The community-based seed-producer groups will be involved in marketing of truthfully labelled seed of enhanced *Jethobudho* in future.

Developing options for incentive mechanisms for custodian farmers

We traced back the custodian farmers who have maintained very high-quality *Jethobudho* accessions on-farm for many years. Out of 338 accessions collected, six accessions from *Fewa, Biruwa* and *Sisuwa Phants* (Table 6) were found to be excellent in terms of various agronomic, post-harvest quality and market traits.

There is a general perception among the custodian farmers that they need to be paid for their high-quality *Jethobudho*. In some cases, these custodian farmers are fetching higher market value for quality traits in their *Jethobudho* such as milling and head rice recovery, aroma and organoleptic traits. The PVS and community-based seed production is trying to link and establish a marketing mechanism to distinguish the incentives between high- versus poor-quality *Jethobudho*. Rice millers, traders, seed-producer groups and farmers were brought together to discuss the willingness of rice millers and traders to pay for the higher postharvest quality traits. It was interesting that millers and traders were ready to pay a higher price if the quality of *Jethobudho* is ensured. Therefore, it is realized that community-based seed production needs to be linked with marketing of enhanced *Jethobudho* to ensure the market quality as well as market incentives to the custodian farmers.

It has been suggested that the enhanced accessions should be proposed for variety release. Therefore, one of the recognitions for custodian farmers would be non-monitory incentives such as recognizing custodian farmers' contribution in maintaining high-quality *Jethobudho* landraces on-farm during *Jethobudho* landrace release. Another incentive is the linkage of custodian farmers as breeder-farmers to the community-based seed production so that they will regularly supply the high quality of seed with premium price in the future.

Table 6. Names of the custodian farmers of *Jethobudho* and respective accessions scaled up in landrace enhancement in *in sit*u activity in 2004.

Source of materials (farmer)	Address	Accessions (subpopulation)
Dhan Bdr. Karki	Lekhnath Phalame Dhab–Sisuwa	JB–T–010–025/5
Meghnath Subedi	Lekhnath–8, Sisuwa	JB–T–023–030/25
Ganga Giri	Kaskikot–7, Pame, Fewa	JB–T–103–237/12
Man Bdr. Sunar	Kaskikot–6, Pame, Fewa	JB–T–105–238/5
Kedar Pd. Kafle	Pokhara–17 Powerhouse, Biruwa	JB–T–147–296/6
Bhim Pd. Baral	Pokhara–7, Maswar, Biruwa	JB–T–168–316/3

Jethobudho landraces are native to the Pokhara valley. In recent years, this landrace has spread to other districts such as Syangja, Chitwan and Gulmi through PVS programmes conducted by LI-BIRD. However, the *Jethobudho* grown in cold-water sources from Pokhara valley is considered to be the best in quality. One of the strategies for securing market incentives for the farmers of Pokhara valley would be the protection of this landrace through the Geographic Indicator. However, at present, we lack a national policy on IPR through geographic indicators but in future it would be an important option for creating market incentives for the farmers of Pokhara valley. The *in situ* conservation thematic group as well as the GRPI group have been contributing to policy framework in this regard.

Community-level seed production for a landrace-enhancement programme (*Jethobudho, Basmati, Anadi, Pahele, Jhinuwa and Kariya Kamod*) would be realized. Those farmers that have been involved with the testing of landrace enhancement and/or PPB varieties would be selected to produce seed for wider dissemination. This scheme is expected to work as an incentive for farmers to participate in such a programme since seed can be sold at a higher price than grain. With increased seed varieties and amounts of seed available, the diffusion bottleneck arising due to limited seed would be overcome. Likewise, those farmers that contributed to landrace conservation would benefit from seed production and sales, in the initial phase. The current case study can be used as a reference to develop incentive mechanisms for farmers, and for sharing the benefits of their knowledge and genetic resources. This will assist greatly in demonstrating to policy-makers and the community how on-farm conservation would provide social and economic benefits for the people.

Impact of germplasm enhancement on social, economic and environmental benefits to society

The *Jethobudho* landrace has been reported to be grown by a large number of farmers in Pokhara valley compared with other landraces owing to its very high value in the market. This indicates that the majority of the farmers grow this landraces as a cash crop because the large volume of *Jethobudho* produced by small- and medium-scale farmers fetches a premium price. For these farmers, *Jethobudho* has been contributing to their livelihood. In this context, the enhanced *Jethobudho* would contribute to the livelihood of the small peasant farmers if the enhanced accessions could be scaled-up in a wider area in the valley.

It has been a challenge to the breeders to deploy more uniform and high-quality enhanced *Jethobudho* on one hand and to maintain the genetic diversity on-farm through deployment of enhanced materials on the other hand. The current *Jethobudho* enhancement is the best accessions collected from six different locations. Therefore, these accessions carry a considerable amount of variation among them at the genetic level and still maintain varietal diversity at the on-farm level.

Landrace enhancement is not new to Nepal but the current landrace-enhancement research is a systematic one in terms of consolidating the clients' knowledge and skills for enhancement. Similarly, the current enhancement activities have tried to link the production-to-consumer chain through research and development. In this work, we have tried to address the issues related to seed regulatory framework for landraces, release of enhanced *Jethobudho* per se, securing the benefits for custodian farmers, developing market incentives for farmers, farmers' rights and geographic indicators. Therefore, we consider this is a policy contribution in terms of genetic resource management on-farm.

Discussion

As mentioned earlier, landrace enhancement is one of the participatory plant breeding options to add values to the landraces through selection from several subpopulations of *Jethobudho* landrace. The project has carried out simple plant breeding with the objective of exploring valuable economic traits from existing local crop diversity. The involvement of the client in the process of locating, assessing and using existing landrace diversity is of prime importance in such initiatives. The process helped scientists in understanding the positive and negative traits, set breeding goals and shape the research methodologies. Different stakeholders such as farmers, rice millers, traders, housewives, scientists and extensionists were involved in understanding *Jethobudho* landrace diversity and shaping research methodologies and scaling-up approaches. Four-cell analysis of local rice diversity revealed that the *Jethobudho* landrace has been maintained by a fairly high number of farmers in large plots because of its market demand. This market demand is associated with the cooking quality of *Jethobudho* rice and its aroma. However, consumers and traders reported that variable quality is one of the problems to be addressed in developing an incentive mechanism for growers of good-quality *Jethobudho*. This kind of problem is associated with several reasons. There must be: (1) inherient genetic variation for quality traits, (2) interaction between GxE for quality traits, (3) no systematic source of quality seed, (4) no formal seed multiplication and marketing system, (5) no mixing of *Jethobudho* paddy by traders, and (5) no adulteration of quality rice with similar-looking, poor-quality rice.

The project hypothesized that there are genetic variations for quality traits, that germplasm can be enhanced from the existing populations collected from farmers' fields, and that the products could be conserved if economic incentive is built. Also it is hypothesized that value-addition to *Jethobudho* landrace could be achieved through the community producing quality seed, and marketing it to traders, millers and owners through better packaging and quality-control systems. The results discussed above suggest that economically valuable populations could be screened from the metapopulations of the common rice landraces and that the community and custodians of the landrace could benefit from value-addition work (see p. 179).

We have to critically evaluate the contribution of landrace enhancement to establish the link between value-addition initiatives, genetic diversity conservation on-farm and rural livelihoods. So far, value-addition initiatives have been much talked about and promoted in the belief that they make a positive contribution to rural livelihoods and, in turn, enhance on-farm conservation. It is, therefore, necessary to verify this hypothesis at this point. The evaluation exercise could also indicate that issues—such as scale of operation and choice of crops/varieties—be included in the value-addition scheme so that they make tangible contributions to genetic diversity conservation on-farm. We can monitor the impact of a few specific examples of *Jethobudho* populations (seed) marketing on the local crop diversity.

The recognition of custodian farmers is a challenge to the project team. The project team has initiated several options to increase the monetary and non-monitory incentives to custodian farmers. Similarly, the geographical indicator for enhanced *Jethobudho* has been proposed to protect the market incentive to the farmers of Pokhara valley. The breeder seed production, linking breeder seed production to DISSPRO and creating market outlets for enhanced accessions have been seen as important incentives by the farmers. The willingness of rice millers and traders to pay for high-quality *Jethobudho* would help increase the monitory incentives to the farmers. The project also intends to initiate work on farmers' rights of products developed by germplasm enhancement or PPB products and establish ownership over selected indigenous crop varieties such as *Jethobudho* and *Basaune Ghiraula* through a *sui generis* system or other intellectual property rights (IPR) regimes.

Conclusions

We conclude that the landrace-enhancement activities could add values to the local crop varieties as a strategy for on-farm management of agrobiodiversity. The assessment of landrace enhancement for improvement needs critical analysis of the traits in landraces through working with diverse stakeholders such as farmers, extensionists, researchers, millers, merchants and consumers. The diversity assessment is the first prerequisite for such enhancement activities. On-farm evaluation of accessions and use of micro-milling and organoleptic quality traits in *Jethobudho* has not only broadened the breeders' understanding of landrace-enhancement initiatives, but also has helped in screening the best accessions to identify superior landrace accessions for quick scaling-up through PVS, community-based seed production, creating market incentives and developing mechanisms for equitable sharing of benefits harvested due to the use of local landraces. The consumer preference analysis for quality traits served as an important criterion for selection of quality accessions for scaling-up. We developed and used participatory evaluation methods for agronomic traits and milling, and organoleptic and laboratory tests for quality rices. The custodian farmers played an important role in scaling-up and dissemination of enhanced accessions quickly through the PVS and community-based seed production. This has been seen as a strategy to develop market incentives for the custodian farmers through the production and marketing of quality seed. Creating market incentives and sharing benefits arising from the use of enhanced *Jethobudho* to the custodian farmers and farming community of Pokhara valley has been the challenge for the PPB team. Thus, the *in situ* team has envisioned influencing the policy for creating and establishing mechanisms for the geographic indicator and IPR-related issues in future.

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Jethobudho landrace enhancement II: a participatory evaluation of agronomic traits

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Abstract

Jethobudho deserves special importance for its superior grain qualities, and therefore fetches a premium price in the local market of Pokhara valley. However, this landrace lodges severely and is susceptible to neck blast (*Pyricularia grisea*) which results in lower grain yield and poor grain qualities. The current study was conducted to assess the existing diversity and evaluate various agronomic traits of 338 *Jethobudho* accessions collected from farmers' fields in seven *phants* (rice-growing areas) in Pokhara valley in 1999. In 2001, we selected 183 of the 338 accessions on the basis of tolerance to leaf and neck blast, tolerance to lodging, plant height (150 cm) and longer panicle length. In 2002, 46 out of 183 accessions were selected and evaluated in on-farm replicated trials in two locations for leaf and neck blast tolerance, yield and yield components, and postharvest quality traits. Screening of these accessions in 2003 resulted in identification of six high-yielding accessions with tolerance to leaf and neck blast, tolerance to lodging and with superior grain qualities; these were compared with a bulk of the 30 best accessions of *Jethobudho*. These six landraces had similar phenotypic and agromorphological characteristics, and superior grain quality traits, and could be scaled-up as improved *Jethobudho*.

Key words: Accessions, agronomic traits, postharvest quality traits, *Jethobudho*, landrace enhancement, on-farm, rice

Introduction

The project on "Strengthening the scientific basis of *in situ* crop conservation" initiated many studies on on-farm conservation of agrobiodiversity through participatory research. The enhancement of local landraces of rice was one of the research activities started with *Jethobudho* and *Ramani* in Kaski (668–1200 masl) and *Kariya Kamod* and *Lalka* Basmati in Bara (80–90 masl) districts of Nepal. Participatory plant breeding (PPB) has been proposed as a strategy to conserve useful genes through inclusion of these landraces as one of the parents in breeding programme (Gyawali *et al.* 2002; Sthapit *et al.* 2001, 2002). However, farmers prefer to grow landraces rather than modern varieties for their certain superior traits with disease resistance, adaptation to marginal environments and excellent postharvest grain quality. These traits make the landraces competitive with the modern varieties and therefore they are likely to be conserved and utilized by the local community from generation to generation.

Kaski enjoys many landraces with varied names and diverse useful traits (Rijal *et al*. 1998). *Jethobudho, Bayerni, Biramful* and *Panhele* are the landraces superior to modern varieties in postharvest quality traits[23]. *Jethobudho* is a widely grown aromatic landrace in Pokhara valley which is known for its high value for postharvest quality traits and good market potential (Sthapit *et al.* 2002). However, *Jethobudho* lodges under high-fertility conditions and is severely susceptible to blast (*Pyricularia oryzea*). Therefore, the *in situ* conservation of agrobiodiversity project initiated *Jethobudho* enhancement activities in 1999 in order to improve the tolerance of this landrace to blast and lodging, and to select for higher grain yield and superior postharvest grain-quality traits through participatory selection on-farm. This paper therefore describes the process of assessing *Jethobudho* landrace accessions for various agronomic traits and the scope of enhancement of the landrace though participatory selection on-farm.

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[23] Postharvest quality traits means the physical and chemical properties of grain which includes micromilling, organoleptic properties and market price.

Materials and methods

In a Focus Group Discussion (FGD) conducted in 1999, farmers reported that neck blast caused by *P. grisea* and lodging were the two major problems associated with low grain yield of *Jethobudho* in the valley. Therefore, the PPB thematic group and farming community of the *in situ* conservation project undertook *Jethobudho* landrace enhancement activity in 1999 to improve the traits.

We selected seven rice-growing *phants* of Pokhara valley for the collection of *Jethobudho* landrace accessions (Table 1). In total, 338 accessions of *Jethobudho* from these seven *Phants* were collected for enhancement through a participatory plant breeding approach. For this purpose, we selected five panicles each from 338 farmers' field households in seven *Phants*. The selected panicles were free of neck blast and tolerant to lodging with a strong culm at the time of harvest. The information on farmers' name, location, soil type and grain characters—awn/awnless and aroma—was recorded during the collection. We threshed all five panicles, bulked the seed and marked it as an accession. Each accession was divided into three bulks and each bulk was established for the blast screening and observation nursery in Agricultural Research Station (ARS), Malepatan and on-farm observation nurseries in Malmul (600 masl) and Fewa *phant* (900 masl). The plot size was 1.5 × 1 m with 20 × 10 cm spacing in Malepatan. Observations on agronomic traits (tillering, plant height, yield, and yield components, blast, lodging and grain characters) were recorded by sampling 30 plants from each accession. Neck blast and lodging were scored on a 1 to 5 scale. The observation nursery in Malmul *phant* was severely damaged by a hailstorm and observations could not be recorded. We rejected 29 accessions because of severe blast infection in the trials. Means and standard deviations were estimated based on the samples to assess the agronomic performance of each accession.

Table 1. The site and number of *Jethobudho* accessions collected for landrace enhancement study in Pokhara valley in 1999.

***Phant* (geographic area)**	**No. of farmers' plots**	**Perceived value of JB rice based upon consumer demand and price by consumers, miller and rice merchants**
Satmuhane and Malmul (600 m)	50	Average
Sisuwa and Maidi (675 m)	50	Average
Khaste (700 m)	35	Average
Arghun and Rithepani (700 m)	50	Average
Kundhar (775 m), Arba (800 m) and Kamal Pokhari (800 m)	50	Good
Buruwa (850 m)	51	Very good
Fewa (900 m)	52	Excellent

In 2000, the PPB team conducted on-farm participatory trials on *Jethobudho* enhancement in Malmul (Kholakochheu), Fewa *phants* and Agriculture Research Station (ARS), Malepatan, Kaski. One hundred and eighty-three accessions—ranked as neck blast tolerant under natural inoculum pressure, lodging tolerant in farmers' management conditions, and with plant height shorter than 150 cm—were selected in the 2000 rice-growing season. The PPB team evaluated the selected 183 accessions in ARS Malepatan, and on farmers' fields in Fewa *Phant* in 2001. Out of 183 accessions, 143 accessions were evaluated for postharvest physical and chemical quality traits of grain in the Central Food Laboratory of NARC and at LI-BIRD's Laboratory in Pokhara in 2002. On the basis of qualitative and quantitative measurement of agronomic and postharvest quality traits, 46 superior accessions were selected for the multilocation replicated yield trials.

We evaluated 46 selected accessions in two locations (Malmul and ARS, Malepatan) using a replicated complete block design (RCBD) with three replications in each location (Table 2).

Table 2. Accessions, farmers and *phant* from where *Jethobudho* accessions were selected for landrace enhancement in Pokhara valley in 2002.

Entry no.	Accession	Hill	Farmer	*Phant*	Remark
1	JB–T–001–020/6	6	Ms Maya Poydel	Sisuwa	
2	JB–T–005–022/8	8	Mr EK Raj Baral	Sisuwa	
3	JB–T–006–022/9	9	Mr EK Raj Baral	Sisuwa	
4	JB–T–007–022/23	23	Mr EK Raj Baral	Sisuwa	
5	JB–T–008–024/1	1	Mr Narayan Datta Subedi	Sisuwa	
6	JB–T–009–025/1	1	Mr Dhan Bd. Karki	Sisuwa	
7	JB–T–010–025/5	5	Mr Dhan Bd. Karki †	Sisuwa	Selected
8	JB–T–011–025/9	9	Mr Dhan Bd. Karki	Sisuwa	
9	JB–T–017–030/11	11	Mr Megh Nath Subedi	Sisuwa	
10	JB–T–021–030/20	20	Mr Megh Nath Subedi	Sisuwa	
11	JB–T–023–030/25	25	Mr Megh Nath Subedi †	Sisuwa	Selected
12	JB–T–028–050/18	18	Mr Surya Dhakal	Sisuwa	
13	JB–T–029–050/27	27	Mr Surya Dhakal	Sisuwa	
14	JB–T–031–062/2	2	Mr Ganesh Adhikari	Arghaun	
15	JB–T–035–062/15	15	Mr Ganesh Adhikari	Arghaun	
16	JB–T–036–062/17	17	Mr Ganesh Adhikari	Arghaun	
17	JB–T–041–065/1	1	Ms Gauri KC	Arghaun	
18	JB–T–042–065/15	15	Ms Gauri KC	Arghaun	
19	JB–T–046–072/5	5	Mr Min Bd. GC	Arghaun	
20	JB–T–048–072/17	17	Mr Min Bd. GC	Arghaun	
21	JB–T–052–083/9	9	Mr Bishnu Khatri	Arghaun	
22	JB–T–056—118/1	1	Mr Tej Bd. Bhujel	Khaste	
23	JB–T–063–121/11	11	Mr Budhi Bd. Ranabhat	Khaste	
24	JB–T–067–121/23	23	Mr Budhi Bd. Ranabhat	Khaste	
25	JB–T–071–133/4	4	Mr Bhim Pani Baral	Khaste	
26	JB T–072–133/5	5	Mr Bhim Pani Baral	Khaste	
27	JB–T–073–133/10	10	Mr Bhim Pani Baral	Khaste	
28	JB–T–076–133/15	15	Mr Bhim Pani Baral	Khaste	
29	JB–T–093–175/4	4	Ms Bhimmaya Sunar	Malmul	
30	JB–T–103–237/12	12	Mr Gagan Giri †	Fewa	Selected
31	JB–T–105–238/5	5	Mr Man Bd. Sunar †	Fewa	Selected
32	JB–T–110–238/30	30	Mr Man Bd. Sunar	Fewa	
33	JB–T–112–240/5	5	Mr Karan Bd. Kahtri	Fewa	
34	JB–T–115–259/13	13	Mr Pashupati Timilsina	Fewa	
35	JB–T–117–262/16	16	Mr Ganesh Pd. Pahadi	Fewa	
36	JB–T–118–262/12	12	Mr Ganesh Pd. Pahadi	Fewa	
37	JB–T–137–283/8	8	Mr Dipendra Thapa	Fewa	
38	JB–T–147–296/6	6	Mr Kedar Pd. Kafle †	Biruwa	Selected
39	JB–T–149–296/12	12	Mr Kedar Pd. Kafle	Biruwa	
40	JB–T–151–296/16	16	Mr Kedar Pd. Kafle	Biruwa	
41	JB–T–167–314/24	24	Mr Dilli Ram Baral	Biruwa	
42	JB–T–168–316/3	3	Mr Bim Pd. Baral †	Biruwa	Selected
43	JB–T–170–319/2	2	Mr Kedar Baral	Biruwa	
44	JB–T–178–319/19	19	Mr Kedar Baral	Biruwa	
45	JB–T–182–336/6	6	Mr Bashudev Baral	Biruwa	
46	JB–T–183–336/30	30	Mr Bashudev Baral	Biruwa	

† Accessions selected for PVS and further scaling-up.

The plot size was 2 × 1 m. Plant height, tillers/hill, culm strength, panicle length, grains/panicle, test weight, grain yield, leaf and neck blast tolerance, and lodging tolerance were measured at different growth stages of the crop. The analysis of variance (ANOVA) and Duncan's Multiple Range Test (DMRT) were employed to compare variances and means of 46 accessions using MINITAB Release 12.21 and MSTATC. We rejected 16 accessions that were poor in agronomic characters, and with higher incidence of neck blast in the field conditions and the remaining 30 superior accessions were further screened for postharvest quality traits.

Six best-performing accessions (out of 30 superior accessions) were selected with high yield, tolerance to neck blast and lodging; they were also superior for physiochemical, milling and organoleptic traits. We rejected the accessions scoring more than 2 for neck blast, scoring less than 400 in postharvest traits, yielding less grain yield and other yield components. Further, a modified bulk of superior 30 accessions was made by mixing 50 g of seed from each accession together to evaluate variable bulks. In 2003, the selected six accessions and modified bulk were evaluated in replicated yield trials in three locations: Malmul and Fewa *phant* (on-farm) and ARS Malepatan (on-station). A randomized complete block design was employed to evaluate the selected *Jethobudho* accessions including modified bulk in 3 × 3 m plots with three replications in each location. Agronomic characters and farmers' preference on selected accessions and a modified bulk were recorded. The trial in ARS Malepatan was severely damaged by large ruminants. Therefore only the observations from on-farm trials and data were analyzed using ANOVA and means of various traits were compared using Fisher's Protected Least Significance Difference (FLSD). These six accessions were used for further evaluation in PVS trials in 2004.

Results and discussion

Observation nursery in 2000

We found variations in agronomic traits among *Jethobudho* landrace accessions (Gyawali *et al.* 2003). The average plant height was 160 cm with 5 tillers/hill. Tillering capacity of accessions collected from Malmul *phant* was very high (8 tillers/hill) compared with accessions from other *phants*. The average panicle length was 27 cm whereas the grain weight/panicle was 2.6 g, and average 100-grain weight was 1.9 g for 338 accessions. It was interesting to note that the grain weight/panicle and 100-grain weight were high for accessions from Fewa and Biruwa *phants.* Similarly the accessions collected from Fewa and Biruwa *phants* were more tolerant to blast severity than the others. We also observed that the grain characters—especially grain length, width and awning—were variable among these accessions. Given these agronomic performances, we selected 183 accessions in the observation nursery 2000.

Evaluation in 2002

The *Jethobudho* accessions from cold-water sources were found superior to those of other *phants* (Gyawali *et al.* 2003). The plant height, tillers/hill and test weight were significantly varied in different locations (Tables 3 and 4). Similarly the interaction of *Jethobudho* landraces and locations were significant for number of grains/panicle, awn and neck blast. The accessions that had long awns and high scores for neck blast were rejected. The evaluation of the best six accessions selected from 46 in 2002 and one bulk composed of 30 best landraces accessions revealed that there was variation in blast tolerance. The selected accessions scored less than 2 for neck blast. Blast infections were higher in on-farm trails than in the trials at ARS, Malepatan. This could be due to the higher natural inoculum pressure in farmers' fields than at ARS and that the situation facilitated the screening of neck blast tolerant accessions. We pooled the data from ARS and on-farm and performed the pooled analysis because *Jethobudho*-by-location interaction was non-significant for major agronomic traits of stakeholder interest such as grain yield, neck blast and lodging tolerance.

Table 3. Mean squares of various agronomic traits combined over locations of *Jethobudho* enhancement in Malmul and ARS Malepatan, Pokhara, 2002.

Source of variation	df	Plant height (cm)	Tiller	Panicle length (cm)	No. of grains/panicle	Test weight (g)	Grain yield (t/ha)
Location (L)	1	34433.76**	28.37**	7.902	147.59	106.81**	57.16
Error (a)	4	77.59	0.067	4.939	924.78	2.73	11.61
Jethobudho (JB)	45	67.86	0.701	3.126**	307.53**	3.31**	0.44
JB × L	45	56.52	1.138	0.906	288.24**	1.42	0.57
Error (b)	180	53.93	0.832	0.775	159.73	1.44	0.46

** Significant at 0.01 probability level.

Table 4. Mean squares of various agronomic traits combined over locations of *Jethobudho* enhancement in Malmul and ARS Malepatan, Pokhara, 2002.

Source of variation	df	Awn	Leaf blast	Neck blast	Lodging tolerance	Culm strength
Location (L)	1	109.69	4.960	0.023	2.001	0.178
Error (a)	4	28.08	1.601	4.407	6.191	1.895
Jethobudho (JB)	45	13.20**	0.124	0.845*	1.941	0.778**
JB x L	45	12.54**	0.123	0.800*	0.808	0.348
Error (b)	180	6.57	0.135	0.546	0.547	0.250

**,* Significant at 0.01 and 0.05 probability level, respectively.

Evaluation in 2003

In 2003, we selected the six superior accessions out of 46 which were tolerant to blast (leaf and neck), tolerant to lodging with high culm strength, high grain yield and yield components, and superior postharvest quality traits. In a comparison of 6 accessions with the modified bulk of 30 accessions, the Jethobudho accessions were non-significant for most agronomic traits observed but were significant for neck blast and sterile number of grains/panicle (Tables 5 and 6). FLSD revealed that the scores of neck blast for all of the accessions were very low (<2) (Tables 7 and 8). The infection of neck blast was frequent in accessions collected from cold water whereas the sterile grains/panicle was lower in these accessions.

The current *Jethobudho* landrace enhancement activities suggest that the landraces could be enhanced on-farm through participatory evaluation and selection. The diversity assessment of agronomic trait is an essential and important process in enhancement activities to advance the improvement in these landraces. Significant improvements have been made for lodging tolerance, leaf and neck blast tolerance. The six selected *Jethobudho* accessions, however, were non-significant for most of the agronomic traits. The joint monitoring team involving scientists, extensionists and farmers suggested making a modified bulk of the accessions based on maturity. The PPB thematic groups of the *in situ* project also suggested bulking selected *Jethobudho* accessions based on similarity of agromorphological characters as well to maintain the diversity of the selected bulks.

Table 5. Mean square of various agronomic traits measured in *Jethobudho* landrace enhancement trial in Malmul, 2003.

Source of variation	df	Plant height (cm)	Tiller	Panicle length (cm)	Grains/ panicle	Grain yield (t/ha)	Straw yield (t/ha)	Neck blast	Sterile grains/ panicle	Culm strength
Replication	2	1498.8	2.00	5.182	2.40	1.40	25.66	0.19	55.19	25.19
Treatment	6	23.5 ns	1.01 ns	0.687 ns	145.3ns	0.155 ns	1.76 ns	1.222**	13.98*	0.41 ns
Error	12	23.23	0.37	0.282	108.0	0.24	1.91	0.079	4.7	0.41

**, * Significant at 0.01 and 0.05 probability level; ns = non significant

Table 6. Mean square of various agronomic traits measured in *Jethobudho* landrace enhancement trial in Fewa, 2003.

Source of variation	df	Plant height (cm)	Tiller	Panicle length (cm)	Grains/ panicle	Grain yield (t/ha)	Straw yield (t/ha)	Neck blast	Sterile grains/ panicle	Culm strength
Replication	2	46.58	0.184	0.47	205.3	0.571	44.71	0.047	5.61	0
Treatment	6	32.25 ns	0.559*	0.817 ns	389.8 ns	0.021ns	3.91 ns	0.19 *	1.86 ns	0
Error	12	12.88	0.147	0.703	195.3	0.096	2.79	0.047	2.28	0

* Significant at 0.05 probability level; ns = non-significant.

Table 7. Mean of agronomic characters measured in *Jethobudho* landrace enhancement trial in Malmul, 2003.

Source of *Jethobudho* landrace	Plant height (cm)	Tiller	Panicle length (cm)	Grains/ panicle	Grain yield (t/ha)	Straw yield (t/ha)	Neck blast	Sterile grains/ panicle	Culm strength
Dhan Bdr. Karki, Maidi	178.4	7.0	24.8	111.6	2.95	13.41	0.66	12.6	2.33
Meghnath Subedi, Sisuwa	171.5	6.4	25.13	129.7	2.96	12.9	0.66	16.3	2.33
Ganga Giri, Fewa	174.3	7.3	26.27	121.5	3.35	14.0	1.00	13.3	2.00
Man Bdr. Sunar, Fewa	178.1	6.8	25.33	131.1	3.40	14.6	2.00	13.3	1.33
Kedar Pd. Kafle, Biruwa	177.5	7.9	25.53	116.7	2.83	12.7	2.00	10.0	2.33
Bhim Pd. Baral, Biruwa	179.4	6.4	25.87	120.7	2.87	12.7	1.00	12.6	2.00
Bulk of 30 landraces	175.3	6.4	25.47	118.3	3.07	12.7	2.00	16.0	2.33
LSD at *0.05* probability	8.58	1.08	0.94	18.4	0.88	2.46	0.50	3.57	1.14
CV%	2.7	8.9	2.1	8.6	16.2	10.6	21.1	16.2	30%

Table 8. Mean of agronomic characters measured in *Jethobudho* landrace enhancement trial in Fewa, 2003.

Source of *Jethobudho* landrace	Plant height (cm)	Tiller	Panicle length (cm)	Grains/ panicle	Grain yield (t/ha)	Straw yield (t/ha)	Neck blast	Sterile grains/ panicle	Culm strength
Dhan Bdr. Karki, Maidi	148.6	5.6	24.6	138.5	2.30	15.09	1.00	10.0	1.0
Meghnath Subedi, Sisuwa	152.4	5.0	23.9	149.9	2.26	12.30	1.00	8.60	1.0
Ganga Giri, Fewa	147.9	5.0	25.0	157.6	2.05	13.43	1.00	8.50	1.0
Man Bdr. Sunar, Fewa	152.8	4.6	24.0	133.1	2.16	14.20	0.66	8.70	1.0
Kedar Pd. Kafle, Biruwa	157.7	4.8	25.1	147.3	2.27	15.35	1.00	9.40	1.0
Bhim Pd. Baral, Biruwa	153.1	4.2	24.5	123.5	2.20	15.00	1.00	9.00	1.0
Bulk of 6 landraces	153.6	5.0	23.8	137.5	2.25	15.30	1.00	7.40	1.0
LSD at 0.05 probability	6.38	0.68	1.49	34.8	0.36	2.97	0.38	2.68	0.0
CV %	2.40	7.80	3.40	9.90	9.80	11.6	19.9	17.1	0.0

Conclusions

The agronomic performance of *Jethobudho* rice landrace accessions evaluated from 2000 to 2003 suggested that breeders could add value to the landraces through enhancement activity. Six *Jethobudho* accessions have been selected and enhanced for participatory variety selection and seed production for scaling-up in future. The enhanced accessions were blast and lodging tolerant which may be incentives for the *Jethobudho* rice-growing farmers. The selected accessions are potential candidates to be scaled-up by the farmers, private entrepreneurs, rice millers and seed-producer groups. We suggest that the landrace could be a potential candidate for release in Pokhara and similar valleys in Nepal.

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Jethobudho landrace enhancement III: postharvest quality traits

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Abstract

Postharvest grain quality traits are important factors for marketing rice varieties. *Jethobudho* is considered to be a high-quality landrace of rice but its postharvest qualities are poorly understood. Therefore, *Jethobudho* landrace enhancement was initiated to understand its quality traits and use them as selection criteria for screening large accessions in *Jethobudho* enhancement activity. The household-level survey on postharvest quality traits indicated that milling and head rice recovery percentage, colour of milled rice, softness, taste, flakiness and aroma were important characters. Using these characters, we screened 143 *Jethobudho* accessions for milling and organoleptic traits, and postharvest physiochemical properties. Laboratory methods for organoleptic assessment were established for *Jethobudho* landraces. Six accessions were selected for scaling-up on the basis of various postharvest quality traits. Milling and head rice recovery were more than 70% which was an attractive trait for rice millers and consumers. The organoleptic scores of selected *Jethobudho* were always more than average in 143 accessions. Amylose content (23–24%), intermediate gelatinization temperature, higher volume expansion and water absorption were recorded for selected *Jethobudho* accessions. These attributes make the landraces competitive for national as well as international markets for high-quality *basmati* type rice.

Key words: Accessions, amylose content, enhancement, milling, organoleptic, postharvest quality trait, rice

Introduction

In quality rices, grain quality traits are highly valued around the world and have a higher price in the market. The Asian market of high-quality aromatic rices is dominated by India, Pakistan and Thailand. The bulk of aromatic rice from India and Pakistan constitutes the *basmati* type (long slender and aromatic rice) whereas Thailand dominates in Jasmine rice (Singh *et al.* 2000c). Studies have shown that the high-quality aromatic rice fetches a premium price three times higher than medium- to short-grained non-aromatic rices. Quality rices are characterized not only by aroma, but also by several other characters such as: milling traits, including milling recovery percentage; head rice recovery percentage; colour, shape and size of the milled grain; organoleptic traits including softness, taste, flakiness, volume expansion, elongation after cooking and amylose content. In Nepal, high-quality rices constitute *basmati* type as well as short, medium-type aromatic rice. This rice represents little in total production but is considered important for consumer preferences in the Nepalese rice market. *Jethobudho, Biramphool, Jhinuwa* and *Panhele* are considered high-quality local rices from Pokhara valley. Among these *Jethobudho* is known for its superiority in softness, taste, flakiness, kernel elongation and aroma (Sthapit *et al.* 2002). Many private entrepreneurs have initiated the marketing of this landrace by its brand name in the Pokhara valley, for example, Karmacharya Group of Food Products has recently launched the marketing of *Jethobudho* landrace by its original name. However, there is a lack of regular supply of high-quality *Jethobudho* in sufficient quantity to meet market demand. There is a general perception of rice millers and traders that the postharvest quality traits of *Jethobudho* are highly variable. This is true because aroma of *Jethobudho* could be influenced by environment (source of water, water availability in the rice field and N fertilizer application) and genetic factors (varietal mixture and unavailability of pure seed). Owing to these environmental and genetic differences, there is high variation in quality traits such as milling recovery, amylose content, cooking and eating qualities.

Participatory plant breeding (PPB) in rice in high-potential production systems in Nepal has demonstrated that micromilling and organoleptic assessments can be efficiently employed to eliminate many poor entries quickly and cost effectively (Gyawali *et al.* 2002). The postharvest quality assessment of *Jethobudho* accessions was, therefore, carried out to identify and select the superior accessions based on physical characteristics of *Jethobudho*, milling and organoleptic traits, and physiochemical properties. As well, molecular markers were used to locate the genes for aroma in *Jethobudho* genome (Bajracharya *et al.*, unpublished).

Materials and methods

Defining postharvest quality traits of Jethobudho

To identify and understand the important postharvest quality traits of *Jethobudho*, we conducted a survey using household-level questionnaires. *Jethobudho* custodian farmers, housewives, hotel owners, cooks, farmers, millers and traders who have been using *Jethobudho* year round were located in Kaski valley in 2002. In consultation with limited stakeholders, the postharvest quality traits such as softness, flakiness, taste and aroma were identified. A questionnaire was developed to rank the important quality traits and document traditional procedures of cooking *Jethobudho* in the valley. Based on importance of each quality traits, the first-ranking trait was given 80% of weightage followed by 50, 30 and 15% for 2nd, 3rd and 4th ranked traits respectively. The weighted scores were calculated by multiplying the frequency of ranks and given weightage. The sum total of the scores for each of the traits formed the basis for selection criteria.

Micromilling

A total of 143 *Jethobudho* accessions were analyzed for milling traits in LI-BIRD's laboratory. A duplicate sample of 162 g of rough rice having 10–12% moisture was used for determination of milling traits. We used a GRAINMAN micromill (model no. 60-220-50-2AT and SERIAL NO. 01LAB2943/5755) for milling *Jethobudho* accessions. The sample was poured into the hopper and milled for 60 s in the first pass with weight. In the second pass, the brown rice was milled for another 60 s to polish the brown rice. The milled rice was collected in plastic bags and cooled before the bran and head rice were separated. The weights of total milled rice, head rice, broken rice and unhulled rice were recorded using an electronic balance and presence or absence of aroma during milling also was recorded. The chalkiness of *Jethobudho* accessions was rated on a 0 to 9 scale. The percentage of various measurements was calculated using the following formulae:

milling % = (total milled rice/total rough rice) x 100

head rice recovery % = (weight of head rice/total rough rice) x 100

Organoleptic assessment

The traits identified in a survey were used as selection criteria during organoleptic assessment. Softness, flakiness and aroma were recorded but the taste could not be recorded because of small samples available for cooking. We adapted traditional *Jethobudho* cooking procedures in the laboratory. The *Jethobudho* collected from market was used to standardize the cooking method in the laboratory. Housewives generally soak *Jethobudho* for 45 min before cooking; therefore the rice samples were soaked for 45 min before cooking in the laboratory. Different proportions of rice samples and amounts of water were used to standardize the cooking procedures.

The multiple samples of *Jethobudho* were collected as *checks* from the market and used to standardize the proportion of rice sample vs. amount of water (Table 1) and pressure inside autoclave vs. cooking time (Table 2). Ten persons judged the cooked rice. Rice samples having 7 g weight and 9 ml water gave satisfactory results in repeated cooking. We used glass test tubes and petri plates for cooking large samples but cooking in a test tube was unsatisfactory. In the test tube (22 × 180 mm), rice was not cooked uniformly, and it was difficult and time consuming to take out cooked rice for judgment. Petri plates of 9-cm diameter were used for cooking in pressure cooker. The petri plates provided sufficient space for spreading cooked rice and facilitated easy judgment for aroma, softness and flakiness. The amount of pressure and cooking time was also standardized.

Table 1. Standardization of rice sample and amount of water in LI-BIRD's laboratory.

Proportion of rice and water	Cooked rice
7 gm rice + 5 ml water	Hard rice and not cooked
7 gm rice + 6 ml water	Hard rice and not cooked
7 gm rice + 7 ml water	Semi-hard and not properly cooked
7 gm rice + 8 ml water	Cooked and rated good
7 gm rice + 9 ml water	Well cooked and rated excellent
7 gm rice + 10 ml water	Cooked and rated good

Table 2. Standardization of amount of pressure and cooking time in LI-BIRD's laboratory.

Amount of pressure and cooking time	Cooked rice
15 lb/in^2 pressure for 5 minutes	Hard rice and not cooked
15 lb/in^2 pressure for 10 minutes	Semi-hard and rated poorly cooked
15 lb/in^2 pressure for 15 minutes	Well cooked and rated excellent

Thus, 15 minutes prior soaking of milled rice in water increased softness of cooked rice. The combination of 7 g of rice with 9 ml of water exhibited excellent cooking qualities in vertical autoclave (Model: 23881, Narang Scientific Works Pvt. Ltd) cooked for 15 minutes under 15 lb/in^2 pressure. Several samples were cooked for standardization of cooking process before cooking actual *Jethobudho* accessions. We cooked 20–22 samples at a time in autoclave released pressure slowly once it reached standardized pressure and cooking time. The cooked rice was first evaluated for aroma by removing the lid of petri plates and smelling the rice. Simultaneously, softness, flakiness, colour of cooked rice and overall characteristics were evaluated and scored for each accession against each trait. The scoring was done by the panel of judges as follows: 1=Excellent, 2=Medium and 3=Poor. The softness was given 80% weightage followed by flakiness and aroma, 50% and 30% respectively. The frequency of each rank was multiplied with weightage to estimate the organoleptic score. The accessions having less than 400 organoleptic score were rejected.

The postharvest quality traits of selected accessions were evaluated by the farmers of Pokhara valley in participatory variety selection (see p. 189). The household level questionnaires (HLQs) were administered to understand farmers' perceptions on milling and culinary characters.

Laboratory assessment of physiochemical traits

The milled samples were sent to the Food Research Unit Laboratory of the Nepal Agricultural Research Council (NARC) for physiochemical analysis. The five randomly selected milled grains were measured for length and width. From the length, width and length-width ratio parameters, the size and shape of *Jethobudho* accessions were determined (Table 3). The gelatinization temperature was indexed using alkali digestibility measured by alkali spreading value (Table 4). Alkali digestion of *Jethobudho* accessions was performed in weak alkali solution (1.7% KOH).

Table 3. Length, length-width ratio, chalkiness and amylose content standard used for physiochemical analysis of *Jethobudho* landrace accessions in laboratory in 2002.

Length (size)		Length / width (shape)		Chalkiness		Amylose	
Size	mm	Shape	ratio	Scale	% area	Group	%
Very long	≥7.51	Slender	≥3.0	0	None	Waxy	0–2
Long	6.61–7.50	Medium	2.1–3.0	1	≤10	Very low	3–9
Intermediate	5.51–6.60	Bold	≤2.0	5	11–20	Low	10–19
Short	≤5.50			9	≥21	Intermediate	20–25
						High	>25

Adapted from Cruz and Khush (2000).

Table 4. Alkali digestion and corresponding gelatinization temperature used in the laboratory analysis of *Jethobudho* accessions in 2002.

Score	Spreading	Alkali digestion	Gelatinization temperature
1	Kernel not affected	Low	High (>74°C)
2	Kernel swollen	Low	High (>74°C)
3	Kernel swollen; collar complete and narrow	Low or intermediate	High–intermediate (70–74°C)
4	Kernel swollen; collar complete and wide	Intermediate	Intermediate (70–74°C)
5	Kernel split or segregated; collar complete and wide	Intermediate	Intermediate (70–74°C)
6	Kernel dispersed; merging with collar	High	Low (55–59°C)
7	Kernel completely dispersed and intermingled	High	Low (55–69°C)

Adapted from Cruz and Khush (2000).

The amylose content of the *Jethobudho* accessions was estimated using manual method (Juliano 1971). The whole grain milled rice of *Jethobudho* was ground and passed through a 100-mesh sieve. We weighed 100-g samples in electronic balance in duplicate, into a 50-ml Erlenmeyer volumetric flask and added 1 ml of 95% ethanol and 9ml of 1N NAOH. The samples were heated for 10 min in a boiling water bath to gelatinize the starch, cooled, and transferred with several water washings into 100-ml volumetric flasks, brought up to volume with water and mixed well. We added 5 ml of starch solution with pipette into a 100-ml volumetric flask with 1 ml of 1N CH_3COOH and 2 ml of iodine solution. The solution was made up to volume with water, shaken and let stand for 20 min. Absorbance of the solution at 620 nm was measured with the spectrophotometer. Amylose content was determined by reference to a standard curve and expressed as a dry-weight basis.

Results

Defining postharvest quality traits of Jethobudho

The analysis of household-level survey on postharvest quality traits of *Jethobudho* revealed that softness was the most important trait in this landrace (Table 5) followed by taste, flakiness and aroma. All respondents except housewives ranked taste highest but both male and female respondents, farmers, cooks and rice millers ranked softness highest (Table 6).

Micromilling and organoleptic assessment

The results of micromilling and organoleptic traits have been presented for 46 best accessions only. We rejected accessions with less than 65% milling recovery and less than 400 organoleptic weighted score (Table 7). The results of physical appearance of cooked rice and organoleptic assessment for 143 accessions have been presented by *phants* using unweighted scores (Table 8). We compared *Jethobudho* accession from different *phants* with *Sugandha*–1 and check *Jethobudho* collected from markets.

Laboratory assessment of physiochemical traits

The physiochemical traits of *Jethobudho* accession are presented in Table 9. We found that the test weight of *Jethobudho* samples of milled rice was always higher than 15 g except for Sisuwa *phant*. In all cases, the accessions were categorized under short grain and medium grain type. The amylose content, and alkali digestion represented by spreading value, was always intermediate type. The volume expansion and water absorption were higher in all accessions.

Table 5. Postharvest quality traits of *Jethobudho* landrace perceived by housewives, cooks, millers and farmers in 2001.

Softness		Flakiness		Taste		Aroma		Volume expansion		Appearance of cooked rice	
Frq.†	Wt.†	Frq.	Wt.	Frq.	Wt.	Frq.	Wt.	Frq.	Wt.	Frq.	Wt.
28‡	2240	9	720	23	1840	10	800	3	240	1	80
23	1150	15	750	12	600	10	500	4	200	4	200
5	150	19	570	15	450	11	330	8	240	2	60
3	45	7	105	6	90	15	225	13	195	7	105
Sum	3585 (I)	Sum	2145 (III)	Sum	2980 (II)	Sum	1855 (IV)	Sum	875 (V)	Sum	445 (VI)

† Frq. = frequency, Wt. = weightage.
‡ The first row represents the frequency of first ranking followed by other rows. 1st rank = 80 weightage, 2nd rank = 50 weightage, 3rd rank = 30 weightage, 4th rank = 15 weightage.

Table 6. Preference ranking of postharvest quality traits by farmers, cooks and rice millers; and differences in male–female response on these traits in a survey in Pokhara valley, 2001.

Postharvest quality traits	Farmers (26)†	Cook (10)	House-wives (12)	Rice millers (12)	Male total (28)	Female total (32)
Softness	15 (I) ‡	3 (I)	5 (II)	12 (I)	16 (I)	28 (I)
Flakiness	2 (IV)	4(II)	2 (III)	3(IV)	6 (III)	9 (IV)
Taste	8 (III)	2 (III)	8 (I)	9 (II)	14 (II)	23 (II)
Aroma	2(IV)	1 (III)	2 (III)	5 (III)	5 (IV)	10 (III)

† Value in parentheses of first row represents the number of respondents.
‡ Value in parentheses within column of quality traits is the ranking of specific traits.

Table 7. Micromilling and organoleptic quality traits evaluated for 46 *Jethobudho* accessions in landrace enhancement experiment conducted in Kaski valley in 2002.

Entry no.	Accession	Milling recovery %	Head rice %	Broken rice %	Unhulled rice %	Physical acceptance	Organoleptic weightage
1	JB-T-001-020/6	72.8	72.38	0.46	0.07	Excellent	450.0
2	JB-T-005-022/8	71.1	70.70	0.34	0.00	Excellent	405.0
3	JB-T-006-022/9	72.3	71.94	0.34	0.13	Excellent	427.5
4	JB-T-007-022/23	72.9	72.57	0.23	0.06	Excellent	412.5
5	JB-T-008-024/1	70.4	70.14	0.25	0.02	Excellent	405.0
6	JB-T-009-025/1	70.3	70.06	0.28	0.07	Excellent	412.5
7	JB-T-010-025/5 ‡	71.2	70.83	0.42	0.09	Excellent	427.5
8	JB-T-011-025/9	72.8	72.58	0.25	0.02	Excellent	405.0
9	JB-T-017-030/11	72.1	71.89	0.16	0.06	Excellent	435.0
10	JB-T-021-030/20	70.4	70.10	0.25	0.00	Excellent	405.0
11	JB-T-023-030/25 ‡	71.2	70.90	0.29	0.07	Excellent	465.0
12	JB-T-028-050/18	70.8	70.51	0.31	0.20	Excellent	450.0
13	JB-T-029-050/27 †	65.7	65.2	0.22	0.06	Excellent	450.0
14	JB-T-031-062/2	75.6	75.24	0.34	0.30	Excellent	420.0
15	JB-T-035-062/15	73.7	73.48	0.23	0.00	Excellent	457.5
16	JB-T-036-062/17 †	65.6	65.26	0.38	0.19	Excellent	427.5
17	JB-T-041-065/1	71.3	71.03	0.23	0.05	Excellent	472.5

Entry no.	Accession	Milling recovery %	Head rice %	Broken rice %	Unhulled rice %	Physical acceptance	Organoleptic weightage
18	JB-T-042-065/15	79.6	79.27	0.33	0.02	Excellent	450.0
19	JB-T-046-072/5	76.7	76.28	0.47	0.00	Excellent	457.5
20	JB-T-048-072/17	72.9	72.51	0.37	0.00	Excellent	427.5
21	JB-T-052-083/9	78.5	78.25	0.26	0.06	Excellent	420.0
22	JB-T-056--118/1	74.5	74.09	0.42	0.05	Excellent	427.5
23	JB-T-063-121/11	79.8	79.36	0.36	0.00	Excellent	442.5
24	JB-T-067-121/23	77.7	77.28	0.33	0.02	Excellent	442.5
25	JB-T-071-133/4	77.0	76.65	0.28	0.14	Excellent	435.0
26	JB T-072-133/5	74.0	73.70	0.36	0.30	Excellent	427.5
27	JB-T-073-133/10 †	67.1	66.61	0.63	0.12	Excellent	435.0
28	JB-T-076-133/15	71.4	71.23	0.17	0.15	Excellent	442.5
29	JB-T-093-175/4 †	61.1	60.60	0.70	1.28	Excellent	412.5
30	JB-T-103-237/12 ‡	68.8	68.21	0.67	1.07	Excellent	427.5
31	JB-T-105-238/5 ‡	72.9	72.31	0.81	1.72	Excellent	427.5
32	JB-T-110-238/30	77.9	77.30	0.63	0.44	Excellent	405.0
33	JB-T-112-240/5 †	67.0	66.35	0.89	0.64	Excellent	420.0
34	JB-T-115-259/13 †	67.4	66.77	0.81	0.65	Excellent	435.0
35	JB-T-117-262/16	68.2	68.10	0.17	1.06	Excellent	427.5
36	JB-T-118-262/12	73.8	73.37	0.52	0.33	Excellent	435.0
37	JB-T-137-283/8 †	64.5	64.07	0.34	0.19	Excellent	450.0
38	JB-T-147-296/6 ‡	70.9	70.52	0.31	0.85	Excellent	420.0
39	JB-T-149-296/12 †	60.7	60.48	0.32	1.04	Excellent	412.5
40	JB-T-151-296/16 †	65.1	64.66	0.59	0.78	Excellent	442.5
41	JB-T-167-314/24	78.6	77.88	0.84	0.50	Excellent	420.0
42	JB-T-168-316/3 ‡	77.2	76.67	0.53	0.50	Excellent	450.0
43	JB-T-170-319/2 †	61.0	60.48	0.42	1.35	Excellent	420.0
44	JB-T-178-319/19	68.6	68.27	0.34	0.65	Excellent	442.5
45	JB-T-182-336/6 †	61.5	61.10	0.53	2.03	Excellent	435.0
46	JB-T-183-336/30 †	63.3	63.08	0.57	0.75	Excellent	427.5
	Mean ± SD	71.04±5.15	70.66±5.15	0.41±0.19	0.39±0.50	–	431.4±16.8
	Range	79.8–60.7	79.3–60.4	0.83–0.19	2.03–0.00		472.5–405.0
	CV %	7.25	7.29	46.06	126.61		3.91

† Rejected due to poor performance either in milling traits or organoleptic assessment index.
‡ Selected accessions.

Table 8. Mean scores of organoleptic assessment of 143 *Jethobudho* accessions of seven different *Phant* of Pokhara valley in 2002.

Name of *phant*	Type of rice	Colour	Soft-ness	Separate-ness	Taste	Aroma	Bright-ness	Overall ranking	Avg. score
Biruwa	2.57‡	1.88	2.14	2.86	2.00	1.43	1.71	2.14	2.09
Check JB	3.71	3.29	3.14	2.29	4.43	4.29	3.86	4.14	3.64
Arghun	3.14	1.86	1.00	3.00	2.43	3.00	2.00	2.71	2.39
Malmul	3.00	2.29	2.43	3.00	3.29	3.71	1.86	2.71	2.79
Sisuwa	3.14	2.14	2.71	3.14	3.29	3.29	1.71	2.86	2.79
Sugandha-1	4.00	2.57	1.29	4.57	3.71	4.43	1.71	4.00	3.29
Kundahar	3.29	2.14	2.00	3.43	2.57	2.86	2.14	2.71	2.64
Fewa	2.43	2.29	2.29	2.29	2.29	2.29	2.57	2.43	2.36
Charade	2.86	2.14	2.00	2.29	2.14	1.57	2.43	2.57	2.25
Mean ± SD †	3.01 ±0.40	2.25 ±0.44	2.21 ±0.62	2.78 ±0.44	2.80 ±0.81	2.8 ±0.99	2.28 ±0.70	2.78 ±0.59	2.61 ±0.48

† Mean and SD does not include the value of Sugandha-1 which is not a Jethobudho (JB) landrace. Check JB (JB = Jethobudho collected from the market) and Sungadha-1 (a variety developed by PPB project of LI-BIRD) were included as check.
‡ Lower scores represent the best-quality rice.

Table 9. Mean of postharvest quality traits (physical and physiochemical properties) measured for the best accessions of *Jethobudho* landrace in an enhancement experiment in Fewa, 2003.

Farmer name, location	TWT of milled rice (g)	Length (mm)	Width (mm)	Vol. expansion %	Water absorption %	Kernel elong-ation %	Spread-ing	Amylose %
Dhan Bad Karki, Maidi	15.35	5.5	2.5	300	185	85	4	23.0
Meghnath Subedi, Sisuwa	14.85	5.4	2.4	305	199	91	4	24.1
Gagan Giri, Fewa	15.30	5.3	2.4	333	209	98	4	24.3
Man Bd. Sunar, Fewa	15.43	–	–	313	213	96	4	23.8
Kedar Pd. Kafle, Biruwa	15.53	–	–	375	229	107	4	23.9
Bhim Pd Baral, Biruwa	15.70	–	–	350	252	135	4	23.7
Overall (143 accessions)	14.99 ± 0.7	5.2 ±0.5	2.41 ±0.1	302 ±85	207.5 ±56.4	96.5 ±22	3.94 ±0.3	23.6 ±1.37
CV %	4.6	11	4.5	28.3	27.2	22.6	7.7	5.8

The average milling recovery was more than 71% and head rice recovery was >70% which indicated that the broken rice % was very low. However, many accessions had poor milling and head rice recovery percentage and these accessions were rejected by the panel of judges. Very interestingly, we recorded as high as 79% of milling and head rice recovery in JB-T-063-121/11, whose organoleptic score was also very high (450).

Discussion

Understanding consumers' preferences

Researchers generally perceived that aroma was the most important valued trait in *Jethobudho* before the household survey, but aroma was ranked 4th by respondents of the household-level survey in 2002. Volume expansion and appearance of cooked rice were ranked lowest because respondents perceived this would depend on cooking procedures. Therefore, only softness, flakiness, aroma and overall ranking were used as selection criteria in the process. Identifying consumers' preferences on postharvest qualities and selection based on these traits increased researchers' efficacy in selecting the large number of accessions in *Jethobudho* enhancement. The enhancement process identified the accessions that were superior for postharvest quality traits.

Milling traits

The milling traits of *Jethobudho* accessions were found to be excellent. The analysis of length–width measurement revealed that *Jethobudho* accessions fell in the short-sized grain category but their shape is medium type. The length–width ratio of selected accessions ranged from 2 to 2.5. Similarly, none of the grains were found to have chalkiness. The grains of all the accessions were ghee coloured. In the Nepalese rice market, ghee-coloured grain is highly preferred for cooking whereas white-coloured grain is preferred for beaten rice. The milling recoveries of the selected accessions were extremely encouraging and appealing to the rice millers and traders. We recorded head rice recovery as high as 79%, although the average was 70.6%. The accessions for which poor milling and head rice recovery percentage were recorded were rejected Therefore, the selection based on milling traits helped researchers to discard undesirable accessions early in the process and select only the superior accessions.

Organoleptic assessment

The organoleptic scores of selected accessions were always more than 420. The accessions scoring less than 400 were rejected before making any comparison with other accessions. Therefore, we selected accessions based on superior milling and organoleptic characters. The mean organoleptic scores of accessions from Biruwa, Fewa and Kharane were higher than the average of all *phants*. Hence, in the overall ranking, *Jethobudho* accessions from Biruwa, Fewa and Kharane were preferred, respectively. Also the aroma of cooked rice of Biruwa and Fewa accessions was interestingly very high compared with other *phants*. Therefore, the current organoleptic assessment revealed that accessions collected from Biruwa and Fewa *phants* (with cold water source) were superior to others. There is a general perception of rice millers and consumers that *Jethobudho* from Fewa and Biruwa *phants* is superior, which is also supported by the current study. Therefore, the price of rough rice is considerably higher for *Jethobudho* grown in these two *plants* than to others in Pokhara valley. However, there are considerable variations within and between *phants* for *Jethobudho* accessions in terms of milling and organoleptic traits.

Farmers' perception on postharvest quality traits were analyzed using HLQs. Farmers perceived that the enhanced *Jethobudho* had high milling and organoleptic traits as compared to their own materials (Figure 1). More than 80% of the farmers reported that the selected materials were superior for milling recovery, milled rice type, colour of the milled rice, aroma and overall cooking. Seventy percent of the respondent farmers perceived that the softness of the enhanced *Jethobudho* was superior to their own *Jethobudho* but 50% reported that the enhanced *Jethobudho* was superior for flakiness whereas others reported it was as good as their own *Jethobudho*. Overall, more than 80% of farmers perceived that the enhanced materials were superior to farmers' own source of *Jethobudho*. The participatory variety selection (PVS) clearly indicated that the enhanced accessions were accepted by the farmers for their superior postharvest quality traits.

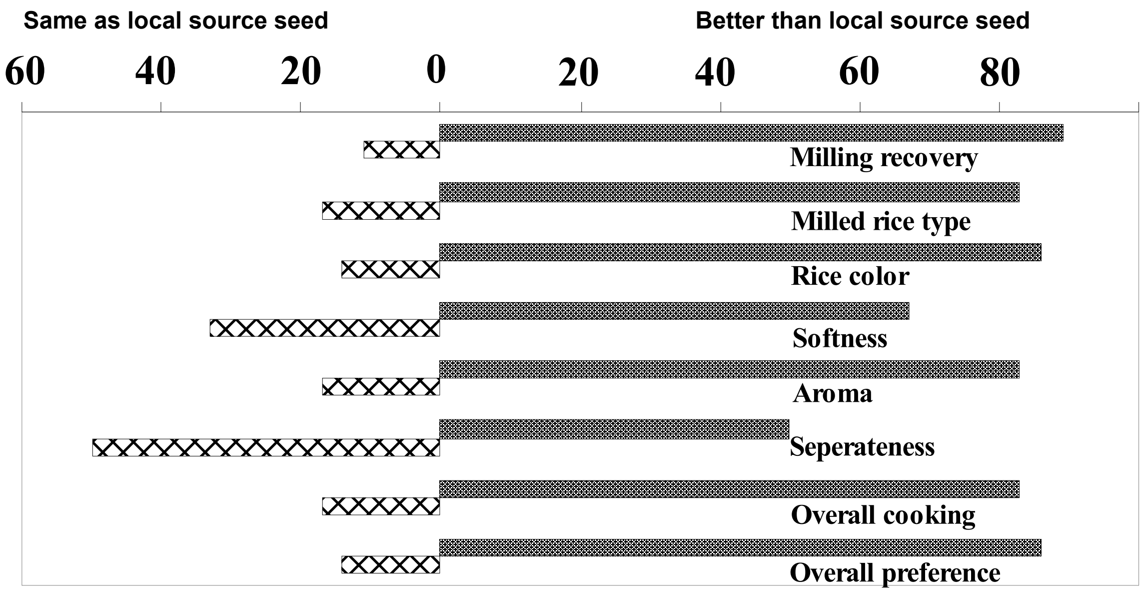

Figure 1. Farmers' perception of postharvest quality traits colleted using HLQ in PVS trials in Pokhara valley in 2003.

Physiochemical traits

Alkali digestion and gelatinization temperature

The gelatinization temperature (GT) affects the water absorption, volume expansion and linear kernel elongation. Rice varieties with intermediate GT are preferred all over the world because the high GT rice becomes excessively soft when overcooked, elongates less and remains undercooked under standard cooking procedures. Therefore, rice with high or low GT is less preferred than those with intermediate GT. Singh *et al.* (2000a) explained that an estimate of the gelatinization temperature can be indexed by the alkali digestibility test. The alkali digestibility value can be measured by the alkali spreading value. The spreading value of individual milled rice kernels in a weak alkali solution (1.7% KOH) is very closely correlated with the gelatinization temperature (Table 4). Rice accessions with low gelatinization temperature disintegrate completely whereas those with intermediate GT show only partial disintegration and those with high GT remain largely unaffected in the alkali solutions. We observed that there was less variation of GT in *Jethobudho* landraces but the value of alkali digestion suggested that enhanced accessions have intermediate GT, meeting the international standard for quality rice. The alkali digestion and correlated GT of *Jethobudho* accessions were found in the most preferable range (intermediate) indicating its good cooking qualities such as softness, moistness, water absorption, volume expansion and softness upon cooling.

Amylose content

The amylose content in milled rice and its starch has a major influence on cooked rice texture. Amylose content correlates positively with water absorption and volume expansion, softness and whiteness (Juliano 1985). It correlates negatively with stickiness and gloss of cooked rice. Intermediate amylose rices are the preferred types in most of the rice-growing areas in the world because intermediate rice cooks moist, soft and tender (Singh *et al.* 2000a). Such cooked rice does not become hard upon cooling. High-amylose rice has high volume expansion, a high degree of flakiness, is less tender, cooks dry, is less soft and becomes hard upon cooling. Low-amylose rices cook moist and become sticky upon cooling and are not preferred except in temperate regions and for special purposes. Most of the Japonica rices have low amylose content whereas the Indica rices have higher amylose.

The amylose content of most *basmati* rices (Basmati 1, Basmati 2, Della AR, Della LA and Jasmine) ranged from 20 to 24% (Singh *et al.* 2000b). The amylose content of all selected accessions ranged between 23 and 24.2 % (intermediate range) (Table 9) indicating they have superior qualities in terms of international standards for *basmati* rices for amylose content. The softness, flakiness and taste of the selected accessions, therefore, recorded very high qualities in organoleptic assessment.

Volume expansion and water absorption

The volume expansion of the aromatic and high-quality rice should be at least 100%. Singh *et al.* (2000a) reported that the high-quality Indian Basmati landraces had more than 300% volume expansion. The *Jethobudho* accessions were found highly variable for volume expansion and water absorption (Table 9). The selected accessions recorded excellent volume expansion and water absorption.

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The authors express their sincere gratitude to the farmers of Kaski valley who have maintained the diversity of *Jethobudho* for many years. The kind cooperation of farmers of Kaski valley in the landrace enhancement activity of *in situ* conservation project is highly acknowledged. Thanks are due to the team of LI-BIRD and NARC *in situ* conservation project for their timely comments and suggestions on *Jethobudho* enhancement. We are grateful to A. Subedi and P.K. Shrestha for their sincere cooperation and commitment to this activity. We appreciate the inputs from PPB thematic group and other members of *in situ* conservation project: B.K. Joshi, A. Mudwari, B.K. Baniya and D. Singh. The untiring and sincere fieldwork rendered by Indra Poudel, Sri Ram Subedi, Mahendra Chaudhary, Narendra Chaudhary, Bir B. Tamang, Lila Rana and motivators of *in situ* Kaski are highly acknowledged. The authors extend their special thanks to Muna Udas and Rajya Shree Sthapit for their guidance in cooking *Jethobudho*. IDRC, Canada is sincerely acknowledged for its financial support for this work.

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Jethobudho landrace enhancement IV: participatory variety selection and community-based seed production

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Abstract

Farmers' preferences and acceptance of enhanced accessions of *Jethobudho* is important in scaling-up of these accessions in future. Also farmers' access to better planting materials, especially in terms of local landraces, is very limited. This paper describes the participatory variety selection (PVS) of enhanced *Jethobudho* landraces and community-based seed production (CBSP) initiated for this landrace in the Pokhara valley of Nepal in 2003 and 2004. Initially only 12 farmers were involved in the PVS programme owing to a shortage of seed but in 2004, 130 farmers participated in on-farm evaluation of enhanced *Jethobudho*. The custodian *Jethobudho* farmers were involved in producing quality source seed whereas other seed-producer farmers were employed in truthfully labelled seed production for scaling-up of selected accessions in future. We have tried to link custodian *Jethobudho* farmers, rice millers and rice traders to the CBSP programme for rapid dissemination of enhanced *Jethobudho*. The government agricultural agency at district level, District Agriculture Development Office, Kaski, has contributed to PVS and CBSP in 2004.

Key words: Accession, community-based seed production, *Jethobudho* landrace, participatory variety selections, rice, seed

Introduction

The *Jethobudho* landrace has special importance in Pokhara valley owing to its high postharvest quality traits for grain; however it has some problems in agronomic traits such as it lodges under high-fertility conditions, is susceptible to insect pests and disease, especially neck blast caused by *Pyricularia greasea*. Therefore *Jethobudho* landrace enhancement was started by the *in situ* conservation agrobiodiversity project in 1999 in order to make this landrace competitive with modern varieties through selection of best accessions from existing diversity of this landrace in Kaski valley (Gyawali *et al.* 2003b). We employed selection of best landraces for agronomic and postharvest quality traits to improve this landrace (see pp. 172, 189). In 2003, participatory variety selection (PVS) was employed to assess the performance of enhanced *Jethobudho* for agronomic and postharvest grain quality traits on-farm in Pokhara valley.

PVS is a research and extension method to deploy the genetic materials on-farm so that farmers will have varietal options to meet niche-specific needs. The steps of successful PVS method are explained by Witcombe 2002 for modern and PPB-bred varieties in rice. However, there are very few examples of PVS being conducted using local landraces only. Gyawali *et al.* (2003a) reported the PVS of upland rice landraces where *Jirechobo* (originally popular landrace of Lamjung district) was the most preferred by the farmers and adopted in Polyangtar and Mohoriyatar/Phediphant of Tanahun districts. The varietal diversity was increased by the intervention of PVS on *Ghaiya* landraces in the project area. The community-based seed production activities are not new to Nepalese conditions. One of the successful community-based seed production of Pithiuwa Seed Producer Group, Chitwan, on cereals (especially maize, wheat and rice) is documented by Diwakar *et al.* (2003). CBSP has provided farmers new options for varietal choices as well as access to farmer-preferred varieties. The District Agriculture Development offices have initiated a District Self Seed Production Program (DISSPRO) for strengthening CBSP initiatives in many districts of Terai and middle hills. Therefore the objectives of PVS of enhanced *Jethobudho* were: (1) evaluate agronomic and postharvest quality traits of enhanced *Jethobudho* accessions on-farm involving many farmers in Pokhara valley, (2) increase the access of enhanced materials to as many as farmers as possible through PVS and CBSP, and (3) assess the acceptance of enhanced materials for wider scaling-up in future.

Materials and methods

PVS in 2003

We employed a PVS approach to explore the *Jethobudho* acceptance by farmers in Pokhara. Field technicians, during a transect walk in 2003, discussed with the *Jethobudho* rice-growers the output of landrace-enhancement activities in strengthening the scientific basis of *in situ* conservation of a local landrace project. It created farmer interest in evaluating the enhanced materials on their farms. We had very limited seed for PVS, so although there was great interest by many farmers, we could involve only 12 farmers in PVS of six enhanced accessions.

Farmers were provided with a 1-kg packet of enhanced accession's seed, each labelled properly with the source of accessions and name of the landrace (Table 1). Farmers were given an explanation of the PVS process. All participating farmers were requested to evaluate the enhanced *Jethobudho* accession with their own source of seed under own crop management practices. The participant farmers were instructed to compare the various agronomic and postharvest quality traits at different stages of crop husbandry. Field staff regularly monitored the fields of all PVS participant farmers (Table 2). At maturity, selected PVS fields were monitored during a travelling seminar by a joint team of scientists and farmers.

The participant farmers were allowed to evaluate the produce of enhanced materials for postharvest quality traits, especially milling, cooking and eating as well as market price until 3–4 months after crop harvest. We conducted a survey of participant farmers using a household-level questionnaire (HLQ) specially designed to collect the perception data on various agronomic and postharvest quality traits. The acceptance of the enhanced accessions and seed saving for next year were recorded.

Table 1. Names of custodian farmers of *Jethobudho* and respective accessions used in landrace enhancement in *in situ* activity in 2004.

Source of materials	Address	Accessions
Dhan Bdr. Karki	Lekhnath Phalame Dhab-Sisuwa	JB-T-010-025/5
Meghnath Subedi	Lekhnath-8, Sisuwa	JB-T-023-030/25
Ganga Giri	Kaskikot-7, Pame, Fewa	JB-T-103-237/12
Man Bdr. Sunar	Kaskikot-6, Pame, Fewa	JB-T-105-238/5
Kedar Pd. Kafle	Pokhara-17 Powerhouse, Biruwa	JB-T-147-296/6
Bhim Pd. Baral	Pokahra-7, Maswar, Biruwa	JB-T-168-316/3

Table 2. Farmer name and location, and source of selected *Jethobudho* accessions landraces employed for participatory variety selection in Kaski valley in 2003.

Participant farmers	Address	Source	Quantity (kg)
Gita Adhikari	Malmul	Megh Nath Subedi	1
Ek Nath Tripathi	Pame (Fewa)	Megh Nath Subedi	1
Radha Ghimire	Malmul	Kedar Pd. Kafle	1
Bhim Pd. Timilsina	Pame (Fewa)	Kedar Pd. Kafle	1
Bishnu Sahi	Kholakochheu	Bhim Pd. Baral	1
Subhadra Adhikari	Begnas	Bhim Pd. Baral	1
Keshab Pageni	Malmul	Gagan Giri	1
Bajra Mohan Parajuli	Pame (Fewa)	Gagan Giri	1
Laxmi Sapkota	Malmul	Man Bdr. Sunar	1
Laxman Timilsina	Pame (Fewa)	Man Bdr. Sunar	1
Bhismakanta Neupane	Sundaridanda	Dhan Bd Karki	1
Dol Raj Subedi	Pame (Fewa)	Dhan Bd Karki	1

PVS of enhanced Jethobudho in 2004

The results of PVS in 2003 encouraged the PPB thematic group to conduct large-scale PVS of enhanced *Jethobudho* in 2004. In the meantime, the District Agriculture Development Office (DADO) and its networks—Agriculture Service Centres (ASCs)—were involved in the PVS process. We invited the agronomist, Extension Officer and JT/A from DADO to the planning meeting for PVS in 2004.

Community-based seed production of enhanced *Jethobudho*

A planning meeting was organized to discuss the scaling-up and seed production of enhanced *Jethobudho* landrace in Pokhara valley. The custodian *Jethobudho* farmers (Table 1), PPB thematic group and other members of the *in situ* conservation project, a scientist from IPGRI, Officer and JT/As from DADO, and rice millers were invited to the planning meeting. We explored the interest of the custodian farmers in breeder seed multiplication for the enhanced accessions. The objective of the planning meeting was to inform the various stakeholders about the *Jethobudho* enhancement activities and to develop the modality of community-based seed production of enhanced *Jethobudho* in Pokhara valley.

Results and discussion

PVS in 2003

The PVS of enhanced *Jethobudho* included 12 farmers but only 10 farmers could complete the PVS trials whereas 2 of them mixed the seed during the transplanting. Therefore, the information of HLQ represents on-farm trials of 10 farmers. The analysis of perception data from HLQ showed that 80% of the participant farmers evaluated enhanced materials in highly fertile land whereas 60% had a perennial source of irrigation water and 40% had partial irrigation for their field.

The farmers' evaluation on agronomic traits of enhanced *Jethobudho* clearly indicated that the selected accessions were superior over their own source of seed (Figure 1). We observed that 70% of farmers perceived better establishment of enhanced accessions in the nursery as well as in the field with 100% lodging tolerance. Farmers reported that although the new *Jethobudho* seed was transplanted into very fertile land, it did not lodge because the selected accessions were strong enough for culm strength. The leaf and neck blast infection was very low—80% of farmers reported that the new *Jethobudho* was free of leaf and neck blast. Farmers (70%) reported that the tillering ability was higher in enhanced *Jethobudho* and it also resulted in higher straw yield than their own *Jethobudho*. The panicle length of the enhanced *Jethobudho* was very attractive to the farmers (70% of farmers reported that it had longer panicles than their own). We noticed that 70% of farmers perceived that enhanced materials yielded higher than local seed. This was due to better establishment, higher tolerance to leaf and neck blast, tolerance to lodging, higher tillering and improvement in yield and yield components. The threshability of the enhanced materials was not a problem to farmers.

Similarly the perceptions of postharvest quality traits were also analyzed using HLQs. Farmers noted that enhanced *Jethobudho* had higher milling and organoleptic traits than their own materials (see p. 186).

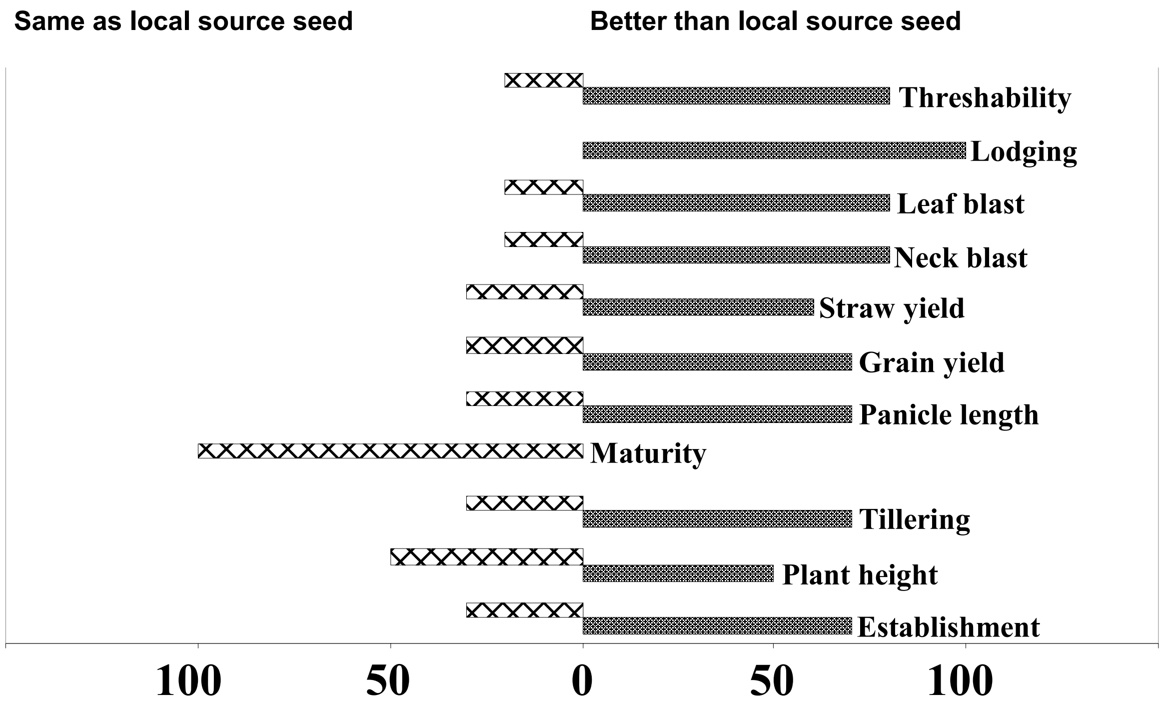

Figure 1. Farmers' perception of various agronomic traits collected using HLQ in PVS trials in Pokhara valley in 2003.

We found that 67% of the participant farmers have selected the enhanced *Jethobudho* for growing in 2004. Farmers have saved 50 kg of enhanced *Jethobudho* which is more than a fourfold increase of adoption by the farmers for 2004. The HLQ revealed that 44% of farmers were asked by neighbouring farmers to save seed for them as well for next year. Also we explored whether farmers are interested in multiplying the seed and disseminating it in their village. In this regard, 67% of farmers were very interested in multiplying enhanced *Jethobudho* and exchanging the seed with their neighbours. We noticed that some farmers have planned to sow their entire field with enhanced *Jethobudho* next year. This indicated that the enhanced *Jethobudho* was highly accepted by the participant and non-participant farmers.

The PVS has been found effective in disseminating the information and genetic materials horizontally, i.e. farmer-to-farmer dissemination of enhanced accessions was higher in high-potential production systems (Witcombe 2002). This is more important in landraces where farmers' own saved seed, exchange and gifts are only seed sources. Realizing this, many PVS trials have been conducted in 2004 for rapid dissemination of enhanced materials among farmers of Pokhara valley. Furthermore, the PVS provided important information on acceptance or rejection of tested materials on-farm. In the case of *Jethobudho* accessions, farmers accepted the enhanced *Jethobudho* to grow and scale-up in their villages but this needs to be verified by PVS with a large number of farmers in 2004.

In 2003, we collected 250 kg of enhanced *Jethobudho* accessions from different trials and seed production on-farm (Table 3). We organized seed production in farmers' fields under the supervision of field technicians. The seed was collected to conduct large-scale PVS and community-based seed production of enhanced accessions in 2004.

Table 3. Amount of seed of *Jethobudho* accessions collected from different sources in 2003.

Source of seed for PVS 2004	Amount of seed collected (kg)
Replicated trial in Pame	50
Replicated trial in ARS Malepatan	45
Replicated trial in Malmul	69
Seed production Farmers field	196
Total	250

PVS in 2004

The PVS planning of enhanced *Jethobudho* was jointly conducted by LI-BIRD, NARC, DADO Kaski, custodian farmers and rice millers on 18 April 2004. In 2004, we have planned 130 PVS trials to reach as many farmers as possible (Table 4). This approach will promote the dissemination of the materials very quickly to a large number of farmers onn one hand, and the enhanced materials will be tested under diverse production environments. The farmers' responses and/or feedback will help researchers to understand the performance of enhanced materials to scale-up the landrace in similar domains.

Table 4. The participatory variety selection of enhanced *Jethobudho* landrace in Kaski valley in 2004.

DADO	Location	No. of sets	Seed quantity (kg)	Total (kg)
ASC, DADO, Kaski	Pame	10	2	20
ASC, DADO, Kaski	Pokhara	10	2	20
ASC, DADO, Kaski	Lekhnath	5	2	10
PVS by LI-BIRD	–	10	2	20
PVS by 5 custodian farmers	–	30	2	60
Total				130

Community-based seed production of enhanced Jethobudho

The planning meeting held on 18 April 2004 proposed an activity to promote the enhanced *Jethobudho* landraces through community-based seed production. Mr Yogendra Prasad Yadav, ASC, Pame, in-charge reported that the PVS and on-farm trials have now created demand for the seed of enhanced *Jethobudho*. The non-participant farmers who visited the PVS plots in 2003 have asked for seed in 2004. Therefore, DADO staff put emphasis on community-based seed production of improved materials by the farmers so that farmer-to-farmer seed distribution could be promoted in future. The meeting proposed a modality of community-based seed production (Figure 2). The custodian *Jethobudho* farmers, under the technical guidance of LI-BIRD, NARC and DADO, expressed their commitment to produce the 1st generation of enhanced *Jethobudho* landrace whereas DADO Kaski showed their keen interest in linking the community-based seed production to the District Self Seed Production Program (DISSPRO).

In 2004, the six custodian farmers (Table 5) have committed to transplant 10 kg of enhanced *Jethobudho* each to produce at least 100 kg of 1st generation seed to produce large-scale second generation of seed and conduct a large number of PVS in 2005.

Similarly, Mr Jayendra Kumar Shrestha, ASC Budhibazar; Ms Subhadra Baral, ASC, Pokhara and Mr Yogendra Prasad Yadav, ASC, Pame of DADO Kaski were very much interested in producing seed for the immediate scaling-up of enhanced *Jethobudho*. Therefore 40 kg of seed were set aside for community-based seed production in 2004. Overall, 60 kg of breeders seed were devoted to large-scale production of breeder seed and foundation seed, 40 kg of seed was used for comunity-based seed production mainly by DADO and 130 kg of seed was used for PVS in 2004.

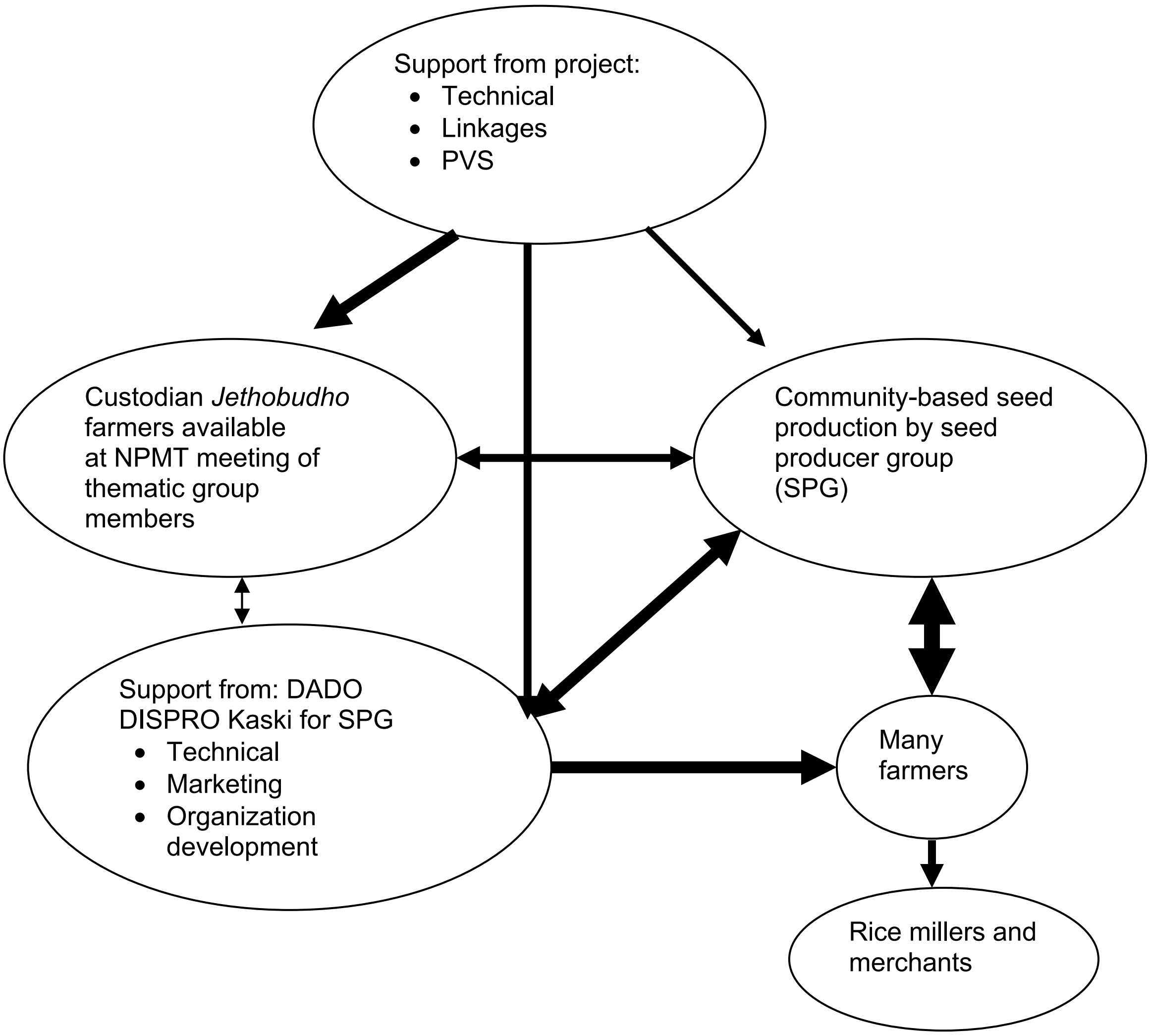

Figure 2. Community-based seed production modality of enhanced *Jethobudho* landraces in Kaski valley, 2004.

Table 5. The breeder seed production activity for enhanced *Jethobudho* by custodian farmers in 2004.

Source of materials	Address	Accessions	Amount of seed (kg)
Dhan Bdr. Karki	Lekhnath, Phalame Dhab-Sisuwa	JB-T-010-025/5	10 kg
Meghnath Subedi	Lekhnath-8, Sisuwa	JB-T-023-030/25	10 kg
Ganga Giri	Kaskikot-7, Pame, Fewa	JB-T-103-237/12	10 kg
Man Bdr. Sunar	Kaskikot-6, Pame, Fewa	JB-T-105-238/5	10 kg
Kedar Pd. Kafle	Pokhara-17 Powerhouse, Biruwa	JB-T-147-296/6	10 kg
Bhim Pd. Baral	Pokahra-7, Maswar, Biruwa	JB-T-168-316/3	10 kg

Conclusions

PVS resulted in quick feedback on farmers' acceptance of enhanced *Jethobudho* in 2003. The results obtained so far indicate that enhanced *Jethobudho* was highly preferred by the farmers for lodging tolerance, neck blast tolerance and superior postharvest qualities. The involvement of scientists, extensionists, farmers and rice millers in the process of planning, implementing and scaling-up of enhanced *Jethobudho* through PVS and community-based seed production will improve farmers' access to *Jethobudho* landraces in future.

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The authors express their sincere gratitude to the farmers of Kaski valley who have maintained the diversity of *Jethobudho* for many years. The kind cooperation of farmers of Kaski valley in the landrace enhancement activity of the *in situ* conservation project is highly acknowledged. Thanks are due to the team of LI-BIRD and NARC *in situ* conservation project for their timely comments and suggestions on *Jethobudho* enhancement. We are thankful to A. Subedi and M.P. Upadhyaya for their sincere cooperation and commitment to this activity. We appreciate the inputs from PPB thematic group and other members of the *in situ* conservation project: A. Mudwari and B.K. Baniya. The untiring and sincere fieldwork rendered by motivators of *in situ* Kaski are highly acknowledged. IDRC (Canada) is sincerely acknowledged for its financial support for this work.

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Jethobudho landrace enhancement V: molecular evaluation of enhanced populations of *Jethobudho* for aroma by SSR

Jwala Bajracharya, Sanjaya Gyawali, Bhuwon R. Sthapit and Devra I. Jarvis

Abstract

Experiences of the global project on "Strengthening the scientific basis of *in situ* conservation of agricultural biodiversity on-farm" demonstrated that the genetic resources with high value and specific traits are well conserved and managed on-farm. A variety of innovative activities with participatory approaches are underway in the study sites to sensitize the farming community to improving local varieties with specific use values for benefits with good incentives. *Jethobudho* enhancement activity is an example initiated by the project to improve its postharvest quality attributes in which aroma is a preferred characteristic in rice; this occurs as a component of 2-acetyl-1-pyroline (2AP). *Jethobudho*, an aromatic traditional rice, deserves its special importance in the Kaski valley of Nepal for its higher postharvest quality traits and premium price for its grain aroma and flavour. In the present study, we used SSR markers to evaluate the enhanced accessions of *Jethobudho* for aroma and compared the trait with other aromatic rices: Azucena, Pusa Basmati and local *Rato Basmati* of Nepal with field fragrance and IR36, a non-aromatic variety. Enhanced accessions carried the same alleles as detected in other check aromatic varieties, but were different from the one in IR36 for RM1 and RM223. Analysis showed that postharvest grain quality traits are positively associated with aroma; this adds value in enhanced *Jethobudho* accessions.

Keywords: *Jethobudho*, aroma, 2-acetyl-1-pyrroline, enhancement, microsatellite markers, market incentives

Introduction

The project on strengthening the scientific basis of *in situ* conservation of agricultural biodiversity on-farm initiated many studies on on-farm conservation of agrobiodiversity through innovative participatory research and has gathered much experience. The enhancement of local rice landraces was one of the research activities started with *Jethobudho* in Kaski and *Kariya Kamod* and *Lalka Basmati* in Bara (see p. 189). Farmers are interested in growing landraces for their particular superior traits such as disease resistance, adaptation to marginal conditions and excellent postharvest traits and these landraces are likely to be well managed, conserved and utilized by the local community.

A range of aromatic landraces of rice is in production on-farm in Kaski. *Jethobudho, Bayerni, Jhunuwa, Biramphool* and *Panhele* are some that are superior to modern varieties in postharvest traits. In Nepal, high-quality rice constitutes the *basmati* type, which dominates the cultivation in mid-hill and *terai* conditions over the other small-grained varieties with aroma like *Jethobudho*. However, these aromatic rice varieties constitute a very small portion of total production, but they are considered important in the Nepalese rice market. *Jethobudho*, a traditional aromatic variety, holds special importance in Kaski for its high value of postharvest quality traits (Gyawali *et al.*, p. 179), good market potential (Sthapit *et al.* 2002) and aromatic flavour on cooking. Therefore, *Jethobudho* enhancement activity was initiated in 1999 by the *in situ* conservation project in order to improve agronomic and postharvest quality traits. Many private entrepreneurs have initiated marketing this landrace by its brand name in the Pokhara valley.

Aromatic rice varieties have become popular owing to their high value trait for aroma and flavour. Among these rice varieties, *basmati* rice is preferred for its unique aroma and the studies on *basmati* rice aroma have shown that it is controlled by a single recessive gene (*fgr*) closely linked to RFLP clone RG28 on chromosome number 8 (Ahn *et al.* 1992; Dong *et al.* 2001; Garland *et al.* 2001) and many markers linked to kernel elongation to chromosome 8 have been mapped (Ahn *et al.* 1993; Lorieux *et al.* 1996). Others have concluded that there are two or three recessive or dominant genes for development of this trait due to the volatile compound 2-acetyle-1-pyrrolline (AcPy) in chromosome 8 (Nagarju *et al.* 1975). Microsatellite DNA (Simple Sequence Repeats, SSRs) markers like RM223, RM42, RM33 and RM85 mapped in chromosome 8 have been successfully used for varietal identification in rice for aroma (Chen *et al.* 1997; Cho *et al*. 2000; Temnykh *et al*. 2000). Besides, many markers have shown association with trait for aroma in rice (Nagarju *et al.* 2002; Dr K.A. Steele, pers. comm.). High milling and cooking qualities are the important traits positively associated with aromatic scented rice (Nagarju *et al.* 1975). Therefore, we tried to evaluate seven enhanced *Jethobudho* accessions for aroma using SSR markers and compared the fragments for aroma with check aromatic and non-aromatic rice varieties of different origins.

Materials and methods

Microsatellite analysis

Seven enhanced *Jethobudho* accessions were evaluated for aroma along with three known aromatic varieties: Azucena (a *japonica,* IRRI), Pusa Basmati 1 (Kernel, Super, India), Nepalese local *Rato Basmati* (red, fine kernels with fragrance in field) and IR36 (an *indica,* non-aromatic, IRRI) (Table 1). DNA was isolated from 0.1 g leaf tissue of four individual seedlings (for enhanced JB accessions) and also in bulk carried out using equal proportions of leaves of the same four young seedlings of each accession/check varieties. Leaves were ground in liquid nitrogen with a pestle and mortar and Qiagen DNeasy kits (Qiagen, Crawley, West Sussex) were used according to the manufacturer's instructions (Qiagen 1999). Microsatellite analysis was carried out with 7 SSR primers distributed in rice genome showing association with trait for aroma in rice using the amplification and analysis procedures developed by McCouch *et al.* (1997) and Bajracharya (2003). Markers examined were RM223 and RM42 in chromosome 8 (Chen *et al.* 1997); RM1 (Chromosome 1), RM241, RM348 (chromosome 4) and RM202, RM229 (chromosome 11) (Nagarju *et al.* 2002, and shared experiences of Dr K.A Steele on adulteration of aromatic *basmati* rices, CAZS, University of Wales, UK).

Table 1. Names of the custodian farmers of Jethobudho and respective accessions used in landrace enhancement in *in situ* activity in 2004.

Name of farmer	Address	Accession	Physical acceptance	Organoleptic weightage
Dhan Bdr. Karki	Lekhnath Phalame Dhab-Sisuwa	JB-T1-010-025/5	Excellent	427.5
Meghnath Subedi	Lekhnath-8, Sisuwa	JB-T2-023-030/25	Excellent	465.0
Ganga Giri	Kaskikot-7, Pame, Fewa	JB-T3-103-237/12	Excellent	427.5
Man Bdr. Sunar	Kaskikot-6, Pame, Fewa	JB-T4-105-238/5	Excellent	427.5
Kedar Pd. Kafle	Pokhara-17 Powerhouse, Biruwa	JB-T5-147-296/6	Excellent	420.0
Bhim Pd. Baral	Pokahra-7, Maswar, Biruwa	JB-T6-168-316/3	Excellent	450.0
Bulk of 30 accessions	Selected from 143 accessions	JB-T7	Excellent	
Azucena	*Japonica* type (IRRI)		Aromatic	
Pusa Basmati-1	An Indian rice		Fine, aromatic	
Rato Basmati	A local of Nepal		Fine, red kernel, aromatic	
Check sample		IR36 (*Indica* type (IRRI))		

Source: Gyawali *et al.*, p. 189.

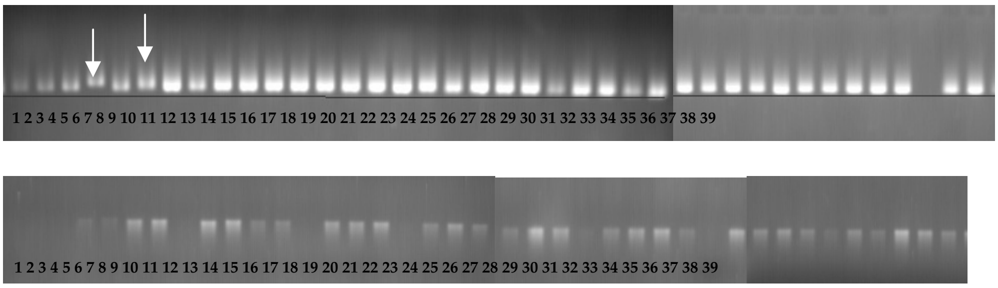
Data analysis

Alleles were recorded for each sample and each marker. Fragments of different sizes were scored as different alleles and presence (1) or absence (0) of each allele was recorded for each accession and compared for fragment size with the check aromatic and non-aromatic varieties. Data were converted into a binary matrix according to presence/absence of each allele. The software NTSYS-pc (Exeter Software) was used. A pair-wise similarity matrix was calculated using Jaccard's coefficient and employed to construct a dendogram (Rohlf 1992) to show the relationships for aroma. Polymorphic information content (PIC) values, also called Nei's gene diversity, were calculated for each microsatellite marker based on the allelic frequency (Nei 1973).

Results

Genetic relationships among seven enhanced *Jethobudho* accessions and four different aromatic and non-aromatic check varieties for aroma were detected by the allelic data of 2 SSR loci (RM42 and RM223) mapped in the location of RFLP probe RG1–RG28 linked to aroma in chromosome 8. In addition, 5 other markers (RM1, RM202, RM229, RM241 and RM348) were used to understand the allelic behaviour of *Jethobudho* enhanced accessions and compare the alleles with that of check varieties under study.

All bulked and individual samples of enhanced accessions of *Jethobudho* were found similar at these two loci and also had the same alleles as check aromatic varieties: Azucena, Pusa Basmati-1, Rato Basmati local, but were different from IR36 at these loci (Figure 1). IR36 had the allele different from the alleles in Azucena, Pusa Basmati-1, Rato Basmati and *Jethobudho* accessions for RM223 except an individual DNA sample with big-sized allele (shown by arrow in Figure 1a). Reported size of PCR products for RM223 in Azucena was 150bp. But RM42 was observed monomorphic with the same product size across the *Jethobudho* accessions and check varieties included in the study. *Jethobudho* had 2 alleles, one similar to aromatic checks (Azucena, Pusa Basmati-1, Rato Basmati) and one different from both Azucena and IR36 at the polymorphic locus for aroma RM223.



a

b

Figure 1. Agarose gel electrophoresis of SSR products amplified using primers (a) RM223 and (b) RM42 mapped close to probe RG28 and linked to fragrance gene (fgr) for aroma in rice. The genetic structures of 7 selected Jethobudho populations for aroma were compared with aromatic scented and non-aromatic rice varieties. (Lanes 1-4 were Azucena, Basmati, Pusa Basmati, IR36, and lanes 5-39 were individual DNAs and bulk DNA of 4 individuals of JBT1-JBT7 enhanced accessions).

However, other markers were observed polymorphic, both among the aromatic varieties in check and *Jethbudho* enhanced populations (Table 2). Association among the enhanced *Jethobudho* populations and the aromatic and non-aromatic rices in check as revealed by UPGMA cluster analysis is presented in Figure 2. All the enhanced *Jethobudho* populations except JB3 (JB-T3-103-237/12) grouped into a cluster and showed close association with Azucena for aroma traits. *Jethobudho* populations were found with unique bands for most of the markers studied. However the JB3 behaved similarly to Pusa Basmati-1, Rato Basmati local and IR36.

Table 2. Microsatellite markers and their gene diversity (PIC) based on fragment's approximate size measured among enhanced *Jethobudho* accessions and three check aromatic rice varieties.

SSRs	Chromosome	Number of alleles			PIC content
		Jethobudho accessions	Aromatic check vars.	Total	
RM1	1	3	2	3	0.46
RM241	4	2	1	2	0.48
RM348	4	2	2	2	0.40
RM42	8	1	1	1	0.00
RM223	8	2	1	2	0.18
RM202	11	2	1	2	0.18
RM229	11	2	3	3	0.46

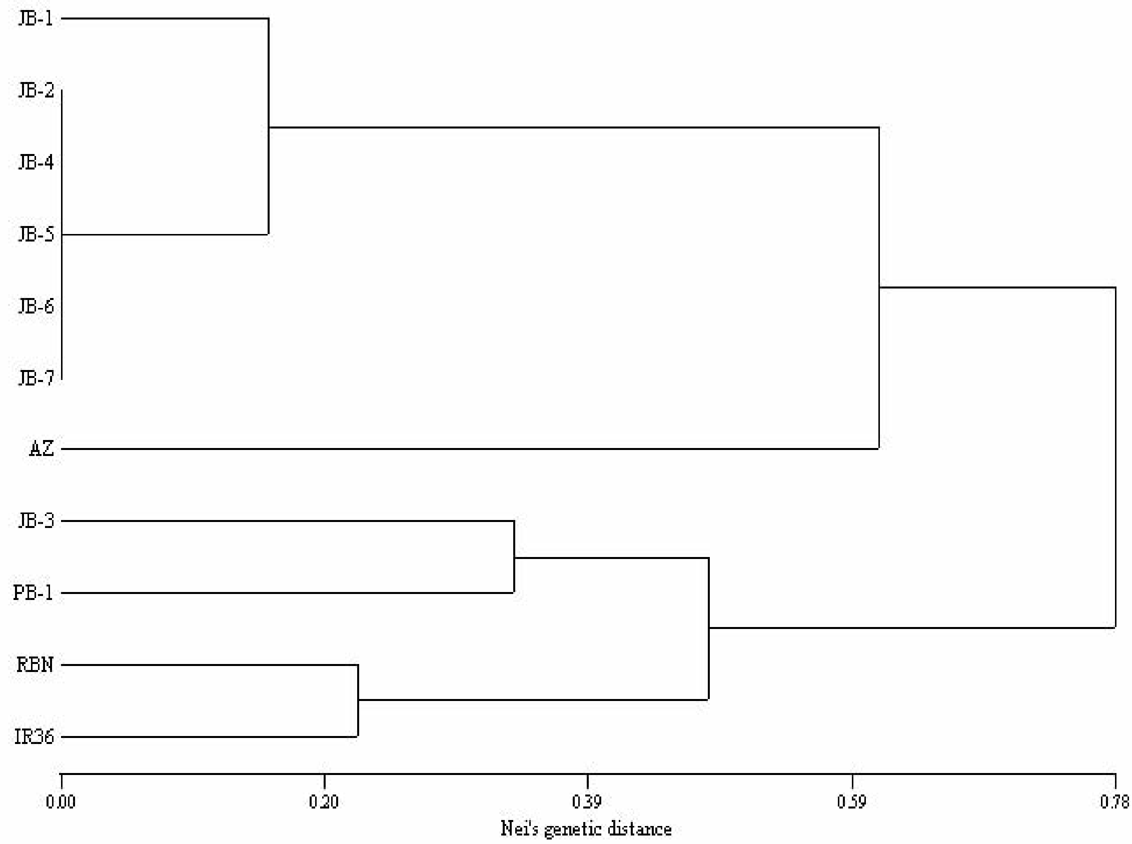


Figure 2. Dendogram of seven *Jethobudho* enhanced accessions compared with aromatic and non-aromatic rice varieties based on SSRs associated with trait for aroma using UPGMA clustering.

Discussion

This result indicates that enhanced *Jethobudho* accessions are improved for both postharvest qualitative traits and the trait for aroma, and are quite similar for this trait with well-known *indica* and *japonica* aromatic rice varieties. The close relationship between the traditional Basmati rice varieties suggests that these cultivars may have been derived from within a single population, which is consistent with their breeding histories and known pedigrees. The crossbred variety (Pusa Basmati–1) showed similarity with the traditional aromatic landraces of Nepal (*Jethobudho* and Rato Basmati). This may be indicative of differential levels of genetic content from their respective *indica* and Basmati rice parents. Traditional landrace varieties (Azucena and cross-bred Pusa Basmati–1) shared the same alleles at the aroma locus and adjoining loci on chromosome 8, which indicates that the aroma locus remained distinct and these markers could be used in identification of the aromatic group of rice landraces. However, the results are limited to a small number of markers, so to improve the precision and efficiency there is a need to carry on with more markers associated with trait for aroma and to map genes/QTLs for grain-quality traits in our landraces.

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Participatory plant breeding: a strategy of *in situ* conservation of rice landraces

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Abstract

Participatory plant breeding (PPB) has been considered a strategy of *in situ* conservation of local landraces at genetic level. However, there is a lack of evidence that PPB approaches are effectively employed and have conserved the farmers' preferred traits in landraces. In Nepal, we have employed PPB in rice for *in situ* conservation of local landraces in Kaski and Bara districts. Diversity fairs and four-square analyses were used to locate and identify the local parents. The farmers and scientists rigorously analyzed the positive and negative traits to set the breeding goals. Our experience shows that the complementary parents also need to be selected using four-square analyses to achieve greater successes from PPB programmes. A few cross and large population (>25 000 plants) were maintained in $F_{3\text{-}5}$ generations to select the rare segregants from segregating populations. To encourage farmers' selections in early generations, modified bulk breeding was employed in *Mansara/Khumal* 4, *Ekle/Khumal* 4 and *Pusa Basmati-1/Jethobudho* crosses. The bulks were modified based on grain colour, maturity and grain type, respectively and selection based on these traits was effective. Postharvest quality traits were employed to screen these crosses. Farmers' participation in PPB programmes has been enhanced by training, exchange visits and mobilization of PPB groups at field level.

Key words: Bulk breeding, *in situ* conservation, participatory plant breeding (PPB), landraces, rice

Introduction

Participatory Plant Breeding (PPB) has been considered as a technical strategy to conserve local genetic resources that are endangered or are on the verge of extinction from their habitat by adding value to them. The project aims to demonstrate that value of farmer-identified landraces, survival of some of which is threatened, is added by the PPB process. PPB offers skill and opportunity to farmers in searching new diversity, selection and exchange of variable populations that match their local preferences and needs. Under PPB, both the farmer and breeder share the selection of segregating populations from the earliest stages. From the standpoint of conservation, PPB has been advocated as a way to maintain or even enhance the level of genetic diversity deployed on-farm. This is argued because PPB is able to breed divergent cultivars for environments that differ on a fine scale, and for diverse uses and because PPB is a way to add value to traditional landraces that would otherwise disappear (Sthapit *et al.* 2001). On the other hand, the success of the products of PPB may stem from the addition of just a few major genes (e.g. for pest resistance or plant height). Their inclusion into some local lines may swamp a significant fraction of local diversity, leading to a short-term gain in productivity, the loss of local unimproved populations and increased vulnerability. PPB is so recent that relatively little can be known about its impact on the conservation of crop biodiversity. The plant mating system is a crucial parameter that affects the predicted outcome of changes in crop-improvement systems. Thus self-pollinators such as barley and rice in isolated or marginal areas may have landraces closely adapted on a fine-scale and the shift from traditional populations to PPB effectively increases geneflow in them. On the other hand the maize system is relatively open with high levels of seed exchange, and a shift to PPB may require more efficient mass selection and less geneflow, both of which can lead to less diversity. It will be important, therefore, as an adjunct to PPB schemes, to define conservation concerns, delineate the research needed to test those concerns and a strategy to meet them. This study is now focusing on self-pollinated rice crop. However, there is a need to measure impact of PPB on the change of genetic diversity over time at village and landscape levels. The PPB activities in the *in situ* project were initiated with the following research questions to be answered:

- Can farmer cultivars, per se, be conserved *in situ*?
- Can PPB contribute to the enhancement and conservation of landrace diversity *in situ* and provide benefits to the community?
- Can genetic improvement be achieved without loss of genetic diversity?

This paper presents preliminary results from the PPB programme in Begnas (600–1400 m), Kaski. Based on the objectives of enhancing biodiversity and production, the methodological constraints of participatory approaches in setting breeding goals, breeding methodology and strategies of PPB in the context of biodiversity enhancement and production have been discussed. The paper also documents: (1) how the needs of farmers can be integrated with the objectives of biodiversity enhancement when breeding goals are set, (2) how useful genetic diversity can be developed by bringing in new and restoring old, (3) generating new genetic diversity (local × exotic) in the agroecosystems, and (4) developing PPB methodologies in the context of adding value to the landraces through crop breeding in Nepal.

Processes of participatory plant breeding[24]

The PPB steps used in the project are listed below:

- Locating agroecosystems and identifying interested communities
- Organizing diversity fairs for locating crop genetic resources and local knowledge
- Understanding local crop diversity
- Monitoring diversity through a community biodiversity register (CBR)
- Developing options for adding benefits
- Setting breeding goals for PPB
- Agreeing on roles among stakeholders in the breeding process
- Developing PPB methodologies and selection strategy
- Strengthening farmers' skill in selection and seed system for rapid diffusion.

Setting breeding goals and selecting landrace parents for PPB

In low-cross-number strategy, an enormous amount of information about parents is required. In PPB, an essential part in selecting parents is that the selected materials should be locally adapted, exposed to farmers and adopted by farm households. Witcombe and Virk (2001) have demonstrated participatory variety selection being used as the first step of selecting desired parents whereas diversity fair and four-square analysis are reported effective when the breeding objective is *in situ* conservation of landraces (Sthapit *et al.* 2001). In all cases, the researchers need to work closely with the farmers to generate maximum information to select the desired parents.

Lessons learned on selecting desired parents

In breeding programmes the parents are selected on the basis of evaluation of either parents or progeny testing. Information generated from Participatory Variety Selection (PVS) programmes is very informative to the breeder for selection of parents (Gyawali *et al.* 2002) since PVS provides feedback on many positive and negative traits of a variety evaluated under farmers' field conditions. A variety selected through PVS or a common local landrace is an ideal parent, since it has local adaptation and traits that farmers prefer, for which other

[24] Adapted from Sthapit *et al.* (2001).

parents with complementary traits must be found. In PPB of the *in situ* conservation project of Kaski valley, the landrace selection was extremely rigorous through four-square analysis where positive and negative traits of individual landraces were critically analyzed with the farmers (Sthapit *et al.* 2001). The researchers facilitated the farmers in taking a lead in setting the breeding goals (Table 1). The selections of eight and four landraces in Kaski and Bara, respectively, were used in crossings based on the criteria developed by farmers and researchers jointly through four-square analysis (Tables 2 and 3). However, the selection of improved parents was less rigorous compared with landraces. Upon analysis of negative traits to be improved in landraces, most of the breeding goals for each crosses were quite different from the breeding goals of conventional systems such as improvement in straw yield, grain sterility, adaptation to warm water, lodging, eating qualities (postharvest quality traits), etc. In this context, the four-square analysis of exotic or improved parents would be useful to select the best complementary parents for a breeding programme with complex breeding goals.

Low cross and high population size

Many interested nodal farmers who were willing to contribute to the selection from segregating population were identified. The F_2 and F_3 seeds of crosses made in PPB programmes were provided to the farmers with an initial 1-day orientation on segregation, heritability, selection techniques, genetic gain and crop breeding methods in simple language. However, in 2001, scientists, collaborating farmers and nodal farmers, during a traveling seminar, realized that the small population sizes were not perceived by farmers to be very promising. Therefore, the PPB team decided to get back the seed from farmers and maintain a larger population size in rented blocks. A large population of segregating generations (F_{3-5}) was maintained in farmers' fields to recover rare segregants as it was observed that in small population sizes, farmers' perception on segregating population would not be very promising because of the low frequency of desired recombinants as well as problems with rats and birds.

Selection under farmers' management conditions

The PPB bulks of segregating generations (F_{2-6}) were grown under farmers' management conditions with an objective of screening PPB materials in target populations of environments (TPEs). For example, *Ekle* was reported to be very poorly adapted to warm water and one of the breeding goals of this cross was to select for the better adaptive progenies under both warm- and cold-water conditions. Therefore, *Ekle* was screened under farmers' management conditions in target environments having both warm and cold water sources. To achieve this, farmers were consulted to identify the appropriate TPEs required for particular crosses in Kholakochheu and Begnas sites in Kaski and Kachorwa in Bara. In a later stage of the programme, PPB groups (composed of interested local farmers) were formed in Kaski whereas ADCS organized field trials with technical support from field staff. The farmers' PPB group helped field technicians to locate the research plots as well as interested farmers for screening PPB materials. The field activities planned by these groups included seeding, transplanting, selection from segregation population, traveling seminar and monitoring of collaborative breeding. The summary of selection under farmers' management conditions for 2002, 2003 and 2004 has been presented in Tables 4, 5 and 6.

Table 1. Local parents, their valued traits, and negative traits to be improved using improved donors in PPB of *in situ* programme.

Local parent	Valued traits	Negative traits to be improved in landrace	Male parents	Negative traits in improved varieties
Anga	Drought tolerance; adapted to poor soil fertility; has medicinal value; soaked rice is perceived as coolant in heat stress; straw has similar effect on animals	Low yield; short panicles; low straw yield	NR 10291	Farmers' preference not known; postharvest traits not known
Biramphool	Fine and aromatic rice; good cooking and eating qualities; adapted to lowlands (Dhab) and low hills	Short panicle; grain sterility; low yield	Himali	Susceptible to blast; poor adoption in hills
Ekle	High tillering and high yielding; tall plant and good straw; good postharvest qualities; adapted to hills	Sparse grain in panicle; poor adaptation to warm water; long maturity; susceptible to drought	Kumal 4	
Jethobudho	High cooking quality, aromatic; good straw yield; cool water tolerant	Lower yield; blast susceptibility; susceptible to lodging	Pusa Basmati-1	Low yield; poor rice recovery; susceptible to blast; not adapted in hills
Mansara	Tolerant to drought and poor soil fertility (marginal) conditions	Poor eating qualities; low yield	Kumal 4	
Naulo madhise	Adapted to rain-fed and hill farming; easy threshability	Low yielder and poor response to fertilizers; higher sterility	IR 36	Not adapted to hills
Sano Gurdi	Good postharvest qualities; soft straw	Low tillering; grain sterility	NR 10285	Farmers' preferences not known; no exposure to farmers
Thulo Gurdi	Higher straw yield and excellent for mat-making; good postharvest qualities of old stocked rice; high yield potential and adapted to hill farming	Low tillering; poor response to fertilizer	NR 10286	Farmers' preference not known; no exposure to farmers

Adapted and modified from Sthapit *et al.* (2001).

Table 2. The population size of each cross in F_3 generation in Kaski, 2002.

Cross	Kholakochheu		Begnas		Total pop.
	Area (m^2)	Plant Pop.	Area (m^2)	Plant Pop.	
Pusa Basmati/ Jethobudho†	500	16667	250	8333	25000
Biramphool/Himali	500	16667	250	8333	25000
Naulo Madhouse/IR 36	100	3333	50	1667	5000
Thulo Gurdi/NR 10285	250	8333	500	16667	25000
Mansara/Khumal 4	150	5000	700	23333	28333
Anga/NR 10291	–	–	250	8333	8333
Ekle/Khumal 4	250	8333	250	8333	16667
Sano Gurdi/NR10285	250	8333	500	16667	25000

† F_4 generation.

Table 3. The population size of each cross in F_3 generation in Kachorwa, Bara, 2002.

	F_3 generation in 2002		F_4 generation 2003	
Cross	Area (m^2)	Plant Pop.	Area (m^2)	Plant Pop.
Lajhi/Rampur Masuli	91	6067	350	23333
Lajhi/IR 62161	20	1333	75	5000
Mansara/IR 62161	443	29533	150	10000
Dudhisaro/BG 1442	140	9333	60	4000
Lalka Basmati/IR 59606	0.045	3	10	667

Table 4. Name of the cross, generations, selected types of PPB Kaski and crosses advanced through shuttle breeding in Taruwa village of Nawalparasi district in 2002.

Cross	Generation	Selected type	Total seed (g)	Selected location	Seed in shuttle breeding† (g)
Pusa Basmati-1/*Jethobudho*	F_4	*Pusa Basmati*–1	272	Begnas	0
Pusa Basmati-1/*Jethobudho*	F_4	*Pusa Basmati*–1	106	Kholakochheu	0
Pusa Basmati-1/*Jethobudho*	F_4	*Jethobudho*	560	Kholakochheu	360
Pusa Basmati-1/*Jethobudho*	F_4	*Jethobudho*	500	Begnas	250
Pusa Basmati-1/*Jethobudho*	F_4	*Masuli*	238	Kholakochheu	0
Mansara/*Khumal* 4	F_3	*Mansara*	2097	Begnas	1113
Mansara/*Khumal* 4	F_3	*Khumal* 4	916	Begnas	420
Ekle/*Khumal* 4	F_3	Medium maturity	304	Kholakochheu	0
Ekle/*Khumal* 4	F_3	Early maturity	123	Kholakochheu	0
Ekle/*Khumal* 4	F_3	Early maturity	220	Begnas	110
Ekle/*Khumal* 4	F_3	Medium maturity	307	Begnas	157
Ekle/*Khumal* 4	F_3	*Ekle* maturity	276	Begnas	140
Thulo Gurdi/NR 10286	F_3	Bulked seed	773	Begnas	0
Thulo Gurdi/NR 10286	F_3	Bulked seed	295	Kholakochheu	0
Biramphool/*Himali*	F_3	Bulked seed	416	Kholakochheu	0
Biramphool/*Himali*	F_3	Bulked seed	366	Begnas	186
Naulo Madhouse/IR 36	F_3	Bulked seed	450	Begnas	0
Naulo Madhouse/IR 36	F_3	Bulked seed	500	Kholakochheu	0
Sano Gurdi/NR 10285	F_3	Bulked seed	390	Begnas	0

† Shuttle breeding was initiated to advance some of the PPB *in situ* materials in Taruwa, Nawalparasi in winter season and the harvest (advanced generation) was screened under the target environment.

Table 5. Name of the cross, generation and number of hills selected in PPB rice in Kaski in 2003

Cross	2003				2004	
	Bulk /hills	Generation	Total area (m^2)	Plant pop	Bulk /hills	Generation
Pusa Basmati-1/*Jethobudho*	Bulk	F_6	1667	111133	Bulk + 40 hills	F7
Mansara/*Khumal* 4	Bulk	F_5	700	46600	Bulk + 99 hills	F_6
Ekle/*Khumal* 4	Bulk	F_5	650	43300	Bulk + 48 hills	F_6
Biramphool/*Himali*	Bulk	F_5	700	46600	Bulk + 74 hills	F_6
Thulo Gurdi/NR10286	Bulk	F_4	750	50000	56 hills	F_5
Sano Gurdi/NR10285	Bulk	F_4	250	16600	50 hills	F_5
Naulo Madhise/IR36	Bulk	F_4	200	16600	30 hills	F_5

Table 6. Name of the cross, generation and number of hills selected in PPB rice Kachorwa, Bara in 2003.

Cross	Generation	Selections	Selected from
Lajhi/*Rampur Masuli*	F_4	91 hills	Bulk (64) †
Lajhi/IR 62161	F_4	21hills	Bulk (21)
Mansara/IR 62161	F_4	52 hills	Bulk (36)
Dudhisaro/BG 1442	F_4	36 hills	Bulk (36)
Lalka Basmati/IR 59606	F_4	Rejected	

† Figures in parentheses are number of hills selected from farmers' collaborative breeding.

Breeding methods

Modified bulk breeding methods

Modified bulk breeding and pure line selection from bulk breeding method were used in the present study (Figure 1). In modified bulk breeding method, the bulk derived from cross *Mansara/Khumal 4*, *Pusa Basmati*-1/*Jethobudho* and *Ekle/Khumal* 4 was divided into three groups based on the grain type and colour at F_3 generation (Table 7). For example the cross *Mansara/Khumal* 4 was modified into *Mansara* type (dark red pigmented colour), intermediate (faded red colour) and *Khumal* 4 type (straw colour). The target population of traits (TPTs) was identified in focus group discussion during a traveling seminar in order to develop these modified bulks in early generations. Farmers identified the best plants from the bulks based on the grain type and colour while modifying the bulks and they were requested to select the desired plant types out of large population sizes.

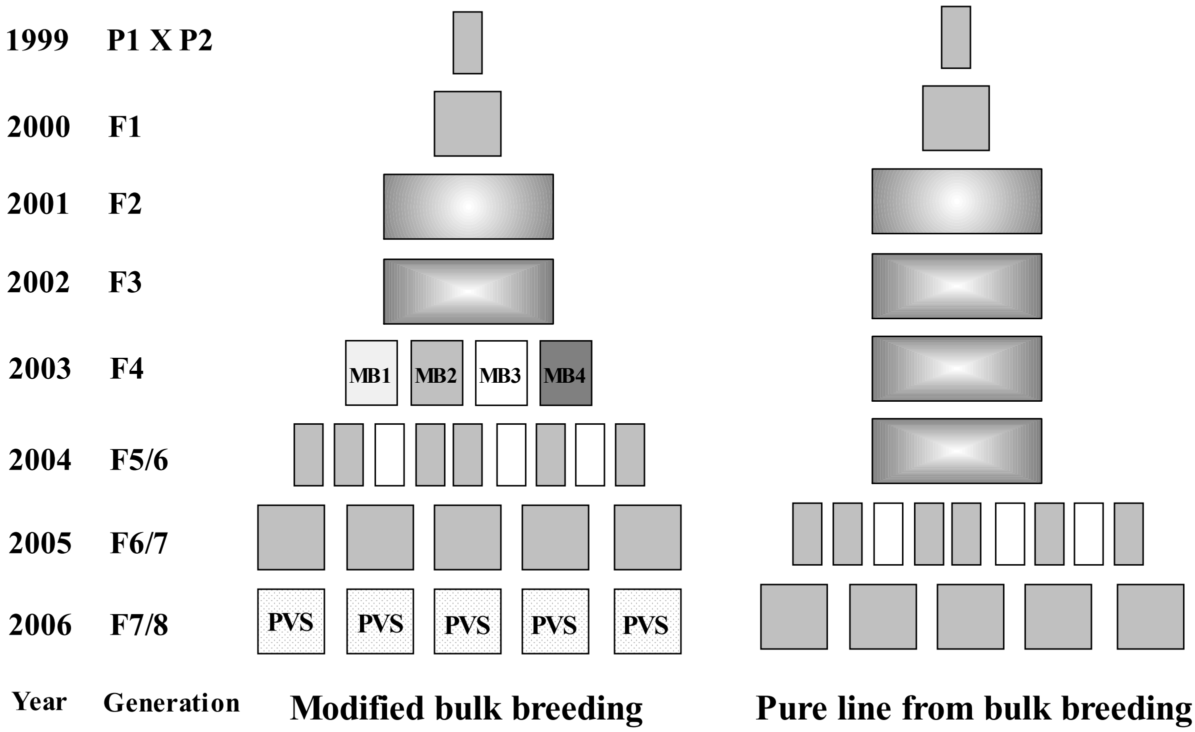

Figure 1. Modified bulk and pure line from bulk breeding method used in PPB in rice in Kaski (adapted from Gyawali *et al.* 2002).

Table 7. Name of the cross, traits used in bulk modification and bulk types in three PPB crosses in Kaski in 2002.

Cross	Modified bulks based on:	Number of bulks	Bulk type
Mansara/*Khumal* 4	Grain colour	3	Deep red colour, *Mansara* grain colour, straw coloured
Pusa Basmati-1/*Jethobudho*	Grain type	2	*Jethobudho* grain type, *Pusa Basmati*-1 grain type
Ekle/*Khumal* 4	Maturity	3	Early maturity, medium maturity, *Ekle* maturity (Late)

Pure line from bulk

The crosses except *Mansara/Khumal* 4, *Pusa Basmati-1/Jethobudho* and *Ekle/Khumal* 4, were selected using consultative-pure line from bulk breeding (Figure 1). Similarly, all crosses in Bara were selected using pure line bulk breeding. The best plants were selected by the team of farmers, field technicians and breeders jointly to form the bulk until the bulk reached F_5 generation. In F_5-$_6$ generation the best hills were derived which were near-pure lines and grown in family rows in the next season (2004) (Tables 5 and 6). The pure line from bulk breeding is an easy and effective method that has been very successfully employed in PPB in high-yield potential production systems in Chitwan (Gyawali *et al.* 2002). In this method, farmers can select the desired plant types that meet their specific needs through one generation of selection from heterogeneous but near-homozygous bulks. Also the selection of pure line from heterogeneous bulk by farmers started at F_5-$_6$ depending upon the selection pressure of the population, which avoids the drudgery of selection of segregants each year in early generation.

Farmers' participation

Collaborative breeding by farmers on *Mansara/Khumal* 4

In 2002, the seed of segregating materials taken back from farmers to maintain the larger plot size was received and selected for rare segregants from the population of modified bulks. The populations were grown in large rented block (>25 000 plants maintained) and farmers were invited to select within the segregating bulks. Mr Bharat Raj Tiwari selected some of the attractive panicles from the rented block of *Mansara/Khumal* 4 crosses and advanced the materials in his farm. The neighbours of Mr Tiwari noticed rice bulk looking similar to *Mansara* but promising for higher grain yield with larger panicles and higher grain per panicle in his field. The neighbours regularly observed his field and asked the source of seed in 2003. Farmers were very much attracted towards this cross. In 2003, five more farmers—Ms Ganga Adhikari, Mr Manahari Kandel, Mr Rudranath Adhikari, Mr Lilanath Dhakal and Ms Sarita Tiwari—selected panicles from this cross. The population size of this cross was considerably high in F_2 and succeeding generations. This perhaps led to the segregation of more rare segregants where researchers and farmers picked up those genotypes from the population. Similarly, Buddhi Sagar Tiwari from Ralmare (a farmer from outside the PPB village) received 4 kg seed (remnant seed) from the rented block of *Mansara/Khumal* 4 cross that he tested in his farm in 2004. Farmer-selected bulks were compared with local *Mansara* and it was found that the selected bulks were more drought tolerant and had higher grain yield with improved eating quality.

PPB group at community level

Members of the National Project Management Team (NPMT) as well as participating farmers, scientists and thematic leaders suggested during a traveling seminar in 2003 that the farmers' participation in PPB activities needed to be strengthened. Therefore a PPB group at each PPB villages in Begnas and Kholakochheu was formed to mobilize interested farmers. The roles and responsibilities of farmers within the proposed PPB group were discussed and interested farmers were selected for the PPB group. The field technicians, plant breeders and PPB thematic leaders were identified as advisors to the PPB group.

Two PPB groups have been formed in each project village in Begnas and Kholakochheu. The PPB group at community level was encouraged to identify interested farmers for on-farm trials with increased farmer participation in PPB activities. In 2004, the local PPB group led the planning of various field activities such as plot selection for screening the breeding materials, selection of farmers, seed distribution, coordinating with field staff on seeding and transplanting of field trials, monitoring of farmers' selection and farmer-to-farmer flow of genetic materials, field-level planning for a traveling seminar, training and exchange visits.

In 2004, the PPB group visited Chitwan to share and learn from the experiences of farmers of different PPB projects of LI-BIRD.

Training in the PPB programme

Training is an important component of the PPB process where farmers' participation and their interest could be enhanced for effective and efficient selection. Therefore, orientation training was organized at each site, led by a plant breeder in 2001. Later on, it was realized that the genetics of crop improvement, segregation, heritability and selection differentials were difficult for farmers to understand. Therefore, a breeder-farmer (Mr Dev Raj Sapkota, from the PPB program in rice in the high-potential production system in Chitwan) and Mr Surya Adhikari (farmer from Begnas site) were invited to share their experiences in collaborative rice breeding. The interaction was found to be very effective since farmers could understand their colleagues' language and shared experiences. Realizing the importance of this kind of interaction, the PPB group organized exchange visits. In 2002, farmers from Kachorwa site also visited the PPB programme in Chitwan and shuttle breeding in Taruwa, Nawalparasi. Similarly, farmers of the PPB group from Pokhara valley visited the Chitwan PPB programme in 2004. These exchange visits and training led by PPB farmers were found to be extremely important in sensitizing and encouraging farmers to learn skills on selecting plants from segregating populations.

Postharvest evaluation

Postharvest quality traits are important criteria of PPB in *in situ* conversation. Most of the local parents (*Jethobudho, Biramphool*, *Ekle, Sano Gurdi* and *Thulo Gurdi*), have superior grain quality but need improvement in other traits, whereas in *Mansara* and *Naulo Madhouse*, the breeding objectives were better cooking and eating qualities. The milled grains from the remnant seed of bulk harvest from crosses like *Mansara/Khumal* 4, *Pusa Basmati*-1 / *Jethobudho* and *Biramphool/Himali*, were provided to farmers for organoleptic evaluations. Farmers' responses were recorded for each of the bulks. It was found that the *Mansara* grain type bulk was superior for its grain quality as compared to faded coloured *Mansara and Khumal* 4 type, which the farmers decided to advance in 2004. Similarly, the bulk of *Biramphool/Himali* was also found excellent for its postharvest quality traits.

Traveling seminar

A transect walk during a traveling seminar was very effective in monitoring the PPB activities by scientists and farmers and to share their experiences. The seminar was very constructive for the plant breeders and farmers who are directly involved in the PPB process. It also helped farmers to understand various crop improvement related techniques, procedures and methods employed in the breeding process. The discussions with professionals at the end of the transect walk are of special importance for PPB groups to plan activities for the next crop cycle. At least one traveling seminar was organized in each crop cycle before or at maturity of the rice.

Discussion

Participatory plant breeding as a strategy of *in situ* conservation of local landraces was employed in strengthening the scientific basis of *in situ* conservation of agrobiodiversity project implemented in Kaski and Bara ecosites in Nepal. The PPB process of *in situ* conservation started much earlier than crossing parents and selection. The diversity fairs and four-square analysis were conducted to locate the diversity of rice landraces in project sites. The four-square analysis helped scientists to understand the existing diversity of landrace and set the breeding goals for the PPB programmes. The positive and negative traits of each landrace were documented and understood. Therefore, the understanding of landrace diversity in space and time is important to set the breeding goal. The rigorous analysis of landraces identified the traits to be improved in a target population in a selected variety. In many cases, these traits may be unexpected, e.g. pericarp colour in rice (Sthapit *et al.* 1996), easy threshability in rice (Joshi *et al.* 2002), milling and organoleptic traits (Gyawali *et al.* 2002). In the present PPB programme, the goal settings of individual crosses were extremely rigorous (Table 1) as compared to PPB explained elsewhere. The four-square analysis conducted jointly by farmers and scientists helped in identifying the local landrace as one of the parents in PPB programme. However, it was realized that the selection of complementary parents was not as rigorous compared with that for the local landraces. The thematic leader of PPB activity and rice breeders were requested to select the complementary parents based on individual knowledge. For example, *Pusa Basmati-1* was selected as a complementary parent to *Jethobudho* but *Pusa Basmati-1* lacked blast resistance and its yield potential is also not comparably higher. In contrast to this, *Khumal* 4, which has *Pokhreli Masino* (local landrace) as an important donor parent in it, was selected wisely to contribute the yield components as well as grain quality traits to the *Mansara* and *Ekle* landraces. The rigorous selection of complementary parents is also extremely important in such PPB programmes where the target population of traits (breeding goals) was complex and mostly governed by quantitative traits.

The PPB programme used eight and five carefully chosen crosses in Kaski and Bara, respectively. Therefore, the breeding theory was based on low cross number / large population size. The population size of the F_2 generation was realized as being extremely small during the traveling seminar and farmers' perception on segregating population in small size was not very promising in 2001. Therefore, the population sizes of each crosses increased in subsequent generations by getting the seeds of $F_{3\text{-}4}$ back from farmers and planting them in the rented blocks (Tables 3 and 7). In some crosses, the population size reached >25 000 plants per generation. The PPB team (farmers and scientists) has now realized that the performance of the crosses whose population was larger is extremely encouraging. For example, the *Mansara/Khumal* 4, *Biramphool/Himali* in Kaski and *Lajhi/Rampur Masuli* and *Mansara*/IR62161 in Bara were grown in larger population sizes. It was found that the large population size resulted in rare segregants/recombinants in the populations. Therefore, farmers were very enthusiastic about selecting the desired plant types from these crosses.

Farmers' selection was based on and effective for visible traits such as plant height, grain colour and days to maturity (Table 7). Therefore, selection for yield components was delayed until $F_{5\text{-}6}$. The modified bulk breeding and pure line from bulk breeding methods (Figure 1) were used as explained by Gyawali *et al.* 2002. The bulks whose population sizes were large enough to advance the generations (Table 7) were modified based on farmers' preferred traits in the crosses. For example, *Mansara/Khumal* 4 was modified on the basis of grain colour in F_3 generation because the farmers preferred *Mansara* grain colour over straw colour. Furthermore, major genes governed the grain colour, and farmers' selections on the basis of these traits were effective in early generations. Similarly, *Ekle/Khumal* 4 and *Pusa Basmati-1/Jethobudho* were modified in F_4 on the basis of maturity and grain types, respectively.

Farmers' collaborative breeding in early generations using F_3 and F_4 bulks was employed in the PPB process (Table 4). However, it was realized later that the small population size maintained by the farmers in collaborative breeding was not effective. The traveling seminar in 2002 decided to pool back the segregating bulks and grow the pooled materials in large populations in rented blocks. Several farmers selected desired plants from the large population of *Mansara/Khumal* 4 and *Pusa Basmati*-1/*Jethobudho* crosses after being impressed by some of the rare segregants within these crosses. The monitoring of farmers' selections would help breeders understand the relationship with TPT and TPEs in PPB in Kaski and Bara.

Pure lines from bulk breeding methods were employed in the PPB programme and selections of the desired plant types were delayed until the population reached F_5 and F_6

generations. This delayed selection was unavoidable because most of the TPTs such as tillering ability, panicle length, higher grain yield, higher straw yield, tolerance to drought and marginal conditions, postharvest quality traits were governed by the quantitative genes. The remnant seed of the selection from segregating bulks was used to analyze the postharvest quality traits to maintain the superior culinary traits in selected progenies.

The postharvest evaluation of selected materials from the remnant seed was extremely important to the PPB programme (Gyawali *et al.* 2002; see also p. 179). This was especially true in *Mansara/Khumal* 4 cross where collaborating farmers evaluated the remnant seed after harvest for cooking and eating qualities such as taste, softness and flakiness. It was found that the complementary parent *Khuma*l 4 contributed to improving the postharvest quality traits in *Mansara/Khumal* 4 crosses. Farmers' perception on cooking and eating qualities for selected bulks in the present programme were recorded and selected materials were further screened for yield components. These screenings for agronomic, milling and organoleptic traits have enhanced the populations to meet the breeding goals in PPB programmes.

Farmers' participation in PPB is extremely important for the success or failure of the programme. Their involvement is important in locating landrace diversity, selection of local parents, setting breeding goals and selection of TPE and TPTs from segregating bulks and postharvest quality assessments. The selection of local parents and setting breeding goals were rigorous where farmers' contributions were higher, compared with crossing and selection from the segregating bulks. This is obvious in PPB programmes where very few farmers contribute to the selection process as it requires farmers' interest, dedication of cultivated land for PPB, understating of genetics, heritability and selection skills. In these conditions, regular training, interactions with scientists during traveling seminars and exchange visits were found important to create farmer interest and enhance participation in the programme. Farmer–breeders (Mr D. Sapkota and Mr S. Adhikari) were employed as resource persons to share their experiences of PPB in rice during farmer training and exchange visits from other PPB programmes. These resource persons helped researchers to disseminate the meaning of complex genetics, heritability and selection skills in simple farmers' languages. The PPB team found that the training and exchange visits using farmer–breeders as resource person was extremely effective to motivate interested farmers. Immediate following the training on PPB and visits to other PPB programmes, two PPB groups were formed and are functional in Kaski to lead the field activities for screening the segregating materials.

In 2004, many selected hills and bulks were evaluated for agronomic traits (Tables 5 and 6) and screened for postharvest quality traits. *Mansara/Khumal* 4, *Biramphool/Himali*, and *Ekle/Khumal* 4 crosses performed extremely well. Similarly, *Lajhi/Rampur Masuli* and *Mansara*/IR 62161 in the main season and *Dudhisaro*/BG 1442 in spring rice performed well in Bara. Farmers rejected *Lalka Basmati*/IR 59606 because of its small population size and less variability in the $F_{3\text{-}4}$ in Bara. These selected lines and bulks will be multiplied and used for PVS in future.

Conclusion

Participatory plant breeding as a strategy of *in situ* conservation of agrobiodiversity is quite different and more complex than other PPB programmes. The breeding goals of PPB in the *in situ* conservation programme—such as adaptation of rice to warm water, straw yield and culinary traits—require special attention by the scientists right through the parent selection. The four-square analysis of local landraces was very effective in selecting local parents and setting breeding goals. Four-square analysis of improved materials would be very effective in terms of selecting the complementary parents. Low cross and high population size was effectively employed from F_3 generation onward, which assisted farmers and breeders in selecting the desired rare segregants from the segregating materials. Modified bulk breeding was effective where farmers can easily desegregate the bulks based on grain colour, maturity and grain types governed by major genes. The selection of breeding materials under a target environment was facilitated by the mobilization of interested farmers in the PPB villages. Farmers' collaboration in selection of desired types is encouraging. Farmers' interest in particular crosses such as *Mansara/Khumal* 4 and *Biramphool/Himali* was higher in Kaski whereas *Mansara*/IR62161 and *Lajhi/Rampur Masuli* crosses impressed farmers in Bara. The milling and organoleptic traits were used as an important strategy to improve the postharvest quality traits of selected materials. A traveling seminar was found effective in getting the inputs from scientists and farmers during a transect walk at crop maturity. Farmer training on PPB and exposure visits could motivate farmers to contribute to PPB activities.

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Indicators for measuring the impact of participatory plant breeding in local crop diversity and livelihoods

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Abstract
Participatory plant breeding (PPB) is considered as an approach to strengthen on-farm conservation of agrobiodiversity and therefore helps to develop farmers' preferred varieties without accelerating genetic erosion. This paper discusses the possible socioeconomic and genetic indicators for measuring the impact of PPB on local crop diversity and livelihoods. Based on the experiences and knowledge gained, we discuss indicators that can be used for measuring the impact of PPB on local crop diversity and livelihoods. The literature was reviewed to broadly outline the indicators, which were shared during a half-day workshop for PPB practitioners. Under socioeconomics, 12 indicators were listed, including increased productivity and production, increased adoption rate, increased varietal choice and increased product diversification, etc. Genetic indicators are options of new genotypes, increased allelic level diversity, and local and introduced genes conserved. Different tools and methods (e.g. survey, observation and analysis) can be used to measure these indicators. Monitoring requires the collection of data at different times and in different spaces.
Key words: Crop diversity, genetic indicators, impact of PPB, livelihoods, socioeconomic indicators

Introduction
Participatory plant breeding (PPB) is considered a method to promote on-farm conservation by improving the private value of farmer's varieties through enhancing the competitiveness of landraces and enhancing the use of local materials in crop improvement (Sthapit *et al.* 2002). The global *in situ* project has adopted PPB as a strategy to conserve local crop genetic resources by adding values to them (Joshi *et al.* 2000). Other factors that promote *in situ* conservation are the fragmentation of land holdings, marginal agricultural conditions associated with hill lands and heterogeneous soils, economic isolation, cultural values and preference for diversity (Brush 1995). Under this project, PPB was started in 1998 in Kaski and Bara ecosites. In Nepal, PPB was started in high-altitude rice in 1993 (Sthapit *et al.* 1996) and a cold-tolerant variety was released in 1996 (Joshi *et al.* 1996). PPB basically helps to develop farmers' choice of varieties, to disseminate technology faster and to enhance biodiversity. PPB in high-potential production systems has demonstrated farmers' preferred rice varieties (Gyawali *et al.* 2002; Witcombe 2002) but there is a lack of information on the impact of PPB on crop diversity and livelihoods There are also few examples where PPB has been used as a strategy for *in situ* conservation (Sthapit *et al.* 2002).

Brown and Young (2000) have described PPB as a recent approach for which relatively little can be known about its impact on the conservation of crop biodiversity. They outlined the potential impact of PPB on biodiversity according to breeding system (self-pollinated, outcrossing and clonal reproductive systems). They summarized conceivable risks to the conservation of plant genetic resources from PPB, which provides evidence that monitoring of the effect of PPB on crop genetic diversity is required.

For wider application of any method, it should provide measurable benefits to the clients. Benefits may be social, economic or environmental, in both the long and short terms. PPB as a new approach is spreading slowly in national research institutes and providing direct benefits to farmers. To measure its impact, considerable time may be required; however, we can identify a possible list of indicators for measuring the impact in some ongoing PPB projects. PPB impacts can be measured in terms of socioeconomic as well as genetic parameters. Indicators are important to measure the impact or outputs of any research and development intervention. Socioeconomic indicators are essential to identify progress made on socioeconomic and livelihoods of farming communities, while genetic indicators are essential to monitor changes in local crop diversity due to PPB interventions. This paper discusses the possible socioeconomic and genetic indicators for measuring the impact of PPB on local crop diversity and livelihoods. A successful PPB programme should not only meet farmers' needs to increase food security but also maintain the process of on-farm crop diversity.

Materials and methods

This is not an appropriate time for measuring the impact of PPB on local crop diversity and livelihoods because of the nature of the technology. It will take a few years to reach a point where final products of PPB began to replace the traditional varieties and to record how farmers allocate their rice fields into available diversity in the context of new PPB products. The purpose of the desk research is to develop indicators that can be validated in the field for measuring the impact of PPB on local crop diversity and livelihoods.

Protocol development

Relevant literature was reviewed to understand and document possible PPB indicators (Kornegay *et al.* 1996; Sthapit and Joshi 1998; Brown 2000; Brown and Young 2000; Witcombe *et al.* 2001). Protocol was developed based on the experiences gained from PPB work in Begnas and Kachorwa. This was refined after discussion among *in situ* team members.

Consultation meeting/workshop

A half-day workshop was organized in Agriculture Botany Division, Khumaltar in February 2004 to identify a list of indicators for measuring impacts of PPB on local crop diversity and farmers' livelihoods. The knowledge and experiences of various scientists related to PPB in rice in Kaski and Bara project sites (Table 1) were shared among the participants, and a list of socioeconomic and genetic indicators was generated from the workshop. During the workshop both qualitative and quantitative indicators for measuring the impact of PPB were considered. These indicators were circulated to other experts for further refinement.

Table 1. Status of PPB materials in Kaski and Bara ecosites.

Ecosite	Crossing, n	Total parent, n	Parents	Generation
Kaski	7	12	*Pusabasmati*, *Jethobudo*, *Biramphool*, *Himali*, *Mansara*, *Khumal* 4, *Thulo Gurdi*, *Naulo Madhese*, IR36, NR 10286, NR 10285, *Ekle*	F_4- F_6
Bara	5	8	*Dudhi Saro*, BG 1442, *Lajhi*, *Rampur Msuli*, *Lalka Basmati*, IR59606-119-3, *Mansara*, IR 62161-134-1-22,	F_4-F_5

Source: Joshi *et al.* (2000).

Findings

Socioeconomic indicators

Farmers' participation

The PPB process assumes that the number of farmers involved in the crop-improvement process and adopting new PPB materials will be increased. Increased participation of farmers in the process is considered an indicator for social benefits. Farmers' roles in decision-making of PPB such as setting breeding goals, parent selection, and selection of segregating materials, maintenance and exchange of PPB materials are more important than physical participation. This is measured by counting the number of farmers involved in such activities. Involvement of farmers and scientists from the earliest stages of segregating materials increased farmers' access to new varieties (Joshi and Witcombe 1996). In recent studies, Witcombe *et al.* (2005) found that farmer involvement in selecting the segregating generations may not be an essential component of PPB but farmers role in identifying the target market or clients; using germplasm that can best meet the needs of target clients; matching the environments of the target clients; and product testing in the target market with target clients are more crucial. Change in the number of farmers and frequency of farmers' participation in such activities may be the indicators of PPB impact.

Production and productivity (comparative advantages of PPB)

PPB is target environment based research. Locally adopted landrace is used in crossing. Deficit trait is assumed to be incorporated in local landrace. Therefore production and productivity of areas adopting PPB products is increased. It is assumed that successful PPB products may increase unit area compared with available cultivars/landraces over the year. Selection of a small number of crosses with large population size increases the probability of recovering superior genotypes (Witcombe and Virk 2001). Witcombe *et al.* (1999) have shown that production increases when farmers adopt new varieties identified in participatory research; if participatory approaches were widely applied in high-potential production systems, they would contribute greatly to the food security of the developing world with its rapidly growing population. PVS (participatory varietal selection) identified new varieties that farmers preferred and increased on-farm varietal biodiversity (Witcombe and Virk 2001; Joshi *et al.* 2003; Mudwari *et al.* 2004). PVS is a simple and powerful method of increasing food production in the high-potential production systems through deploying varietal options to farmers. Smale *et al.* (2004) argued that the multiple values of crop diversity help to shape up increased genetic diversity instead of focusing on a single trait (e.g. yield).

Area coverage by each variety and frequency of households (pattern of varietal distribution)

Sthapit *et al.* (2001) and Rana (2004) suggest that varieties with multiple traits, stable yields and local adaptation tend to be grown by many households in large areas and therefore the most successful PPB products might be grown by many farmers in large areas by replacing local diversity. Therefore, the area under each variety and number of households growing each variety are important indicators of measuring PPB impact, in addition to the number of varieties grown by each household. In the PPB approach, farmers benefit from new genetic material 5–6 years in advance of introduction via formal systems and with minimal effort (Joshi 2000; Joshi *et al.* 2001) and therefore, they may enhance genetic erosion faster than conventional breeding. It is argued that PPB addresses the needs of diverse types of farmers and circumstances and, therefore, different clusters of farmers prefer different varieties, thereby enhancing biodiversity.

Adoption rate

It was also assumed that PPB increases the farmers' access to locally adapted and preferred PPB products and, therefore, adoption rate is perceived to be higher than for other introduced cultivars. A variety highly preferred by farmers was developed through PPB and spread rapidly among farmers (Witcombe *et al.* 1999) but recent studies from *Chhomrong* showed that PPB products did not cover more than 40% of one of the parents (Witcombe *et al.* 2001). So adoption rate can be used as an indicator for measuring the impact of PPB on local crop diversity and livelihoods.

Farmers' relative income

Resource-poor farmers in marginal areas are benefiting less from high-yielding varieties (HYVs) than farmers in more favoured regions (Witcombe *et al.* 1996, 1998). Farmers quickly replace old varieties when there is a continuous supply of new and superior varieties (Cuevas-Perez *et al.* 1995). Owing to the high productivity and adoption rate, income of farmers might increase compared with the existing varieties. Cash profit obtained from adopting PPB materials is defined as income.

Market demand

Improving certain traits of landraces and enhancing diverse market demands for landraces is the way of increasing market local products. If the value of PPB products is increased compared with other existing products, the demand for such products will increase in the local market. If the market is expanded further, it may have a negative impact on local biodiversity.

Market price

Aroma or other quality-related traits may provide a premium market price (Gauchan 2004). When consumers are willing to pay price premiums for products that are from traditional sources and these products are readily identified by physical appearance and postharvest traits, on-farm conservation is possible through market incentives (Smale *et al.* 2004). PPB that aims for quality goal (e.g. *Mansara* x *Khumal-4* cross or enhanced *Jetho Budho* landrace) may be maintained by market incentive and such traits could act as indicators for socioeconomic factors. If the international market is willing to pay premium prices for quality traits, it may encourage uniformity and reduce genetic diversity in the population.

Quality

Food culture shapes the taste and preference for the traits of food prepared from a crop (Smale *et al.* 2004). It is also assumed that PPB facilitates selection of diverse varieties that match food habits and preferences of local people and, therefore, promotes biodiversity. Nutritionally better and tasty products traditionally identified by farmers for specific local cuisines also promote maintenance of local diversity and thus the quality traits could be proxy indicators for PPB as well.

Cropping intensity and cropping pattern

It is also believed that farmers' participation in the PPB process encourages farmers to identify diverse genotypes suitable for local cropping patterns and systems, which leads to different types of cropping intensities and systems. For example, development of short-duration rice varieties with dwarf stature helps to intensify the cropping area and changes the cropping pattern. Changes in cropping sequences and number of crop species/varieties could be proxy indicators for measuring PPB impact on species and ecosystem diversity. Mainstreaming a PVS approach and the use of the farmers' network of information and seed exchange involving relevant grassroot-level institutions can enhance the pattern of biodiversity in the cropping system (Joshi *et al.* 1997).

Awareness (capacity-building)

The PPB process encourages both farmers and breeders to learn from each other's experiences and build the capacity to appreciate diversity, target environments, selection methods and postharvest traits. Training of farmers and regular field interaction among farmers and scientists promotes community awareness of the value of local landraces and its use in crop improvement. Changes in awareness level can be considered socioeconomic indicators for measuring the impact of PPB in terms of knowledge and skills gained on PPB.

Varietal choice (varietal richness)
Development of different lines increases the choice options for farmers. If farmers have more varietal choices than before, it could be a positive impact of PPB on local biodiversity. Reduced choices for land types, uses and system might be considered as negative impacts of PPB.

Product diversification
Different types of products are available by improving diverse landraces, considering postharvest traits. With focus group discussion and field visits, this is documented. Diverse products can indicate the impact of PPB.

Genetic indicators

New genotypes (number of options available)
Site-specific and farmer-targeted PPB work increases the number of genotypes in a specific niche/environment. Increased number of options for marginal and complex risk-prone areas could be considered a positive impact of PPB, as options of varietal richness are only high for high yield potential and favourable ecologies (Rana 2004). Sthapit *et al.* (1996) and Witcombe *et al.* (1996) have reported that PPB has increased biodiversity and developed varieties much better and faster than the products of conventional centralized breeding. Selection of segregating materials by diverse farmers enhances hidden genetic diversity. Joshi *et al.* (1997) reported increased varietal diversity through PVS.

Allelic richness and multilocus genotypic diversity
Allelic richness (isozymes, SSR), number of distinct morphological phenotypes, morphological major gene polymorphisms (colour, pubescence, awn, etc.) and variation in human use value (aroma, softness) of PPB products can be considered as genetic indicators for measuring impacts on genetic diversity (Brown 2000).

Local and introduced genes conserved
The genetic diversity of locally grown landraces has been measured at a given time and location using genetic diversity indices of allelic richness or allele evenness within the population (Zimmerer and Douches 1991) but the primary concern is the continuation of the processes by which farmers select, maintain and exchange the population of useful traits (genes) that remain adapted to local farming systems. Genes considered important by farmers continue to be conserved and maintained by human and natural actions. Availability of these genes locally indicates the positive impacts of PPB on local crop diversity. Use of local landrace as a female parent in PPB helps to conserve local genes and possibly co-adapted complexes (Witcombe *et al.* 1996; Sthapit *et al.* 2002). Replacement of landraces by PPB products is also possible; however, loss would be minimized.

These are the indicators broadly discussed. All indicators may not be measured in a particular PPB target area. Some are applicable to a particular area and some to other areas. Different tools and methods (e.g. survey, observation and analysis) can be used to measure these indicators. Monitoring requires the collection of data at different times and spaces to trace the effects. The next section discusses the indicators listed by Brown and Young (2000) for measuring the impact of PPB on biodiversity under two groups: farmers' perspective and conservation and sustainable use of PGR. Some of them are similar to previous ones even though these are given below in view of emphasizing the indicators.

Farmers' perspective

1. The number of different varietal options available to the farmers is an important question to note where PPB is targeted and where it is effective in increasing options. It includes both the existences of adapted varieties and access to their seed.
2. The comparative evaluation of performance of PPB varieties—preferably both on-farm and in field stations—is needed to monitor real progress. Ideally, for comparison the improved local varieties, both the parental populations and realistic exotic alternative, are needed for comparison.
3. The list of farmers' selection criteria is a fundamental description of the selection regime to which PPB varieties are attuned and must continue to be so. The diversity of such a list, and its changes in time, can be linked with evidence on performance to assess whether needs are being met effectively.

Conservation and sustainable use of PGR

1. The geographic pattern of landraces in use aims to summarize the landrace richness of an area in relation to the ecological variation included. This indicator is put forward as a key one for monitoring biodiversity on-farm. The effective number in areas at different spatial scales can be computed from the frequencies of occurrence of specific landraces. Indeed, a net increase in the cropping area devoted to PPB-improved landrace derivatives could be the clearest indicator of biodiversity gain.
2. The effective population sizes of the several parents and their PPB derivatives needs estimating for assessment of retention of genetic variation on-farm. Pedigree analysis, the actual numbers of genotypes in selected generations and the level of polymorphism for genetic markers provide ways of estimating this fundamental yet abstract quantity. A practical way is to record the number of households growing a particular allele at a given time and location.
3. The linkage of PPB programmes with *ex situ* conservation strategies is crucial for insurance against loss of biodiversity and for benefit-sharing. If the number of Red List cultivars is identified on a regular basis and they are conserved in genebanks, then this indicates positive impacts of PPB on genetic diversity management.

Conclusion

In order to monitor impact of PPB on genetic diversity maintenance and sustainable livelihoods, a few socioeconomic and genetic indicators were identified from the desk research. There is a need for time series information to measure change. Socioeconomic indicators are necessary to measure impact of PPB on livelihoods of farmers and genetic indicators are necessary for measuring impact on crop diversity. All indicators discussed in the paper cannot be measured from a practical point of view and some are too expensive to do. Among them, the most important ones are:

- number of varietal options available to the farmers, for their diverse needs
- area and number of households growing PPB products
- The geographic patterns of varietal distributions
- comparable advantage of PPB products
- willingness to retain or exchange seeds
- Percent of successful use of locally adapted traditional varieties in breeding programmes.

These six indicators are deemed practical to monitor the impacts of PPB on local crop diversity and livelihoods. For a better understanding, all these indicators should be measured with real data.

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Disseminating the results

Developing a resource guidebook on agrobiodiversity for secondary schools

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Abstract
Agrobiodiversity is one of the important components of biodiversity but there is lack of access to resources and information related to agrobiodiversity conservation for secondary school children in Nepal. This paper describes the process adopted to prepare a resource guidebook on agrobiodiversity to strengthen the public-awareness capacity of schools in *in situ* conservation of agrobiodiversity. In the process, a thematic team composed of different subject matter specialists from LI-BIRD and NARC was formed to review and develop the course outline, the final course content was agreed among the team members. Secondary-level students and teachers from different schools (private, governmental, community-owned, and charity schools) and other stakeholders like the District Agriculture Development Office and District Education Office were involved in the process. A resource guidebook on agrobiodiversity conservation and utilization for school children was drafted with the involvement of subject-matter specialists, artists, teachers and concerned stakeholders. The paper highlights the participatory process adopted during the course of guidebook development. The draft guidebook was reviewed by school teachers and also by specialists on agrobiodiversity.
Key words: Agrobiodiversity, conservation, awareness, resource guidebook, and secondary-school students

Introduction
Nepal is rich in biodiversity, ranking 25th globally and 11th on the continent of Asia (MoFSC 1997). Agrobiodiversity accounts for the majority in overall biodiversity. Nepal is an agricultural country and 80% of its population is dependent in agriculture (MOPE 2001). The country, being a signatory of the Convention on Biological Diversity (CBD), is one of the pioneer countries to ratify the convention of 1992 and is committed to conserving biodiversity. Therefore, the country has taken measures with initiatives at grassroot, regional and national levels to conserve its agrobiodiversity. Some initiatives are: project on Strengthening the Scientific Basis for *In situ* Conservation of Agrobiodiversity, Community Biodiversity Register, Community Seed Banking and Genetic Resource Policy Initiatives (GRPI). These aforementioned programmes have been implemented at grassroot level (IPGRI 2002; Sthapit *et al.* 2003; Subedi *et al.* 2004) and have contributed to understanding the need for and conservation of agrobiodiversity.

Nepal has made significant progress in education at all levels during the past three decades. The literacy rate in 2001 was 54.1% for both the sexes. Education is a basic foundation that plays an important role in the development of the country. Currently, 15 million students (43.8%) are enrolled in secondary-level education (CBS 2003). However, with regards to education on agrobiodiversity conservation, very minimal efforts have been made by either formal or informal education sectors. Many students still do not have access to a resource book and information on this subject matter.

At the grassroot level, it is obvious that farmers, knowingly or unknowingly, have been conserving many crop genetic resources and the overall agrobiodiversity through growing the crops in their farmlands and home gardens. But the young generations, especially the school-level students, have not been exposed to such activities and lack both awareness of and access to information related to agrobiodiversity conservation. Today's students are the nation-builders of tomorrow so, considering the role of youth at present and in future, it is an emerging issue to invest school children with the knowledge required to ensure future harvests and transfer of knowledge on agrobiodiversity for the coming generations. Schools can become powerful means of increasing public awareness about biodiversity.

The joint project of National Agricultural Research Council (NARC), Local Initiatives for Biodiversity, Research and Development (LI-BIRD) and International Plant Genetic Resources Institute (IPGRI) on ''Strengthening the Scientific basis for *In situ* conservation of agrobiodiversity'' has been successful in creating awareness on the need for on-farm conservation of agrobiodiversity at different levels—students, farming community, policy-makers and different actors such as private entrepreneurs—through many awareness tools such as essay and art competitions among students, diversity fairs, rural poetry journey, etc. Along with this the project aims to develop a guidebook on agrobiodiversity conservation in a simpler form for secondary-level students to make information available as a resource/reference book. This paper describes the process adopted to prepare this guidebook.

Materials and methods

Formation of task team and need assessment

A task team composed of different subject-matter specialists was formed by a National Project Management Team (NPMT)[25] (Figure 1). It was realized that public awareness on agrobiodiversity conservation is important at different levels (e.g. students, farmers) for successful conservation activities. The involved subject-matter specialists were socioeconomist, conservationist and public awareness specialist. The team was assigned to develop the course content and to produce a resource guidebook on agrobiodiversity conservation for secondary-level students.

Literature review

Different references such as published articles, proceedings, baseline surveys and site selection reports of *in situ* project Nepal were reviewed. Similarly, other reference materials related to biodiversity and agrobiodiversity, published by different organizations like IPGRI, King Mahendra Trust Conservation Nepal, Pro-Public Nepal and IUCN Nepal, were collected and reviewed. The literature review guided the team in identifying existing scenarios and gaps in agrobiodiversity related to a reference guidebook for secondary-level students.

Rapid informal interview with schoolteachers

The team visited some selected schools and interacted with the teachers to learn whether the school was teaching any subject related to agrobiodiversity. They then discussed possible course contents and the information to be included in the proposed reference guidebook. During this visit the team also explored the possibility of the use of the reference guidebook in future with the respective schools.

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[25] National Project Management team is an implementing body of ''Strengthening the Scientific basis for *in situ* conservation of agrobiodiversity, Nepal''. The NPMT is responsible for developing protocol for research and guiding field staff in the execution of the project. The team is composed of thematic leaders, *in situ* conservation experts, and site coordinators from NARC and LI-BIRD.

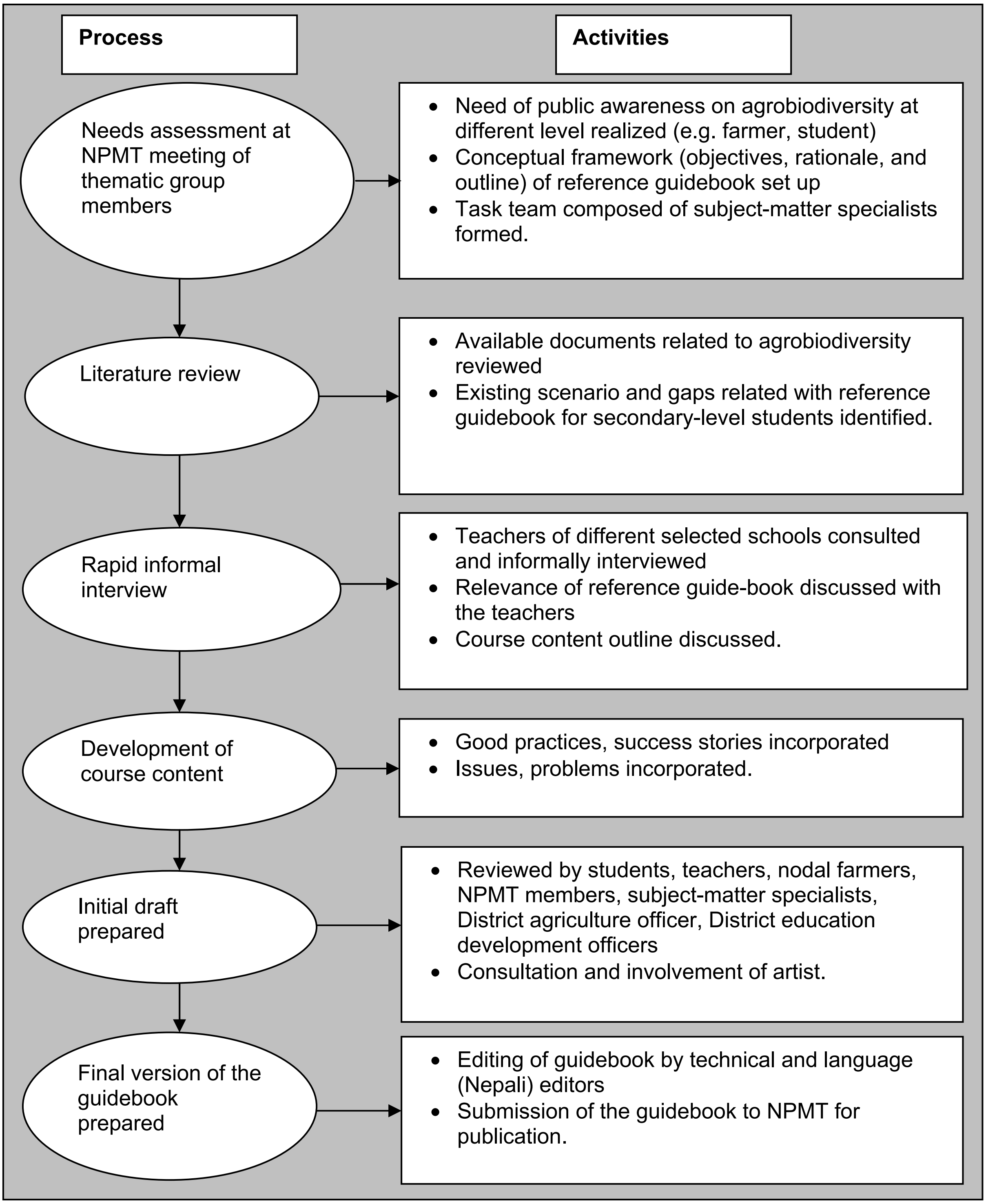

Figure 1. Processes and activities adopted in development of an agrobiodiversity reference guidebook.

Development of course content

The task team reviewed available literature from *in situ* project outputs, published papers, journals, books on agrobiodiversity and a guidebook for children developed in other countries to develop an outline of course content for the proposed guidebook (Quek and Hazliza 2002). During the process of developing the course content, the key points shared by teachers were taken into consideration, and finally the outline of course content was developed. The NPMT members reviewed the outline of the guidebook and both the task team and NPMT members agreed on the course content for the proposed guidebook.

Initial drafts

The initial draft of the guidebook on ''*Krishi Jaibik Bividata: Bidhyarthi ka Laagi Parichayatmak Sahayogi Pustika*" literally meaning "Agrobiodiversity: an introductory guidebook for students", was developed with the involvement of different stakeholders from the beginning of the planning process. The book was circulated for correction, comments and feedback to all NPMT members, school teachers and students from government-owned, private boarding, community-owned and charity schools, nodal farmers, cooperative members, the District Agriculture Development Officer and the District Education Officer. We collected many valuable comments from the students and teachers to improve the quality of the guidebook. There were valuable comments from students and teachers on initial drafts. We repeatedly followed the same process by updating the guidebook with received comments and feedback and again sending it to the same institutions, personnel, students, teachers and farmers' cooperative for assessment of the quality of the guidebook.

Consultation with artist

Following the comments that we received from students, teachers and individual subject-matter specialists, the task team then consulted the artist for his contribution and involvement in the guidebook, for both technical input and sketching of the figures and illustrations. We purposely selected an artist from LI-BIRD, who had a technical background on agriculture and conservation.

Review of the final version of the guidebook

Once we received comments on the initial draft we incorporated the comments from all the members, students and school children and we gave the final shape to the guidebook. After the aforementioned steps and process, we prepared a final version of resource guidebook on agrobiodiversity for the students. The final version was edited by technical editors followed by a vernacular language editor. The final version of the resource guidebook was then submitted to the NMPT for publication.

Results and discussion

In our rapid informal interview with schoolteachers it was found that there has been a regular course text on population and environment in use, agrobiodiversity references were limited. Very few schools taught the students about biodiversity because they lacked the proper resource guidebooks on the subject matter, especially in government-owned schools. There are some reference books related to the environment and biodiversity (Belbase and Belbase 2060 BS), but these books are targeted to the general public and not school children; also, the agrobiodiversity aspect is less described. In the process of planning, the informal interviews with schoolteachers at very first stage of the guidebook development provided us with guidelines for drafting an outline of the guidebook contents. The key expert from NPMT and *in situ* project team has greatly contributed to the guidebook development process. The review and feedback process from students and teachers suggested simplicity of text, use of illustrations, facts and figures, sketches and exercises related to Nepalese agrobiodiversity.

Some exercises with each chapter have been incorporated. The inclusion of exercises, especially those that promoted student interactions with their parents, grandparents, friends and elders of village/town on agrobiodiversity at different time periods were reported as interesting exercises. These exercises will be helpful in increasing the students' awareness of the value of agrobiodiversity in popular culture and will help them realize its importance in their livelihood. As well, it increases their awareness of the erosion of genetic resources and the need for conservation of agrobiodiversity for the future. This might help to create interest among the students to use the guidebook and help to develop a future green mind that cares, saves and shares the biodiversity. Similarly, sketches were frequently used to impart clear messages and to help students understand the text.

Conclusion

The guidebook that gives an introduction of agrobiodiversity to secondary-level students has been developed. It documents knowledge gathered from the joint project of NARC/LI-BIRD/IPGRI on "Strengthening the Scientific Basis for *In situ* conservation of Agrobiodiversity in Nepal". Consultation with the target client was an important process used to prepare the guidebook. Similarly, the involvement of the target client from the beginning stages and their feedback are crucial to development of such a guidebook, as was the involvement of multi-subject matter specialists.

The role of the artist can be the most important as the pictorial explanations could be more understandable for the school children than the plain text.

The inclusion of exercises in many chapters may help students to understand and realize the value of agrobiodiversity. Finally the developed guidebook is a milestone for school children to understand about agrobiodiversity but the book itself is not perfect since the subject matter is complex and still there is a lack of adequate resources for the understanding of agrobiodiversity. Therefore, there is a need for investments from the secondary-level curriculum development division, policy-makers and concerned stakeholders to create awareness in involving the younger generation in agrobiodiversity conservation through education.

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Rural radio programme: good practice for raising public awareness on biodiversity conservation

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Abstract

Increased appreciation and awareness of biodiversity's value and importance is essential for a successful conservation programme. Different methods and tools have been developed for information dissemination and awareness creation of which radio broadcasting is the fastest and most powerful one, reaching huge masses of people at a time. Radio remains the most important and effective medium for communication with the rural population of developing countries. Local Initiatives for Biodiversity, Research and Development (LI-BIRD) launched a rural radio programme 'LI-BIRD KO CHOUTARI' on 1 October 2001 to provide a common discussion forum for sharing and learning of biodiversity-related information by farmers and farmers' organizations, consumers and consumer organizations, students, academicians, research and development workers and policy-makers and to increase appreciation of, and awareness for, the value and importance of biodiversity conservation among farmers and other key stakeholders. The programme has aired 268 episodes during a period of 51 months. The programme disseminates farmer-friendly information through poems, slogans, folk songs, proverbs, news, interviews, talks, quiz, debates and discussions. The programme not only disseminates information to stakeholders but also helps to form public opinion and policies on biodiversity issues. The programme has broadcast methods and good practices mainly related to the importance, conservation and utilization of biodiversity for sustainable agriculture.

After the initial year, a study was conducted to learn the response of listeners about timing, appropriateness of contents and overall strengths and weaknesses of the programme and to acquire their suggestions and feedback. A randomly chosen 106 listeners were interviewed with semi-structured, pre-tested questionnaires and the results analyzed. The findings reveal that the programme has become very popular, particularly in rural areas, and is playing a vital role in information dissemination and awareness creation. Different stakeholders and farming communities have now realized the value of conserving their local natural resources and local food crops. Demand for products of neglected crops like millet has increased in Pokhara valley as a result of the awareness raised through this programme, encouraging farmers to continue production of these crops, which leads to biodiversity conservation. It has become a platform for disseminating agricultural technologies suitable for local conditions, sharing success stories and farmers' experiences and solving the problems faced by the farmers in the area of agriculture and biodiversity conservation. It has also helped form a public opinion forum and thus put pressure on concerned authorities, particularly on agrobiodiversity-related issues. The programme learned that sharing of success stories through a mass media approach is a very effective means of information dissemination.

Despite the popularity of the radio programme, key learning issues were identified during the survey and from feedback of stakeholders. There are some limitations of the programme as it cannot reach wider areas and population, it lacks adequate financial resources to run and the time is limited. Given the initial findings and feedback, there is greater scope for this programme to expand to other areas. Being the pioneer, LI-BIRD should capitalize on this good initiative and collaborate with other stakeholders for its replication and sustainability.

Key words: Agrobiodiversity conservation, rural radio programme, public awareness, LI-BIRD Ko choutari, Nepal

Introduction

Community participation is central to on-farm conservation and use of local biodiversity and a community will conserve biodiversity if they know the importance and value of their biodiversity (Sthapit and Jarvis 2003). At the same time farmers and farming communities may not be as conscious of the benefit of the local biodiversity they have. Therefore awareness creation and sensitization of farming communities on the value of local genetic resources and need for their conservation is very important. Public awareness is the initial foundation for sensitization and dissemination that ensures effective participation of farming communities (Chaudhary *et al.* 2003; Jarvis *et al.* 2000). Public awareness adds value to the local crops and makes consumers, development workers, policy-makers and farming communities conscious of conservation and utilization of local biodiversity (Rijal *et al.* 2000; Chaudhary *et al.* 2003).

Different methods and tools have been developed for awareness creation and sensitization of community for conservation of biodiversity. Chaudhary *et al.* (2003) have broadly categorized these various methods into three groups: personal contact, group approach and mass media approach, of which the mass media approach is most cost-effective, reaching a large population. Among the different means of mass media, radio broadcasting is the fastest and most powerful means of reaching large areas and masses of rural people at a time.

Radio broadcasting deserves special importance in Nepal because very few people have access to television and electronic communication. The use of other means such as printed materials and internet has not been as effective because of the higher percentage of illiteracy in rural areas. It has been reported that rural and small farmers are regular listeners of radio programmes (FAO 1980 cited in CEDA 2001). In a study carried out by New Era in 1980, 48% of the respondents were found to listen to agricultural programmes on the radio (New Era 1981 cited in CEDA 2001). Moreover, radio broadcasting to people in a local language with their own voices has been a powerful and comparatively cheap way to reach a large portion of the communities. As one such initiative, Local Initiatives for Biodiversity, Research and Development (LI-BIRD) has implemented a radio programme 'LI-BIRD KO CHOUTARI' with initial financial support from IPGRI in partnership with Anapurna FM, Pokhara. Literally, *Chautari* in Nepalese means a resting place under the shade of a tree—usually *Ficus religiosa* and *Ficus bengalensis*—with social, cultural and religious values. Traditionally it is an important place for meeting people and sharing information. The project was started on 1 October 2001 and IPGRI provided funds until 31 October 2003 (Subedi *et al.* 2001). The project has now finished after the termination of IPGRI support, but owing to higher demand and growing popularity and impact, LI-BIRD is still continuing the programme through its own resources.

Goal and objectives of the programme

The overall goal of the programme is to sensitize different stakeholders on the importance and value of biodiversity conservation and use in Nepal. The specific objectivesof the project were:

- To provide a forum for researchers and farmers for sharing experiences and good practices based upon local innovations and scientific research
- To provide a discussion forum to debate current emerging biodiversity-related issues among different stakeholders and help in forming public opinion and policies that support biodiversity-friendly approaches
- To disseminate innovative research findings and technologies on agriculture and biodiversity that provides benefits to people.

About the programme

The programme is broadcasted through Annapurna FM Pokhara. The programme broadcasts information related to management and utilization of agrobiodiversity using different methodologies. Specifically the programme focuses on issue-based discussion with farmers, community people, local leaders, development workers, researchers and policy people; farmers' problem-solving; poetry and folk songs related to agrobiodiversity; agricultural news; information on agricultural technologies of the season, and weekly questions and answers. Although no systematic studies have yet been done to determine the coverage area of Annapurna FM, based on the listeners' responses through letters and phone calls, it can be said that the programme covers about 13 districts in the central and western development region of Nepal (Figure 1).

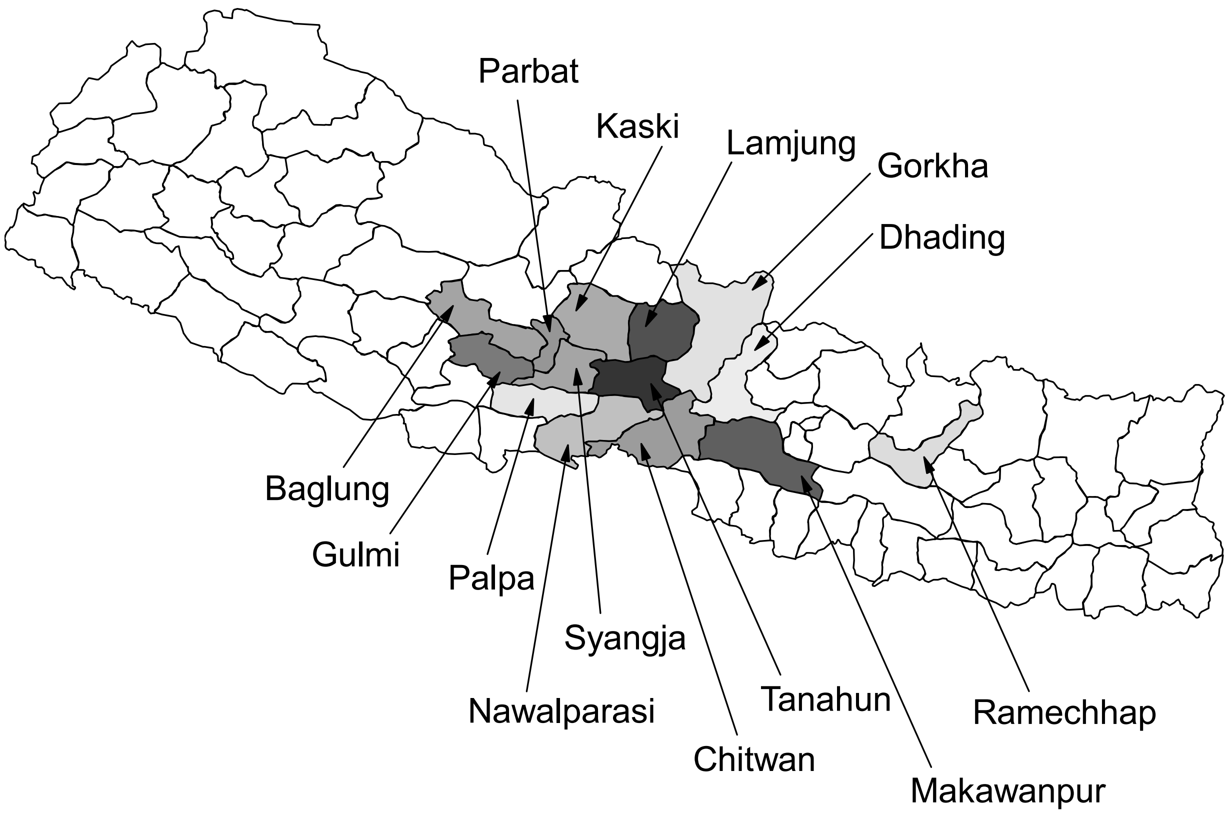

Figure 1. Coverage area of LI-BIRD KO CHOUTARI.

Working approach

This programme not only disseminates information to stakeholders but also provides a forum for sharing and giving opinions. Therefore, the programme is participatory in nature. The core team of LI-BIRD is responsible for production of programme in coordination with the relevant partners and the programme is then broadcast with the help of a professional anchor. The responses of listeners—collected through letters, phone calls and personal visits—and their suggestions are incorporated into future programmes. Ten listeners' clubs have been formed where members of the club listen to the programme as a group, discuss topics with each other, share with other members of community and send the queries of the group to the programme. The working approach and sphere of partnership in LI-BIRD KO CHAUTARI are presented in Figure 2.

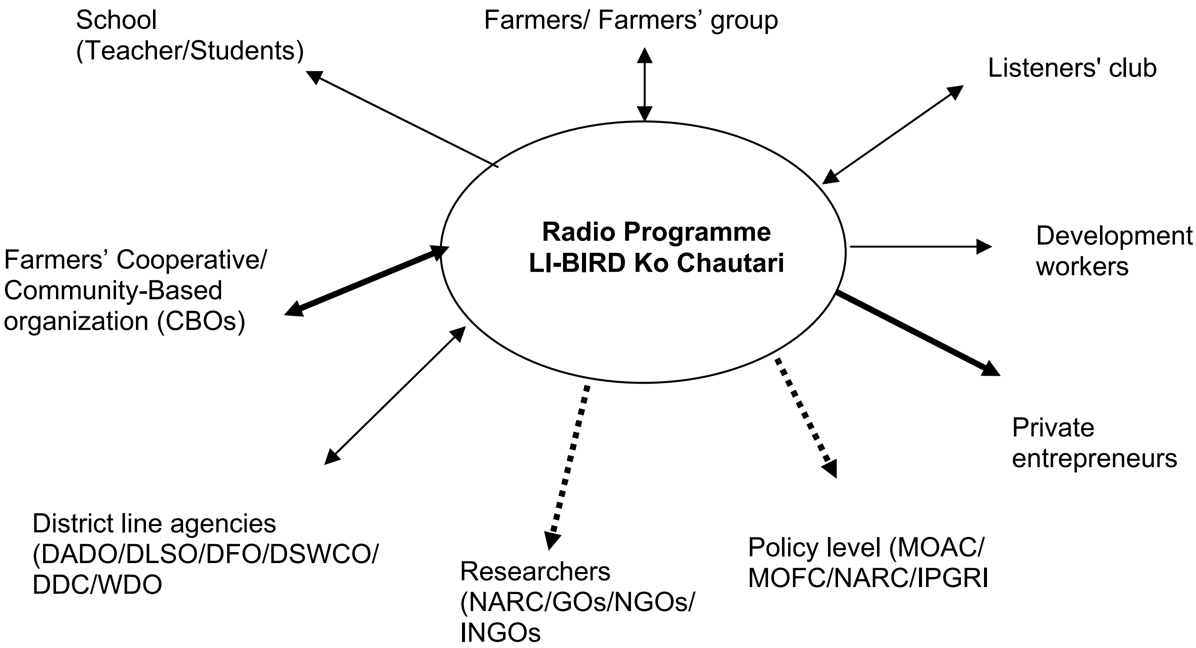

Figure 2. Sphere of partnership through Rural Radio Program Network.

Materials and methods

Setting up multidisciplinary team

Prior to actual implementation of the programme, staff together with Executive Board of LI-BIRD met to discuss the prospective and consequences of launching the rural radio programme with the objective of disseminating outlets and reaching a large group of people. An in-house meeting among LI-BIRD professionals identified Annapurna FM as a partner organization for the programme. Annapurna FM 93.4 was selected because of its wider coverage among the FM stations in Pokhara and the interests of the radio station. The meeting also identified the working team of the programme and assigned roles and responsibilities to the team for preparation, production and broadcasting the programme. Broadcasting time was carefully chosen (evening from 7:30 to 8:00 pm) to make it appropriate for farming communities. Initially, the programme was broadcast once a week on Wednesday for half an hour (7:30–8:00 pm), outside the prime news time of Radio Nepal (7:00 pm) and Nepal Television (8:00 pm). But, given the reviews and growing demand from the listeners, it is now broadcast twice a week.

Designing the programme

A multidisciplinary team consisting of LI-BIRD's professionals were involved as a core team in designing and implementing the programme. Professionals are also involved in periodic monitoring and review. Feedback comments are incorporated into designs of future programmes. The following topics were broadcast through the radio:

- Discussion with farmers
- Issue-based discussions
- Problem-solving
- Poetry/Folk songs
- Agricultural news
- Information on agricultural technology
- Weekly question and answer.

Periodic review

The programme was reviewed after six months, which involved different stakeholders (farmers, government and non-government organizations and policy personnel). This review meeting agreed to increase the broadcasting frequency from once a week to twice a week and also the time from 30 to 45 minutes. Issue-based talk, debates and discussion are broadcast on Sunday while queries and questions of listeners are broadcast on Wednesday. Information on the latest technologies in agriculture is broadcast through poems, folk songs, slogans, proverbs and news.

Feedback collection

This programme not only disseminates information to stakeholders but also provides a forum for sharing and giving opinions for farmers and stakeholders. The design and working modality of the programme makes it participatory in nature. Responses of stakeholders are collected regularly through lettera and also online at 6-month intervals. The programme is scrutinized regularly, incorporating the response, suggestions and feedback of the stakeholders. After 1 year, a study was conducted to determine the response of listeners about timing, appropriateness of contents and overall strengths and weaknesses of the programme and to acquire their suggestions and feedback. A random selection of 106 listeners was interviewed with a semi-structured interview. The questionnaires were pre-tested before the actual survey. The information, which was both qualitative and quantitative, was analyzed using simple statistical tools.

So far, different issues related to policy have been dealt with on the programme. For example, debates and discussions are held on different issues such as governments' entry to the World Trade Organization, Farmers' Rights, Intellectual Property Rights, etc. The programme also disseminates information through a weekly quiz and rewards one listener per week who comes up with the correct answer. This reward system has created positive impact and encouraged the listeners. The database of the broadcasted programmes is maintained and made available to the different stakeholders upon request.

The findings of this study are based on the listeners' responses through letters and phone calls and is also based on the results of a listeners' survey. The outputs of the programme are summarized below in subheadings.

Results and discussion

Public awareness on value of biodiversity and conservation

The programme has become very successful in creating awareness and disseminating information about sustainable agriculture, biodiversity and natural resources management. In order to create awareness on the importance of biodiversity among different stakeholders including farming communities, issues and information regarding conservation and utilization of agrobiodiversity were broadcast. Some of the examples are biodiversity poem, talk programme on linking biodiversity with culture, discussion on production, uses, value-addition and marketing of different local crops. It was found that about 53% of the listeners were in the age group of 25–50 years. In Nepalese society, this age group is the decision-maker of agriculture. Therefore, this programme is very effective in creating awareness on agriculture, biodiversity conservation and utilization. About 56% of listeners were found to be engaged in farming, the balance of listeners being from service industries, business and students (Adhikari *et al.* 2004). So, farming communities are the major target group of the programme.

The programme has created awareness among students, researchers, academicians and policy-makers on issues related to biodiversity conservation and sustainable natural resource management. Much information has shed light on the issues and development at national and international levels.

Linking farmers with markets

This programme has helped to link producers' groups with traders and then with consumers. After consumers learn the value of local nutritious food products through a radio programme, demand for local products in urban and peri-urban areas has increased tremendously, which in turn has encouraged farmers in the production of these local crops. Owing to increased demand for local products in the market the private intermediary entrepreneurs are also motivated to deal with local products. Karmhacharya Enterprises, Sital Agroproducts and Sri-complex are some examples of such entrepreneurs. This initiative has helped utilization of local crops and landraces leading to biodiversity conservation. This programme has also encouraged private intermediary entrepreneurs to conserve and utilize biodiversity. Many of the listeners perceive that there is growing demand and interest on the part of producers, sellers and consumers for local products and according to them one of the credits goes to the radio programme. This programme has, in fact, helped in raising awareness of stakeholders in the importance of local products and the scope for value-addition of local products and market linkages.

Information outlets

It has also become a means of notifying and different and wide range of stakeholders about biodiversity conservation activities such as fairs, competition and folk songs. It will be a forum for inviting a large number of participants as well as broadcasting the major findings of such activities for further dissemination. Some of the examples are yam fair, sugarcane fair, orchid fair, orange fair and that of uncultivated foods and medicinal plants. This helped in not only knowing the species diversity but also in collecting knowledge associated with the crop species.

The next important thing of mass media programming is whether they listen themselves only or also share and discuss with others after listening to the programme. All these activities are necessary to determine the effectiveness of the programme. Results of a listeners' survey indicate that, after listening to this program, 36% of the listeners discussed topics with neighbours, 32% has discussions with their own family members, followed by farmers' groups (22%) and development workers (11%).

Increased value of underutilized crops

Issues and information related to neglected but nutritionally superior food crops were broadcast so as to increase awareness on the value of these crops. One of the initiatives taken by the programme is on finger millet, which was regarded as a food of poor and neglected people. This crop was selected in order to highlight its importance and significance in nutrition. A live discussion was organized, involving agronomists, dieticians, doctors and some prestigious personnel of the society on nutritional and medicinal value of finger millet, to increase awareness on its importance and its adaptation to dry conditions. Information on the diversity of finger millet (24 varieties) in peri-urban areas of Pokhara valley was also broadcast. Similarly, the nutritional importance of buckwheat, taro, yam and other crops was also disseminated through the programme.

This has increased the demand for products of these neglected crops in Pokhara valley. Interaction with stakeholders and a study carried out by DF project of LI-BIRD suggest that customers are enjoying buckwheat noodle, cake, bread and biscuits of millet and buckwheat in different restaurants in Pokhara, such as Madav's café and Almond's restaurants. This has encouraged farmers to continue growing these crops, thus helping in biodiversity conservation (Sapkota *et al.*, unpublished).

Information on agricultural technologies suitable for local farm situation

The programme has dealt with the use of different seeds, fertilizer and other technologies suitable for local farm conditions under farmers' own management, through a series of discussions, debates and presentations. Seasonal and important land-management technologies and agricultural practices of different crops suitable for local farm situations are presented so as to benefit farmers. Information on integrated nutrient management and integrated pest management is delivered on a regular basis. The members of community-based organizations, farmers' cooperatives and heads of different farmer communities were invited to share their success and experiences. This process of involving farmers helped in enhancing their communication skill and empowerment. It also facilitated in recognition of the farmers through providing an opportunity to share their views in different fora. This has led to an increased level of adaptation of the technology in the farming community as the farmers and community people are more apt to follow the technology shared by their neighbour and leader than those introduced by outsiders.

Popularity of the programme

LI-BIRD KO CHAUTARI is the most popular programme among the farming communities, service-holders, students and business people. It was reported that this programme was one of the most popular and interesting programmes aired by Annapurna FM. From the analysis it was found that Annapurna highlight (news) was the most-liked programme (43%) of Annapurna FM followed by LI-BIRD KO CHAUTARI (36%), i.e. the second-ranked programme of those aired by FM. This certainly indicates that the content of the programme is relevant to the listeners. The programme has much influence in rural area and listeners have been sending their wishes and responses every week. On an average, about 45 letters are received every week. It was interesting to note that one of the national newspapers, Gagan Daily, carried out a response survey of the programme broadcasted through Annapurna F.M and according to the survey results, LI-BIRD ko Chautari was among the most popular programmes (Box 1).

Box 1. The popularity of LI-BIRD KO CHAUTARI in rural areas.

LI-BIRD in partnership with Annapurna FM 93.4 MHZ broadcasts LI-BIRD KO CHAUTARI every Sunday and Wednesday at 7:15 pm, which is becoming popular nowadays. This programme, as it deals with agriculture and biodiversity, is informative for rural farmers. Farmers claim that the programme is very useful and must be listened to as it provides information on agricultural products and their management and biodiversity.

Mrs Shila Devi Pouldel of Gharmi, Kaski, a regular listener of the programme, expresses her view that the programme must be listened to by all the framers as it encourages farmers to participate in the programme directly and also deals with the use of different seeds, fertilizer and other technologies suitable for the local farm conditions under farmers' own management. She emphasizes that the programme is so important because it explains the importance of biodiversity of the region and its conservation needs. The presentation skill of the programme host is so simple and attractive that she keeps on listening, as if the experts are directly visiting her field and giving information, she adds.

Not only from Gharmi, farmers from Hemja, Begnas, Bhalam and those of Tahanun claim that the programme is suitable and fruitful for them. As our life is closely associated with nature, conserving biodiversity is conserving ourselves. This is the knowledge given by LI-BIRD KO CHAUTARI, says Pramod Poudel, a regular listener of the programme from Gharmi, Pokhara. This programme has added a brick for the uplifting of agriculture in our locality, so it is popular in rural areas, he says.

(Gagan National Daily, 2059-9-23)

Among the seven subjects frequently broadcast from this programme, discussion with farmers was found to be the most useful, followed by problem-solving, issue-based discussions, agricultural news, weekly questions and answers, and information on agricultural technology as identified by priority index analysis from listeners' survey (Table 1).

Table 1. Priority index analysis from listeners' survey.

Subject broadcast in the programme	Index	Ranking
Discussion with farmers	0.81	I
Issue-based discussions	0.67	III
Problem-solving	0.69	II
Poet/Folk songs	0.54	VII
Agricultural news	0.66	IV
Information on agricultural technology	0.55	VI
Weekly questions and answers	0.57	V

Policy influence on biodiversity

One of the major objectives of LI-BIRD KO CHOUTARI is to highlight issues that have direct linkage with farmers' livelihood and concerns and bring them to the forefront for debate and discussion. Different kinds of advocacy and debates were organized on emerging issues (particularly related to biodiversity) of local, national and international levels by inviting the concerned authorities and stakeholders. This helped in forming a public opinion and put pressure on the concerned authorities. Some of the examples are seed quality standard, citrus market management at local level, biodiversity conservation, participatory plant breeding, Nepal being a member of World Trade Organization (WTO), farmers' rights, intellectual property rights. Similarly, critical and analytical comments on some of the government's policies such as seed act, food distribution, fertilizer quality control, community forestry and community biodiversity registration have helped influence government policy for improvements. It is very interesting to highlight the fact that recently the agrobiodiversity component has been reflected in the government's 10th Five-Year Plan.

Good practices of the programme

Contribution of the programme in raising awareness and disseminating information, including policy advocacy

- The programme has contributed in raising awareness in biodiversity and natural resource management among farmers, scientists and students
- It has helped in technological transfer (good practices of *in situ* and biodiversity-related projects and programmes are shared)
- It has helped in promoting indigenous culture and technology through sharing of information and knowledge (sharing from farmers, researchers, scientists, policy-makers, students and the public)
- It has helped in advocating on emerging issues and concerns of farmers.

Contribution to methodology and process development for effectiveness of rural radio programme

- The programme has developed methodologies, processes and means through which the message is effectively delivered to the listeners. The methods include poems, folk songs, slogans, proverbs, question and answer session, talk, debate, live broadcast, voices from the field, panel discussion and news.
- The programme has been highlighting culturally and religiously important events and days linked with farming activities. This has brought new direction in empowering

communities towards conserving traditional and rich knowledge and practices. People have the perception that it is their radio programme.

Issues and challenges

- **Financial resources**: Owing to limitation of financial resources, the programme has limited coverage. Despite the overwhelming positive responses of farmers and other listeners, LI-BIRD could not extend this to wider areas.
- **Coverage area:** The coverage area is limited to some districts in the Central and Western region of Nepal. The messages and information are very necessary in wider geographic area as LI-BIRD is extending its projects in various districts. It would be more effective if the area coverage were larger.
- **Listeners' demand**: The radio station management is receiving a number of letters from the listeners demanding an increase in the duration of the programme. Some of the feedback and comments related to the programme led to adjustments, but regarding the duration, the management has some limitations.

Lessons learned

LI-BIRD KO CHAOUTARI is popular, gaining support and inspires many farmers and listeners' clubs. There are some limitations as it has not been able to expand its coverage area or even the duration of programme. The programme has been very effective in disseminating information that is directly related to farmers and farmer communities. It has been successfully exploring ways and means through which farmers have access to information and knowledge. It has contributed to raising awareness among farmers and policy-makers regarding certain issues like biodiversity, natural resources management and livelihoods. It has also contributed to building consensus among farmers, researchers and policy-makers on agenda and issues of common interest.

Radio is one of the best means of transferring knowledge and information to a wide farming population in a very short duration of time. These good initiatives now need critical review and some new mechanisms need to be developed to take it to national and international levels. LI-BIRD, as the pioneer in the region, should now collaborate with various stakeholders and think of generating local resources for sustainability of the programme.

Conclusion

There are different means for awareness rising of promoting conservation and utilization of biodiversity, but radio broadcasting has been a powerful and comparatively cheap tool to reach a large section of the communities. LI-BIRD KO CHOUTARI has played a crucial role in creating awareness on biodiversity and its importance among different stakeholders including farmers. Different stakeholders and farming communities now realize the value of conserving their local natural resources and local food crops. As a consequence, demand for local food items has increased, thereby encouraging farmers to conserve and utilize them. Demand for previously neglected food crops such as finger millet and buckwheat has increased after sensitization from the radio programme. The programme has encouraged private intermediary entrepreneurs and farmers' groups in collecting, value-addition and marketing of local products and also has helped influencing government policy on agrobiodiversity.

This is a programme that family members listen to and discuss during their family gathering. An increasing number of listeners' clubs have been formed because of their interest, attraction and learning attitude on agrobiodiversity conservation. The programme is very popular, particularly in rural areas where farming communities reside. The programme has not been extended to a larger area and communities because of financial limitations. Judging by the initial impact of this programme, there are opportunities for its replication and uptake at national and international levels.

Acknowledgements

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Effectiveness of diversity fair in raising awareness of agrobiodiversity management

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Abstract

Diversity Fair is a tailored approach for public awareness intended to positively influence the attitude of a specific audience (the farming community). Of the public-awareness tools tested, experiences of project staff and general observations have shown that diversity fair presented the utmost promise for scaling-up and scaling-out. However, no deliberate effort has been made to investigate its effectiveness in raising awareness across the intended target groups. Thus, a study was conducted in Lekhanath municipality of Kaski district and Kachorwa village of Bara district, Nepal, in order to investigate how far the Diversity Fair has been successful in creating public awareness on the need for on-farm conservation, and to understand the strengths and weakness of Diversity Fair at different levels. The data were collected through individual interviews at farmer level, and focus group discussions and key informant interviews for other stakeholder groups. The findings show that Diversity Fair is able to create more favourable effects on the farming community, scientists, researchers and private entrepreneurs. Diversity Fair is an effective tool in raising awareness on agrobiodiversity conservation and management within and outside the farming community. The effect of Diversity Fair on farmers was seen more in Kaski site than in Bara site. Farmers as well as researchers and private entrepreneurs benefited from the Diversity Fair, which created market linkage as well as promoted social interaction and strengthened the seed supply system. Respondents could differentiate between the Diversity Fair and Agricultural Fair. Most of them chose the Diversity Fair as a more suitable method than Agricultural Fair from a biodiversity conservation point of view in both areas. Although Diversity Fair was chosen, even then this method also has scope for improvement, i.e. it covers a small area which is limited, and has been conducted only in a few up to now. Names of varieties were found to be unreliable and differed from one village to another, which makes it difficult to access the level of diversity within the areas. Appreciation of farmers' crop varieties through display and awards has encouraged the farming community to realize the importance of conserving and maintaining greater on-farm diversity and it can further contribute to increasing the diversity. To ensure sustainability and effectiveness of the Fair, it should be organized every year and overall responsibility for organization in future should be handed over to the local community-based organizations (CBOs), farmer groups or government organizations (GOs) after the concerned personnel from these institutions have been advised on by experts on organizing a Diversity Fair.

Key words: Agrobiodiversity, diversity fair, *in situ* conservation, Nepal, public awareness

Introduction

The Diversity Fair is one of the most popular and useful participatory methods for raising awareness from local community to policy levels. Public awareness is the initial foundation for effective participation of farming communities in research and development activities related to agrobiodiversity conservation (Jarvis *et al.* 2000). Raising awareness is the first step in promoting conservation and use of local plant genetic resources. It adds value to the local crops and encourages consumers (both rural and urban), development workers, policy-makers and farming communities to conserve and make continued use of these crops (Rijal *et al.* 2000a). Diversity Fair has been found to be a simple and low-cost approach for locating biodiversity. It helps to identify custodians of rare and unique crop genetic resources and local knowledge, and establish links for future studies (Sthapit *et al.* 2003). Currently, Diversity Fairs are being used to locate diversity and recognize custodians of this diversity, to enhance farmer participation and inspire management of rich diversity. Diversity Fair is a fair of local crops or livestock diversity organized by a local organization or genebank with the objectives of sensitizing the local community, locating and identifying custodians of biodiversity, and collecting genetic resources and associated knowledge to promote the exchange of materials and information. The importance of plant genetic resources in food security and sustainable development is increasingly being realized at different levels right from grassroots to policy-makers (Thrupp 1997; Pratap and Sthapit 1998). As a consequence, different institutions are putting in substantial efforts on conservation and utilization of plant and animal genetic resources with increased sensitivity to equity in benefit-sharing. The key international players in biodiversity conservation have highlighted the importance of public awareness and education at different levels in meeting the goals of conservation (Sthapit and Hansen 2000).

The Nepal component of the global project "Strengthening the scientific basis of *in situ* conservation of agrobiodiversity on-farm" emphasized public awareness and community participation as one of the major components of the project. Public awareness or community sensitization is one of the initial activities of the project, focused on educating farmers about the value of local crop diversity and fostering a sense of pride in their cultural heritage of local diversity (Jarvis *et al.* 2000). In the Nepalese context, project staff successfully experimented with a variety of innovative public awareness tools such as Diversity Fair, rural drama, rural poetry journey, travelling seminar, diversity blocks, folk song competition, etc. (Rijal *et al.* 2000a, 2000b). Diversity Fair has increasingly been used in India and Bangladesh as well as Nepal, and there is a strong tradition in Latin American countries to organize a Diversity Fair at regular interval at regional levels (Brush 1991; Tapia and Rosa 1993). Diversity Fair has been used as an entry point for on-farm conservation activity in Vietnam (Trinh *et al.* 1999). Compared with conventional baseline or informal Participatory Rural Appraisal (PRA) survey, this method is able to sensitize the farming community and also to categorize crop diversity into a group of common, rare, endangered and lost cultivars.

Diversity Fair provides a unique opportunity for individual farmers and community members to display their local genetic materials as well as to share and document associated indigenous/local knowledge held by the custodians of the genetic materials. It is expected that exchange of materials would take place through a Diversity Fair. Thus, the approach identifies any valuable genetic resources along with the custodians and promotes exchange of useful materials. For researchers, Diversity Fair provides the opportunity of scoping promising materials that could be used in breeding programmes, and also enables collection of any endangered material for *ex situ* conservation in a genebank. Above all, by handing over the responsibility of managing Diversity Fair to local community-based organizations and farmers' groups the project contributes in capacity-building of local institutions active in agrobiodiversity conservation. Adoption of biodiversity-friendly practices by the farmers is very much influenced by farmers' attitudes towards a given practice. Carefully planned communication can help to reinforce attitudes that support adoption and counteract those that act as barriers (LINK 2003). Diversity Fair is a tailored approach for public awareness creation intended to positively influence the attitude of a specific audience (the farming community) so that they adopt biodiversity-friendly practices. Among the public awareness tools tested, experiences of project staff and general observations have shown that Diversity Fair has presented the utmost promise for scaling-out. However, no deliberate effort has been made to investigate its effectiveness in raising awareness across the intended target groups. Thus, this study is precisely intended to do so. In addition, the study will look into strengths and limitations of Diversity Fair so that the tool can be further refined in the process of scaling-out.

Materials and methods

Literature review

Relevant literature on Diversity Fair was reviewed to update the protocol of the study and to understand Diversity Fair. From the review and past experiences in Diversity Fair, research questions were identified, then survey questionnaire, and a sampling frame for study purposes was developed.

In-house discussion

After developing a protocol, a 1-day in-house discussion among the professionals of Local Initiatives for Biodiversity, Research and Development (LI-BIRD) was carried out for common understanding on the nature and purpose of the study. At the same meeting the team agreed upon the target groups or individuals for the study. The team divided the study into five groups, i.e. farmers (both within and outside the project area), community-based organizations (CBOs)/schools, non-governmental organizations (NGOs)/international non-governmental organizations (INGOs), governmental organizations (GOs) and private entrepreneurs. The team agreed on preparation of different sets of questionnaires for individual groups.

Questionnaire preparation

From the review of relevant literature and inputs from different professionals, different sets of questionnaires were developed for individual groups, which were thoroughly discussed with team members. The suggestions received from the group were incorporated and a refined version was developed. Eventually, the improved version was submitted to IPGRI experts for comments. Comments received from IPGRI experts were also incorporated. After incorporating all comments and suggestions, the questionnaires were finalized.

Data collection

By using structured and semi-structured questionnaires, data on a number of items reflecting the effectiveness of Diversity Fair were collected. Different sets of questionnaires for different groups were used for gathering information regarding the Diversity Fair. Once the questionnaire was finalized it was translated into Nepali for field implementation. The different techniques used for data collection are:

- **Individual Interviews:** Before conducting the interview, the field staff involved in the data collection were oriented on the objectives of the study. At the time of orientation, they were briefed about data-collection methods and contents, for the purpose of reliable and consistent data collection. After this structured interview, a schedule was used for individual interviews of sample households. Random and purposive sampling methods were used for individual interviews. In both (Kaski and Bara) study sites there were 22 farmers' groups in each site. For the selection of farmers inside the *in situ* project area, the first 10 groups in each site were selected randomly and after selection of farmers' groups, 50 farmers from each site were selected randomly. The farmers outside the *in situ* project area were also selected for assessment of the effect of Diversity Fair. For these, 20 farmers from villages adjoining the Kaski site and 20 farmers from villages adjoining the Bara site were randomly selected. A purposive sample of 23 from Kaski and 20 from Bara was selected for the purpose of identifying as well as verifying the strengths and limitations of Diversity Fair.
- **Focus Group Discussions:** Among the different PRA tools, FGD is an important tool for gathering the necessary information. A separate FGD representing 22 farmers' groups in Kaski and Bara sites was conducted in order to gather the overall perception of farmers. CBOs and NGOs, which were involved or working in the area of Diversity Fair, were purposely selected for the study. In the case of CBOs and NGOs, both Key Informant Interview (KII) and FGDs were conducted.

- **Key Informant Interviews:** Key informant interviews were carried out to collect information from GOs, NGOs and CBOs for which a separate checklist was prepared. In this case certain key persons from selected organizations were identified before conducting the study.

Data analysis

After finishing the information collection task, the collected information was cleaned, edited and coded for data entry. Then the data were entered into a statistical package (Statistical Package for Social Sciences, SPSS) and analyzed using simple descriptive statistics.

Results

Effect of Diversity Fair from farmers' perspectives

Awareness about Diversity Fair

Most of the surveyed farmers of both sample groups, i.e. farmers inside (67.5%) and outside (75%) the project area, were familiar with the term Diversity Fair and its purpose. Respondents in both study sites mentioned that they get information about the Diversity Fair from the project staff stationed in the field (i.e. *in situ* project), their farmers' group and neighbours. Farmers in Kaski get information from LI-BIRD *Ko Choutari*, a radio programme run by LI-BIRD in Annapurna FM station, and the Agriculture Sub Centre (ASC). The farmers of Bara site get information from their own genebank, the Agriculture Development and Conservation Society (ADCS), and from school children (Table 1).

Table 1. Percent source of information about Diversity Fair in farmers' level by ecosite.

Information source	Kaski		Bara	
	Project area	Outside area	Project area	Outside area
LI-BIRD †	49	50	50	33
Farmer group	51	19	10	27
Neighbour	–	12	33	27
FM Radio	–	13	–	–
Agriculture Sub Centre	–	6	–	–
ADCS ‡	–	–	–	13
School children	–	–	7	–

† Local Initiatives for Biodiversity Research and Development.
‡ Agriculture Development and Conservation Society.

Diversity Fair as source of information and knowledge

A higher proportion of farmers in Kaski than of farmers in Bara site (both inside the project area), and a few farmers outside the project area have learned new information about crop variety, agrobiodiversity, importance and benefits from biodiversity conservation through Diversity Fair. They also found new material, such as species diversity of rice, sponge gourd, finger millet, fish, taro and other vegetables in the Kaski site and species diversity of rice and sponge gourd in Bara site from Diversity Fair. Farmers from both sites reported finding new materials at Diversity Fair (Table 2).

The Diversity Fair is used as an awareness-raising tool; it is able to provide knowledge about diversity. More farmers from Kaski than from Bara reported that they get knowledge on genetic materials from this Diversity Fair. They also obtain knowledge on the importance of biodiversity conservation and knowledge on local landraces. The study revealed that the Kaski farmers (53%) and Bara farmers (56%) also use the Diversity Fair as a place of exchange and for sharing their knowledge of on farm conservation. As Diversity Fair is a method of raising public awareness, the farmers reported that they will also get a chance to display their capabilities at the time of Diversity Fair, i.e. 36% of farmers in Kaski and 21% of farmers in the Bara site.

Table 2. Farmers' responses (%) on different activities/aspects of Diversity Fair by ecosite.

Activities / Aspects	Kaski		Bara	
	Yes	No	Yes	No
Purpose of Diversity Fair known	63	37	40	60
Participation in Diversity Fair	64	36	34	66
Learned new information from Diversity Fair	60	40	27	73
Found new materials at Diversity Fair	51	49	35	65
Gained knowledge on genetic material	67	33	30	70
Chance of showing own capabilities	36	64	21	79
Change in agrobiodiversity	57	43	52	20
Having rare crop species	36	64	27	73
Get benefit from Diversity Fair	56	44	42	58
Increased interest in agrobiodiversity conservation	68	32	42	58
Opportunity to exchange seed	56	44	40	60
Create market linkage	75	25	38	62
Promote social interaction	49	51	42	58
Increased awareness	67	33	35	65
Interested in further participation	90	10	48	52
Participated in Diversity Fair other than in village	90	10	46	54
Value of resource raising	89	11	42	58
Perceived difference between Diversity Fair and Agricultural Fair	72	28	44	56
Seed exchange	44	56	47	53
Knowledge exchange	53	47	50	50

Strengthening of seed system

The study revealed that surveyed farmers of both Kaski and Bara sites had an opportunity to exchange seed at the Diversity Fair. Farmers explained that this was true especially for seed of landraces, which are available in small amounts and are culturally important in their village. Farmers from both sites reported that the Diversity Fair helped them to create a market linkage, which also helps in strengthening the seed system (Table 2). Other things they indicated were that many people from different regions or places came to the Diversity Fair, so it is also good for promoting social interactions among farmers and scientists, and is helpful in strengthening their seed systems. During the time of Diversity Fair there are informal exchanges and sharing of skills, ideas and knowledge about different things, so the Fair is a good place for interaction with people from other areas. Farmers were also able to get information, knowledge and skills about seed production and management and from this experience they started to maintain the quality of seed.

Change in agrobiodiversity

The farmers of surveyed sites also felt that, after organizing the Diversity Fair in their area, this was the best mode to learn about different aspects and importance of biodiversity conservation. However, they disagreed that the Diversity Fair increased the awareness of on-farm management of biodiversity among the farmers: Kaski (67%) and Bara (35%). More Kaski farmers (58%) believe that the biodiversity is increasing in their area than believe that it remains the same (40%). Similarly in Bara, 38% of farmers believed that biodiversity has increased whereas 35% believed it to be the same. More than half the farmers of both sites said that the condition of biodiversity has been changed, from which we can infer that there is a slight increase in agrobiodiversity. To support these arguments, farmers reported that after Diversity Fair they have started activities related to conservation of rare crop species and their habitat, and provided the names of different varieties of different crops at the time of the interview.

Diversity Fair as a resource benefit

The study showed that 56% of Kaski farmers and 42% of Bara farmers received benefits from Diversity Fair. They were able to get knowledge on landrace conservation, importance of landraces and importance of agrobiodiversity. Diversity Fair also helps to increase social interactions, create market linkages, increase seed production, enables them to get prizes and provides new opportunities to observe a large number of rare crop species in one place at one time as well as obtain knowledge of planting practices. Most (90%) farmers of Kaski and about half (48%) of Bara site showed interest in participating in Diversity Fair organized by others and the same percentage of farmers participated in a Diversity Fair organized by a village other than their own. At the time of study they also mention that after a Diversity Fair in their locality, 90% of Kaski farmers and 42% of Bara farmers learned more about the value of resources. So from the study it can be concluded that value of crop genetic resources in their village has increased after Diversity Fair.

Effect of Diversity Fair from CBO perspective

Diversity Fair as source of information and knowledge

In the case of CBOs, almost all of them know about the Diversity Fair, having initially received information about it from LI-BIRD, i.e. the *in situ* project. All the CBOs claimed that at Diversity Fair they had the chance to see and learn new information about different crops, including medicinal plants and other endangered species, and had the chance to exchange knowledge and skills. Thus, their level of awareness toward agrobiodiversity was raised which helped to create market linkages and to identify the area or location of different crop species; they also got new materials of different crop species. Only 25% of CBOs participated in Diversity Fair organized by others (CBOs, NGOs outside their village) (Table 3). One-third of CBOs conducted the Diversity Fair in their own command area. All CBOs mentioned that they get benefits from Diversity Fair.

Table 3. CBOs' response (%) on different aspects of Diversity Fair.

Response	Yes	No
Participated in Diversity Fair organized by others	25	75
Conducted Diversity Fair	33	67
Found new materials	100	–
Diversity Fair is effective for agrobiodiversity conservation	87	13
Learned how to organize Diversity Fair	78	22
Want to continue Diversity Fair in future	100	–

Agrobiodiversity conservation

The study indicated that all the organizations have common interests in biodiversity conservation, which increased after Diversity Fair. They also initiated some biodiversity conservation activities like conservation of endangered species by maintaining the diversity block, disseminating information among the different groups of their working areas, collection and identification of medicinal plants and sensitization on conservation of local crop species. The value of agrobiodiversity was also increased after organizing the Diversity Fair: before the value of landraces was not clear but after, most of the farmer were aware of it. All the CBOs claimed that after Diversity Fair there was a change in level of agrobiodiversity conservation, i.e. it increased in their working area.

Knowledge-sharing

All the CBOs reported that Diversity Fair created better opportunities for seed exchange, exchange of knowledge, innovation and experiences, created market linkages, promoted social interaction, increased the use value of crops, contributed in increasing the diversity of crops and created awareness to conserve rare crop species in their locality. They understood the difference in purpose of Diversity Fair and an agricultural fair. A few CBOs reported that both fairs were equally important from a biodiversity conservation point of view but the majority reported that Diversity Fair is more effective than an agricultural fair. This study indicated that the Diversity Fair is a good medium for gaining and sharing knowledge. The overall performance of Diversity Fair was considered good, and all organizations want to continue it in future for continuation of agrobiodiversity conservation, further scaling-up of methodology and collection of endangered crop seeds and to learn how to organize the Diversity Fair.

Effect of Diversity Fair from GO perspective

From the study during interview it was revealed that all the GOs also heard about the diversity fair from *in situ* project (LI-BIRD, IPGRI, NARC, Agricultural Botany Division of NARC), which indicates that before the *in situ* project began, they did not know about the Diversity Fair in the study area. The government officials also mentioned that there is a difference between agricultural fair and Diversity Fair, but among the sampled GOs, only one GO had organized a Diversity Fair in collaboration with others. Some of the government officials reported that the information about diversity was not adequate for further organization of the fair. The government officials also indicated that the benefits of Diversity Fair are information exchange, learning the value of germplasm, awareness creation among the general public, ideas about varietal diversity, information flow between policy-makers and researchers and the chance to collect seeds of endangered species. They felt that researchers received the most benefit, as did organisers, extension workers, community, policy-makers, and farmers, but from the government officials' perspectives, researchers received the most benefit and farmers the least benefit from Diversity Fair. However, the study further showed that government officials agreed that Diversity Fair creates opportunities for locating promising materials that could be used in breeding programmes and it also enables collection of any endangered material for *ex situ* conservation in genebanks. Diversity Fair, to some extent, contributes to research and development activity but needs to modify in some aspect, e.g. needs to become more regular and crop specific in a decentralized way, needs to be scaled-up at least to Village Development Committee (VDC) level at initial stage, needs to be organized in different places within a district over a year and it should be shifted from project-based to district- or community-based. The government officials were also interested in continuing in future with GO funds if their resources are available. District Agricultural Development Offices (DADOs) are thinking about scaling-up the programme in larger areas as well.

Effect of Diversity Fair from other perspectives

During the time of study different personnel from NGOs and private entrepreneurs were also interviewed. The study showed that the NGOs other than LI-BIRD were also involved in organizing a Diversity Fair in the Kaski area. They got information from sources other than the *in situ* project (e.g. NPG, UMN), which indicates that the concept of Diversity Fair is not only in project sites (Kaski, Jumla and Bara), it is also scaled-up in other parts of the country. From the NGO’s perspective, farmers received more benefit from the Diversity Fair than community, researchers, organizers, extension workers and policy-makers. NGOs and private entrepreneurs both feel that Diversity Fair offers opportunities to explore marketing potential, get knowledge on old and new crops, exchange seeds, and learn about innovation, technology and experiences. Diversity Fair enabled organizations to practically evaluate themselves the state of agrobiodiversity within the areas and creates opportunities for locating promising materials that could be used in breeding programmes, thus enabling them to collect any endangered material for *ex situ* conservation in genebanks. So the capacity of a farming community is enhanced through Diversity Fair. Diversity Fair brings to the fore any local material with prospects for good consumer demand in the market. It also allows private entrepreneurs to come in contact with local producers from which point further negotiations and planning could take place.

Place for improvements

All the surveyed farmers, GOs/NGOs officials, CBOs members and private entrepreneurs seemed satisfied with Diversity Fair and agreed that this helps in landrace conservation. They stated that they found many varieties in the fair, which they had never seen, and also had the opportunity to exchange knowledge, experience, information and seed. During the time of study different groups presented their views towards Diversity Fair in different ways. All the groups of this study shared their experiences and suggested different ways to further improve the Diversity Fair. They mentioned that at present Diversity Fair could not involve all the groups of a village as one group, i.e. 22 groups into one group, so in future they would try to involve all the groups into one group. The fair is confined to a small area and therefore it could scale-up to a larger area. It was felt that judging for prize distribution was unfair so it was better to improve the judging criteria. The Fair was organized only at limited times and therefore needs to become a yearly event. The information available and collected at the fair time could be published in subsequent years for the database. Materials such as posters, pamphlets and leaflets would be produced for wider dissemination of information. Exchange visits are lacking between the villages as well as outside the village, so it would be better to organize exchange visits from which they would be able to learn about the Diversity Fair. Names of the varieties at the fair were found to be unreliable and differ from one village to another for the same variety so it is better to identify the right name for those varieties; a mechanism to do this could be devised. The Fair period is short and time consuming. There are limited participants and low or no media coverage due to geography limitations. Display material (seed) is inadequate for distribution so could be produced in large amounts and displayed as well as marketed. Diversity Fair is not included in the government policy so there is a need to have it included. Diversity Fair is used for project purposes only; therefore farmers could maintain diversity block of display materials after Diversity Fair.

Discussion

In Vietnam, Trinh *et al.* (1999) found that Diversity Fair is the best way to participate in project activities to share information and materials from farmers' perspective. From the PGR researchers' perspective, this could be an entry point to reach the farming community; to locate genetic diversity; and to identify custodians of genetic resources more precisely than the conventional exploration mission. In Nepal this study shows that Diversity Fair is able to create positive effects for the farming community, scientists, researchers and private entrepreneurs. As mentioned by Rijal *et al.* (2000b), Diversity Fair is an effective medium to sensitize communities on the value and use of conserving local landraces, and to assess genetic diversity at community level in Nepal. Diversity Fair is organized in three sites of the *in situ* project and has been useful in raising awareness on the value and uses of local crop landraces within as well as outside the community. This study also found that Diversity Fair is an effective tool in raising awareness on agrobiodiversity conservation and management within as well as outside of the farming community. The effect of Diversity Fair on farmers was seen more in Kaski site than in Bara site. As the farmers as well as researchers and private entrepreneurs reported that they were able to get benefit from the Diversity Fair in different perspective—gaining knowledge, sharing knowledge and learning more about agrobiodiversity and its importance—the fair provided a good opportunity for farmers, researchers and development workers to share information and planting materials of local crops. Chaudhary *et al.* (2003) also found that Diversity Fair was successful in collecting materials and knowledge associated with a farming community.

Sthapit *et al.* (2002) reported that Diversity Fairs strengthen the traditional seed supply system and enable custodians of Plant Genetic Resources (PGR) to locate genetic diversity more precisely than the conventional exploration missions. From this study it is also revealed that Diversity Fair strengthened the seed supply system as it created market linkage as well as promoted social interaction. The study group also distinguished between the Diversity Fair and agricultural fair and most of them chose the first one as a more suitable method than agricultural fair from a biodiversity conservation point of view in both areas. A few farmers reported that both methods were suitable but certain principles of the agricultural fair need to be modified. Upadhyay *et al.* (2003) also found that unlike agricultural fair where recognition is awarded to the largest or highest-yielding variety, Diversity Fairs encourage and recognize farmers and farming communities who maintain important but rare species and varieties, and Diversity Fairs have a wider role in creating public awareness through demonstration and documentation of genetic resources and indigenous knowledge held by the farming communities.

Although Diversity Fair has strength in various aspects, there are also certain things that need to be improved in future, which were shared by the different groups during the study time. Farmers of study site reported that seeds of rare species were in small quantity and kept only for display purpose, so they could not get adequate quantity for distribution purposes, as they want to test a new variety. So CBOs and the project staff will have to think of ways of multiplying such seed and making it available to those who asked for the seed in the first place. Farmers as well as other officials also feel that the Diversity Fair should not be conducted only during the project period but also after the project period on a yearly basis if it is felt necessary, and information collected during the project period should be maintained in a database for future reference. Names of varieties were found to be unreliable and differed from one village to another village which makes it difficult to assess the level of diversity within the areas. Hence any provision to ensure the name of varieties would be more beneficial than the present one. Although the award system of Diversity Fair encourages the farmers in conservation, certain improvements in the judging criteria are required, for example, determine whether displayed diversity is available in their village or not. The Diversity Fair provides a good forum and opportunity to individual farmers and farming communities to display their crop genetic wealth and indigenous knowledge held through generations and to get recognition for those valuable resources through diversity awards (Rijal *et al.* 2000b). Appreciation of farmers' crop varieties through display and recognition through words has encouraged the farming community to realize the importance of conserving and maintaining greater diversity on-farm. Thus it can contribute to the increase of diversity.

Ways forward

From the study we can conclude that Diversity Fair is one of the important tools for agrobiodiversity conservation. Although study groups mentioned things that need to be improved to make the Diversity Fair an effective tool for biodiversity conservation, all the study groups recommend that it is important tool for agrobiodiversity conservation. The study groups mentioned that Diversity Fair raise public awareness on different aspects like importance of agrobiodiversity and its conservation, encourages community towards conservation and conservation of endangered landraces, provides opportunities for exchange of knowledge, information, skills, technology and seed, helps in transfer of knowledge over generations, creates market linkages and increased demand for local crop species, increases interaction among farmers. The genetic diversity of a crop in a village can be understood and information can be updated and custodians of the rare and unique crop genetic resources and local knowledge can be identified. From the sustainability point of view, the overall responsibility of organizing Diversity Fair in future should be handed over to the local CBOs and farmers' group in all the places. Therefore, different stakeholders would have to be included in every step of the organization and unfolding the activities of diversity fairs. Furthermore, prior to handing over the organizing responsibilities orientation and capacity-building of government officials, CBOs, NGOs and farmers' groups is essential. Then they could eventually take responsibility for organizing Diversity Fair in the future.

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Note: IPGRI = International Plant Genetic Resources Institute; LI-BIRD = Local Initiatives for Biodiversity, Research and Development; NARC = Nepal Agricultural Research Council.

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