Rice landrace diversity in Nepal. Socio-economic and ecological factors determining rice landrace diversity in three agro-ecozones of Nepal based on farm surveys

J. Bajracharya[1], R.B. Rana[2], D. Gauchan[1], B.R. Sthapit[3], D.I. Jarvis[4] and J.R. Witcombe[5,*]

[1]Nepal Agricultural Research Council (NARC), Khumaltar, Lalitpur, Nepal.

[2]Local Initiatives for Biodiversity, Research and Development (LI-BIRD), Kaski, Pokhara, Nepal.

[3]Bioversity International Office for South Asia National Agriculture Research Centre, DPS Marg Pusa Campus, New Delhi 110012, India.

[4]Agricultural Biodiversity and Ecosystem. Bioversity International, IPGRI, Via dei tre Denari 472/a 00057 MACCARESE (Flumicino), Rome, Italy.

[5]CAZs-Natural Resources, Bangor University, Bangor, Gwynedd LL57 2UW, Wales, UK.

[*] Corresponding author. Tel: +44-1248-382116; fax: +44-1248-371533.
E-mail: j.r.witcombe@bangor.ac.uk

Abstract

In Nepal, in traditional rice farming systems many diverse landraces are grown in all of the rice agro-ecosystems from low to high altitude. Three case study sites were selected to represent the major rice agro-ecozones: Bara (100-150 m) for the low-altitude *terai* (plain); Kaski (700-1,206 m) for the mid-hill zone; and Jumla (2,200-3,000 m) for the high-hill zone. The diversity in rice varieties was compared in these three sites and nine survey villages in a series of surveys conducted in 1998, 1999 and 2006. The level and distribution of diversity on farm varied with the physical and socio-economic settings of the farming communities. The mid-hill site (Kaski) had the highest rice landrace diversity. This was adapted to the diverse agro-ecosystems found there and there was equal diversity in *Kule khet* (irrigated lands by seasonal canals) and *Sim khet* (marshy wet land). The next most diverse system was *Nicha khet* (irrigated lowlands) in Bara, the low-altitude site. The high-hill site (Jumla) had the lowest rice diversity. Across all sites many of the landraces were rarely grown and then only in small areas, reflecting the specialized uses to which they were put. At all sites the most common single landrace occupied less than half of the rice area. Resource-rich farmers were the more important custodians of on-farm rice varietal diversity across the sites. There was more rice diversity in favourable environments than in less favourable ones. This was true whether diversity was measured across sites or across rice domains within sites.

Key words: Agro-ecological diversity; Farmers' unit of diversity (FUD); Landrace diversity; Nepal; *Oryza sativa*;

1. Introduction

Rice (*Oryza sativa* L.) is one of the most important food crops of Nepal that occupies over 50% of the total agricultural land and accounts for nearly 60% of total grain production. The rice-growing environments are highly diverse, ranging from warm subtropical in the plains to temperate in the mountain region of the Himalayas, where its cultivation at 2,621 m in Nepal is the highest recorded (Shahi and Heu 1979). However, 71% of the rice area is at low altitude in the *terai* (plains), 25% in the mid-hills and only 4% in the high-hill districts (CBS, 2007).

In Nepal, extreme variations in altitude, topography, physical and climatic conditions and the antiquity of its agriculture have enriched the country with an immense crop genetic diversity in the form of traditional cultivars or landraces (Upadhyay, 1995). These are a valuable genetic resource for crop improvement and a primary resource for crop production in resource-poor farming communities. However, only 13% of the total rice area was devoted to local traditional varieties in the 2006 rice season (CBS, 2007) and there have been few detailed studies on this remaining landrace diversity.

In this paper we describe the landrace diversity from three case study sites representing three agro-ecological zones using information obtained from farmers. We examine how this diversity relates to socio-economic and ecological environments. In later papers, we describe the diversity from agro-morphological and molecular marker evaluations.

2. Materials and methods

Three case study sites also called case study villages were selected to represent three agro-ecosystems: Talium and Kartikswami (referred to as Jumla) for the high-hill, Begnas (referred to as Kaski) for the mid-hill and Kachorwa (referred to as Bara) for the lowland (plains) (Table 1). In 2006, rice diversity survey was carrried out in nine villages and called survey villages (Table 2, Fig. 1).

(Table 1 and Figure 1…)

2.1 PRA survey

Participatory rural appraisals (PRAs) were used to identify and assess the rice diversity in the three case study villages and to give an understanding of the socio-economic and cultural diversity that influences agricultural diversity. The tools used in the PRAs were direct observations and group interviews. Key informants were asked from mouth to mouth in 1999 what rice landraces were grown in the village and the names by which farmers identified them – the farmers' unit of diversity (FUD) (Rijal *et al*., 1998, Paudel *et al*., 1998 and Sherchand *et al*., 1998).

2.2 Baseline survey

In the baseline survey, farming households (HHs) were the basic sampling unit. The study employed a proportionate stratified random sampling design to identify the HHs to be included in the survey, where the strata were wealth categories i.e., resource-rich, resource-medium and resource-poor. These categories used criteria, that were the consensus of key informants (3-9 farmers) within each study village, such as landholding size, food self sufficiency, size of orchards, livestock resources and off-farm sources of income. A sample of 22-23% of the total HHs completed a survey form (either independently or with assistance from project staff) and responded to questions in an interview: 180 in Jumla, 206 in Kaski and 202 in Bara. The survey provided information on rice cultivation e.g., area under farmers' varieties, agro-ecological conditions and socio-cultural systems (Rana *et al*., 2000a,b,c). However, the number of households that responded to the questions on rice landrace diversity was somewhat lower in Kaski (174 HHs from 206) and in Bara (197 HHs from 202). In 2006, the baseline survey was repeated in nine more villages in each of the three situations (high-hills, mid-hills and lowlands). In this case, the method used was a group discussion (GD) (Table 2).

(Table 2…)

2.3 Diversity fairs

Diversity fairs were organised in the three case study sites in 1998: 24th Nov in Jumla, 5th Jun in Kaski and 23rd Dec in Bara. Groups of 21-85 HHs were formed according to agro-ecological boundaries: 20 in Jumla, 16 in Kaski and 22 in Bara. Groups were asked to complete information sheets that were distributed the day before the fair on the landrace diversity in the village (names, characteristics, adaptation, social, religious and cultural importance, source of seed). The groups took part in the fair and displayed seeds of the landraces, which, with the agreement of the groups, were then retained for further study.

2.4 Analysis

In each case study site, the extent of genetic diversity in rice landraces in farmers' fields was measured by the number of named landraces, number of farming households growing each landrace, and the area covered by each of them. The relative importance of each landrace, the diversity of rice-growing domains, and landrace distribution over domains were determined. Statistical analysis was done with the statistical software package Minitab 12 and with Excel. The distribution of rice landrace in different agro-ecosystems was compared with the chi-square test, and difference in rice diversity among wealth categories was also examined and compared using analysis of variance. The relationships between agro-ecozones and the categorical variables of rice diversity were examined with chi-square tests using bivariate analysis.

3. Results

3.1 Amount of rice genetic diversity on-farm: total number of rice varieties

At all three case study sites in 1998 and 1999 farmers grew a range of rice landraces as identified by the farmer-given names. The number of rice varieties reported varied by the method. The most intensive method, the diversity fair, gave the largest number of landraces, and the least intensive method, the PRA survey, the fewest. Jumla always had fewer landraces, whatever the method (Table 3). The mid-hill site had somewhat fewer landraces than the low-altitude site in the PRA survey and the diversity fair, but somewhat more in the baseline survey (Table 3). In the mid-hills and *terai* (lowland) sites both landraces and modern varieties (MVs) of rice were grown but no modern varieties were grown in the high-hill site. The average number of MVs in Kaski was half that of Bara (0.5 per HH in Kaski, 1.1 per HH in Bara). Essentially, all three methods gave the same relative results i.e., that Jumla had the lowest diversity and that Kaski and Bara had an approximately equal but higher diversity.

(Table 3…..)

The rice diversity associated with altitude was tested in nine survey villages and compared with the results from the most reliable method used in the three case study villages. Again the high altitude sites had the lowest diversity and there was no significant difference between the higher diversity of the mid-hill and lowland sites (Table 4). The difference in diversity between high-hills and mid-hills and between high-hill and lowland were significant (p <0.001 for both comparison), but the differences between mid-hills and lowlands were not significant (p = 0.12).

(Table 4…..)

3.2 Distribution of rice diversity on-farm: number of households and areas under rice cultivars

From the baseline survey the landraces were categorized into four classes by the frequency they were grown by households and the average area on which they were grown. In all three study sites the distribution was similar (Table 5; Figure 2). The most frequent category was of landraces that were less frequently grown and on a small area and the least common categories were for landraces that were common.

The means of the four categories showed large differences (Table 5). Uncommon landraces were always grown by fewer than 6% of the households in contrast to over 38% for common ones. Differences in areas also tended to be large but across sites the areas overlapped e.g., 0.11 was a large area in Jumla and 0.18 ha a small area in Bara reflecting the differences in mean areas. At all case study sites about half of the named landraces (63% in Jumla, 45% in Kaski and 53% in Bara) were grown by only one or two households (not sown data). Over 50% of the landraces were grown in a below average area (63% in Jumla, 56% in Kaski and 63% in Bara). The most rarely grown landraces were those that were grown by only 1 or 2 households and then on a below average area. These accounted for 31% of the landraces in Jumla, 32% in Kaski and 37% in Bara. These rarely grown landraces were grown in small plots across the rice growing environments either for their particular use value e.g., *Jhinuwa*, *Kalo Bayarni* (aromatic rice), and *Sathi* (black-glumed rice of religious significance) or some were specifically adapted to a rare, marginal rice-growing environment. Landraces *Naltumme* and *Tunde* in Kaski and *Darime* in Jumla were grown in marginal environments of droughted and shaded lands; whereas in Bara, *Bhatti, Silhat* and *Mutmur* were landraces adapted to the stress environment of water. It is because in tearai environment, the pokhari (ponds) occurs very commonly and modern varieties could not be grown in this environment. Similarly in most upland conditions (Uncha khet) *Mutmur* was grown abundantly.

At all three case study sites, only a few landraces (5-17%) were commonly grown and in large areas (Table 5). The baseline survey showed that these commonly grown landraces were highly preferred for their quality, had wide adaptation to adjacent domains, and had a high market demand and a high demand for local consumption (Sthapit *et al*., 2000). However, no one landrace covered more than 17% of the rice area in Kaski and the highest coverage of a single landrace was 39% in Jumla.

(Table 5 and Figure 2…)

3.3 The social environment – resource-rich farmers grow many cultivars

The baseline surveys showed that households in each site grew from one to many landraces. The diversity of rice at the household level was highest in the mid-hill (Kaski) case study site with an average of about 4 landraces per household with a maximum of 22 (Table 6). A lower diversity was observed in Bara where the households grew an average of about 3 landraces and a maximum of 12. The lowest diversity was in the high-hill case study site of Jumla where 92% of the households maintained just a single variety (average 1) and the most landraces grown by a single household was only three (Table 7).

(Table 6….)

Wealth affected the number of landraces that were grown on farm (Table 7). Resource-poor farmers grew fewer landraces than the resource-rich farmers in Kaski and Bara. In Jumla, however, there was effectively no difference among the wealth categories (the range was only 1.1 to 1.2). In Kaski, the resource-rich grew more landraces than the other two wealth categories, while in Bara it was both the resource-rich and resource-medium who grew more landraces than the resource-poor (Table 7). Hence, overall across the case study sites, resource-rich farmers grew and conserved more diversity ($P<0.001$). Resource-rich farmers could afford to grow low yielding but high quality landraces, such as *Pahele*, *Jetho Budho*, *Biramful, Jerneli*, *Ramani* and *Basmati*, varieties used in food culture and rituals, such as *Anadi* and *Sathi*, and varieties considered to have medicinal values such as *Anga* and *Bayarni*. However, although resource-poor farmers grew fewer landraces they grew landraces specifically adapted to their marginal lands. For example, *Mansara* a landrace maintained by resource-poor farmers in Kaski, is adapted to drought-prone marginal land.

(Table 7…)

3.4 Ecological environment – landraces are adapted to agro-ecological domains. Across the three case study sites, farmers classified agro-ecological domains of rice based on the sources of irrigation.

In Jumla, *Sim khet* (waterlogged marshy land with poor drainage), *Gadkule khet* (irrigated from snow-melted rivers) and *Kholapani khet* (irrigated with water from seasonal streams) were the rice domains classified by the farmers. The *Marshi* groups of landraces were the most common varieties and they were grown by most farmers across all three domains. The landraces could not be classified according to domains as all the named landraces were grown across all the domains.

In Kaski, the rice domains were *Mule khet*/*Kule khet* (irrigation by seasonal canals), *Sim khet* (marshy wet land), *Tari khet* (rainfed good fertile land) and *Pakho tari* (completely rainfed marginal uplands) each having a diverse set of landraces (Fig. 3). *Kule khet* and *Sim khet* were the most favourable and productive domains for rice and had the greatest diversity. *Tari* and *Pakho tari* were two less productive domains where water was limiting and diversity was lower. Out of the 69 landraces in Kaski, 38% were specific to a particular domain while the remainders were grown in two or more adjacent domains. An accession named *Jhinuwa*, small-grained, aromatic rice, was the only one reported to be grown in all the three domains.

(Figure 3…)

Farmers in Bara classified the rice fields into four different domains based on moisture and soil fertility: *Ucha khet* (rainfed land), *Samatal khet* (flat land with possible irrigation), *Nicha/khalar khet* (irrigated/wet land) and *Pokhari/Man* (accumulated water as a pond). Of these, *Samatal khet* and *Nicha khet* were the most productive and common domains of the region and had the greatest diversity of landraces (Fig. 34). *Samatal khet* represents the domain where both *Bhadaiya* (early-maturing rice) and *Aghani* rice (normal rice) were grown and was most diverse. However, the most favourable domain, *Nicha khet*, had the greatest diversity of normal duration rice. On the other hand, *Ucha khet* and *Pokhari* were marginal domains representing the two extremes of water availability from drought-prone to flooded land where few landraces were grown (Fig. 4).

The type of rice landraces in these domains varied with the adaptive traits of the landraces. In *Ucha khet*, only *Bhadaiya* (early-maturing) landraces were cultivated where as in *Pokhari* only deep-rooted rice varieties were grown. Out of 21 landraces reported in the survey in Bara, 13 (62%) were specific to domains while 38% grew across two or three domains.

(Figure 4..)

4. Discussion

Three methods of assessing diversity were used. The method least subject to error because it relied on a large, randomly selected, stratified sample of individual households was baseline. The PRA would miss landraces depending on the knowledge of the members that made up the group, and in the diversity fair there was competition to have the greatest number of landraces and hence a motive to invent or report on rarely used names for minor variants. However, although the baseline survey may give the most accurate results it requires far more resources than a PRA survey and diversity fair. An average of these last two methods would give similar results to those of a baseline survey.

The distribution of landraces was very uneven with many being rare and grown on small areas. This means that much of the landrace diversity, at first sight, appears vulnerable (many landraces are not widely grown) but this vulnerability is reduced when there is strong ecological and economic reasons for growing these rare landraces. The uneven distribution also has important implications for an optimal collection strategy. It emphasizes the need for farmer interviews on landrace names because collecting from a random sample of households, as is commonly the case, will fail to obtain all of the named landraces unless a highly sample size is used that adds to the high costs of maintaining diversity in *ex situ* collections.

A major factor determining landrace diversity was the ecological conditions - the mid-hill and low-altitude site conserved the greatest diversity. Among the three case study sites, the high-hill site (Jumla) had the lowest rice diversity when measured by number of named landraces. Chilling temperature was the limiting factor for rice cultivation and the *Marshi* groups of landraces were the predominant cold-tolerant varieties. Rice diversity was greatest in the mid-hill site (Kaski) a mountainous site well known in the Western hills of Nepal for its high quality rice (Sthapit *et al.,* 2000). The range in altitude in the mid-hills results in great environmental heterogeneity and diverse agro-ecosystems, and great diversity in the socio-economic structure of the farming communities. Bara in the *terai* was the most fertile and favourable site, lying on the fertile low-altitude strip of the Indo-Gangetic plain. This region, known as the granary of the country for its high production potential, is famous for its aromatic rice and its diversity. The environment is more homogenous than that of Kaski, as it lacks altitudinal variability and in much of the area traditional landraces have been replaced by modern varieties. Despite this, the favourable environment supported much rice diversity that was greater than might be expected because the majority of the landraces grown there were specifically adapted to only a single domain. The lower diversity at high altitude sites was confirmed in the nine survey villages. Again the mid-hill site supported most diversity although the lower diversity in the lowland sites is almost certainly not due to ecological constraint but the replacement of landraces by modern varieties.

In many countries and areas high landrace diversity is no longer found in favourable environments because they have the highest adoption of improved varieties and, hence, the highest replacement of landraces. Perhaps as a consequence, many studies on on-farm conservation have shown that diversity is high in marginal environments and subsistence farmers have maintained diversity in agro-ecological niches in their marginal lands (Harlan, 1975; Brown, 1978; Brush, 1995). Marginal growing environments, traditional farming practices, and diverse food culture of the farming community, have also been found to have a significant role in the maintenance and conservation of diversity on farm (Thurston, 1992; Gurung and Vaidya, 1998). A clear but contrary picture emerges from this study. The irrigated rice domains: *Kule khet* and *Sim Khet* (marshy wet land) in Kaski, and *Nicha* and *Samatal khet* in Bara, had the most landraces. Most of the landraces in these irrigated rice domains also had adaptation to adjacent domains. There were fewer landraces in the marginal environments (stress prone domains). These seemingly contrary results agree with the ecological principle that when environments are more favourable greater diversity is maintained (Witcombe, 1999). He also argued that farmers in favourable environments have more options in choosing varieties than farmers in marginal areas. This could be seen in Bara, where favourable environments (lack of chilling temperature and high water availability) allow temporal diversity. Farmers had the options to grow varieties with different growth durations because more than one crop a year can be cultivated. The conservation of greater diversity in more favourable environments in Kaski and Bara were examined in more detail by considering the rarity of landraces found there. In general, more landraces occurred in both marginal and favourable environments but they were more commonly found in Kule khet and Simkhet in Kaski and Samatal and Nicha khet in Bara.

Variation in social environments and the range of uses of the landraces also determined diversity. Landraces play a pivotal role in the folk community, and are maintained and managed by the farmers in their fields for a diversity of uses, indigenous beliefs and rituals and adaptive functions over space and time (Pham, 1999; Thurston *et al*., 1999). In this study it was found that the better off conserved more diversity on farm, almost certainly because they had more resources to devote to growing varieties for specific cultural and religious uses, and for growing high quality but low-yielding landraces. Social and physical factors are interrelated because the better off cultivate more favourable environments that generally can support the greatest on-farm diversity. However, in Jumla, where the environmental diversity was lower – all environments were cold stressed – the better off were not able to cultivate a greater diversity of landraces.

The surveys have shown that much can be understood about landrace diversity when named varieties – the farmers' unit of diversity – are studied and it is a valuable starting point for diversity studies. Determining the named varieties by diversity fairs and baseline surveys demands more resources than participatory rural appraisals but reveals more landrace names. A knowledge of diversity based on farmers names provides an essential basis for a sampling strategy, which takes into account both physical and social factors, because there is no doubt that names reflect the diversity in utility and adaptation among the named landraces. Landrace names were related to agro-morphological traits in all three study sites (Bajracharya et al., 2006 for the case of Jumla, forthcoming for Kaski and Bara).

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References

Brown, A.H.D., 1978. Isozymes, plant population genetics structure and genetic conservation. *Theor. Appl. Genet*. 52, 145-157.

Brush, S.S., 1995. *In situ* conservation of crop landraces in centres of crop diversity. Crop Sci. 35, 346-354.

Centre Bureo of Statistics (CBS), 2007. Statistical information on Nepalese agriculture 2006/2007. HMG/MOA/Agri-Business Promotion and Statistic Division, Singh Durbar, Kathmandu, Nepal.

Gurung, J.B., Vaidya, A.K., 1998. Cultural context of agricultural biodiversity and sustainable agriculture in the Nepalese hills and mountains. In: Pratap, T., Sthapit B.R. (Eds), *Managing Agrobiodiversity: Farmers' Changing Perspectives and Institutional Responses in HKH Region*. ICIMOD/IPGRI, pp 55-60.

Harlan, J.R., 1975. Our vanishing genetic resources. *Sci.* 188, 618-621.

Paudel, C.L., Tiwari, P.R., Neupane, J.D., Devkota, D.P., 1998. Strengthening the scientific basis for *in situ* conservation of agrobiodiversity: Findings of *in situ* selection exercise in Jumla. NP Working Paper No. 3/98 NARC, LIBIRD and IPGRI.

Pham, J.L., 1999. Traditional management of rice diversity in Southeast Asia. In: Wood, D., Lenne, J.M. (Eds), *Agrobiodiversity: Characterisation, Utilization and Management.* CAB Publishing, pp 229-232.

Rana, R.B., Chaudhari, P., Gauchan, D., Khatiwada, S.P., Sthapit, B.R., Subedi, A., Upadhyay, M.P., Jarvis, D.I., 2000a. *In situ* crop conservation: findings of agro-ecological, crop diversity and socio-economic baseline survey of Kachorwa ecosite, Bara, Nepal. NP Working Paper No. 1/2000, NARC/LIBIRD/IPGRI, Rome, Italy.

Rana, R.B., Paudel, C.L., Tiwari, P.R., Gauchan, D., Subedi, A., Sthapit, B.R., Upadhyaya, M.P., Jarvis, D.I., 2000b. *In situ* crop conservation: findings of agro-ecological, crop diversity and socio-economic baseline survey of Talium eco-site, Jumla, Nepal. NP Working Paper No. 3/2000. NARC/LIBIRD/IPGRI. Rome, Italy.

Rana, R.B., Rijal, D.K., Gauchan, D., Sthapit, B.R., Subedi, A., Upadhyay, M.P., Pandey, Y.R., Jarvis, D.I., 2000c. *In situ* crop conservation: findings of agro-ecological, crop diversity and socio-economic baseline survey of Begnas ecosite, Kaski, Nepal. NP Working Paper No. 2/2000, NARC/LIBIRD/IPGRI. Rome, Italy.

Rijal, D.K., Rana, R.B., Sherchand, K.K., Sthapit, B.R., Panday, Y.R., Adhikari, N.A., Kadayat, K.B., Gautam, Y.P., Chaudhary, P., Paudel, C.L., Gupta, S.R., Tiwari, P.R., 1998. Strengthening the scientific basis for *in situ* conservation of agrobiodiversity: Findings of *in situ* selection exercise in Kaski. NP Working Paper No. 1/98 NARC, LIBIRD and IPGRI.

Shahi, B.B., Heu, M.H., 1979. Low temperature problem and research activities in Nepal. In: Report of a Rice Cold Tolerance Workshop, IRRI, Philippines pp 61-68.

Sherchand, K.K., Adhikari, N.P., Khatiwada, S.P., Shrivastav, A.C., Bajracharya, J., Joshi, K.D., Kadayat, K.B., Chaudhary, M., Chaudhary, P., Bishwakarma, S.S., Yadav, S., 1998. Strengthening the scientific basis for *in situ* conservation of agrobiodiversity: Findings of *in situ* selection exercise in Bara. NP Working Paper No. 2/98 NARC, LIBIRD and IPGRI.

Sthapit, B.R., Joshi, K.D., Rana, R.B., Upadhayay, M.P., Eyzaguirre, P., Jarvis, D., 2000. Enhancing biodiversity and production through participatory plant breeding: setting breeding goals. In: *An exchange of experiences from South and South East Asia. Proceedings of the International Symposium on Participatory Plant genetic Resource Enhancement*.

Thurston, H.D., 1992. Sustainable Practices for Plant Disease Management in Traditional Farming Systems. Westview Press, Boulder, Colorado.

Thurston, H.D., Salick, J., Smith, M.E., Trutmann, P., Pham, J.L., McDowell, R., 1999. Traditional management of agrobiodiversity. In: Wood, D., Lene, J.M. (Eds), *Agrobiodiversity: Characterisation, Utilization and Management*. CAB Publishing, pp 211-244.

Upadhyay, M.P., 1995. Food crop genetic resources. In: Plant genetic resources: Nepalese perspectives. Proceedings of the National Workshop on Plant Genetic Resources Conservation, Use and Management Organized by NARC at Kathmandu, 28 Nov-1 Dec 1994 pp 35-51.

Witcombe, J.R. 1999. Do farmer-participatory methods apply more to high potential areas than to marginal ones? *Outlook Agr.* 28, 43-49.

Table 1.

Description and characteristics of the three case study sites.

Site	Village boundaries	Zone (altitude)	Administrative zone	Climatic range	Level of crop diversity	Ease of access (Degree of interventions)
Jumla	Talium and Kartikswami	High hill (2,240-3,000 m)	Mid-western region	Cool temperate to alpine	Moderate to high	Low
Kaski	Begnas	Mid hill (668-1,206 m)	Western region	Sub-tropical	Very high	Slight
Bara	Kachorwa	Terai (100-150 m)	Central region	Sub-tropical to tropical	Moderate to low	High

Table 2,

Details of survey by agro-ecological zones.

Zone/districts	VDCs	Survey methods	Year of survey	No of participating farmers		
				Male	Female	Total
High-hill						
Jumla	Talium	HH survey	1998	na	na	180
Rasuwa	Nangbukuna	GD	2006	12	4	16
Sankhuwasabha	Mawadini	GD	2006	12	3	15
Mid-hill						
Kaski	Begnas	HH survey	1999	na	na	206
Sankhuwasabha	Mamling	GD	2006	10	2	12
Salyan	Khalanga,	GD	2006	16	5	21
Nuwakot	Kalyanpur	HH survey /GD	2006	42	12	54
Dhankuta	Mugha	GD	2006	10	2	12
Lowland						
Bara	Kachorwa	HH survey	1999	na	na	202
Banke	Monikapur	GD	2006	23	9	32
Nawalparasi	Kusuma	GD	2006	18	2	20
Sunsari	Simriya	GD	2006	23	2	25

HH survey = household survey; GD = group discussion

Table 3.

Number of rice varieties with different names documented by three methods in three case study sites, Nepal (1998-1999).

Methods	Talium & Kartikswami, Jumla (2,240-3,000m)	Begnas, Kaski (600-1,400m)	Kachorwa, Bara (80-90m)
PRA survey	10	38	49
Diversity fair	11	75	79
Baseline survey	21	69	55
Av. area under landrace (ha)	0.13	0.36±0.02	0.3±0.03

Table 4.

Distribution of rice landraces documented by baseline (1998/99) and group discussions (2006) conducted in different agro-ecosystems.

Agro-ecosystems	1998/99	2006	Total
High-hill	21	12	33
Mid-hill	69	22	91
Lowland (terai)	55	16	71
Total	145	50	195
df	2		
Chi-square	2.45		

Table 5.

The average area (ha) and households (HH) growing them (percent of total household in site) according to four categories determined from the baseline survey.

Sites	Common, large			Rare, Large			Common, small			Rare, small		
	n	Area (ha)	HH(%)	n	Area (ha)	HH(%)	n	Area (ha)	HH (%)	n	Area (ha)	HH(%)
Jumla	1	0.11	58.3	6	0.74	0.8	2	0.09	38.4	10	0.03	2.5
Kaski	10	0.14	48.1	17	0.19	5.1	5	0.04	44.3	35	0.03	2.5
Bara	4	0.32	52,8	13	0.39	5.6	3	0.18	38.8	26	0.12	2.8

These are: large area and HH (common, large); large area and few HH (rare, large); small area and many HH (common, small); small area and few HH (rare and small) (n = no of landraces in each category).

Mant, few, large and small are all defined relative to the mean e.g. few households means a below average number. Percent of households are from 180 in Jumla, 206 in Kaski and 197 in Bara. The overall mean areas across all landraces per site are 0.11 ha for Jumla, 0.09 for Kaski and 0.23 for Bara.

Table 6

Ecological adaptation of abundant, common and rare varieties in Kaski and Bara in the main season

Kaski						Bara					
Domain	Rare Small (%)	Rare Large (%)	Common Small (%)	Common large (%)	Total (N)	Domain	Rare Small (%)	Rare Large (%)	Common Small (%)	Common large (%)	Total (N)
Pakho tari	5	0	0	22	4	Uncha khet	20	50	0	100	4
Tari khet	23	0	7	11	12	Samatal khet	80	100	50	0	14
Kule khet	43	100	87	78	43	Nicha khet	30	50	63	0	9
Sim khet	75	100	93	67	55	Pokhari	0	0	25	0	2
Total (N)	40	5	15	9		Total (N)	10	2	8	1	

Table 7.

Number of rice landraces per household by wealth category at the three ecosites determined in baseline survey carried out in 1998 in Jumla, 1999 in Kaski and 1998 in Bara.

Site	Number of landraces per household	Number of households growing specified number of landraces				
		Rich	Medium	Poor	Total	(%)
Tallium,	1	34	53	78	165	91
Kartikswami,	2	6	6	2	14	8
Jumla	3	0	0	1	1	1
	Total HHs	40	59	81	180	100
	Average N^{o} of landraces	1.2±0.05	1.1±0.04	1.1±0.03	1.1±0.02	
	Total FUDs	11	11	9	18	
	Max N^{o} of landraces	2	2	3	3	
	P-value	0.876 not significant among the wealth categories				
Begnas, Kaski	1-2	9	21	20	50	29
	3-4	19	24	15	58	33
	5-6	20	16	3	39	23
	7-8	7	6	1	14	8
	9-10	5	0	1	6	3
	11-12	3	0	0	3	2
	13-15	3	0	0	3	1
	22	1	0	0	1	1
	Total HHs	67	67	40	174	100
	Average N^{o} of landraces	4.7±0.4	3.2±0.2	2.9±0.3	3.8±0.2	
	Total FUDs	63	41	26	68	
	Max N^{o} of landraces	22	8	9	22	
	P-value	0.0001 highly significant among wealth categories				
Kachorwa, Bara	1-2	7	14	80	111	55
	3-4	9	35	19	63	32
	5-6	4	9	4	17	9
	7-8	2	4	0	6	3
	9-12	1	1	0	1	1
	Total HHs	23	73	103	197	100
	Average N^{o} of landraces	3.7±0.4	3.6±0.2	1.9±0.1	2.7±0.1	
	Total FUDs	27	46	24	52	
	Max N^{o} of landraces	9	12	6	12	
	P-value	0.0001 highly significant among wealth categories				

Fig. 1. Map of Nepal showing the district location of study sites representing three agro-ecosystems of the country in transect.

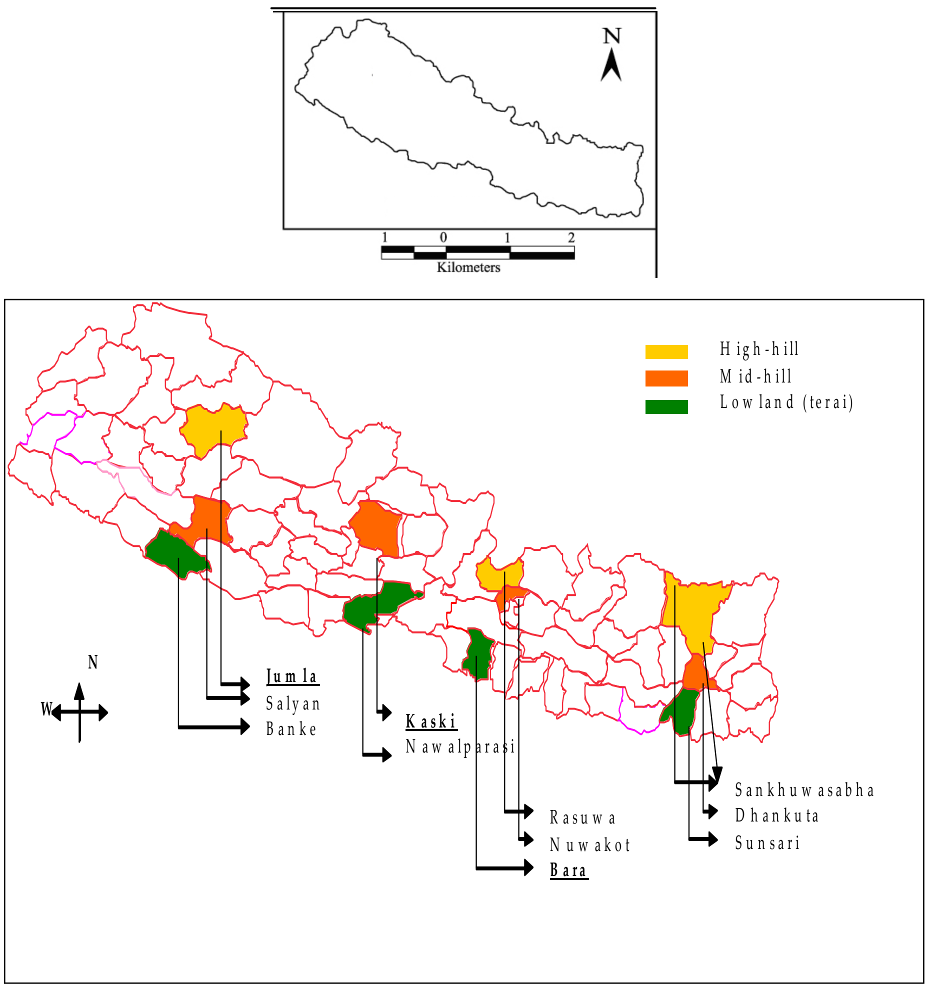


Fig 2: Frequency of landraces by categories shown in Table 5 (common, large = large area and many HH; uncommon or rare, large = large area and few HH; common, small = small area and many HH and uncommon or rare, small = small area and few HH)

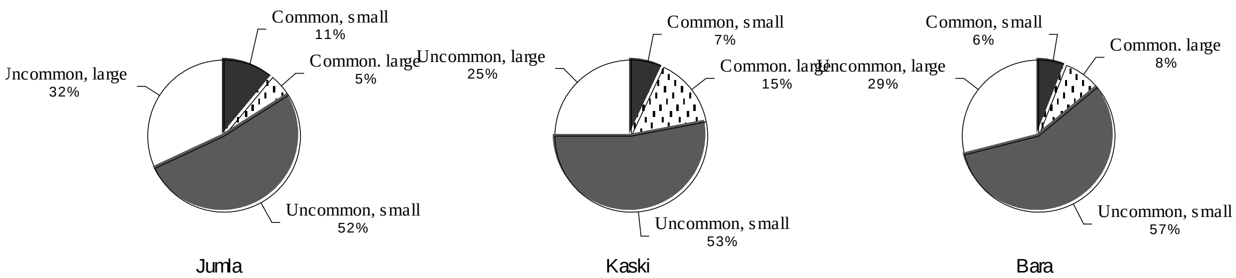


Fig. 3. Agro-ecological domains and distribution of rice diversity in Kaski

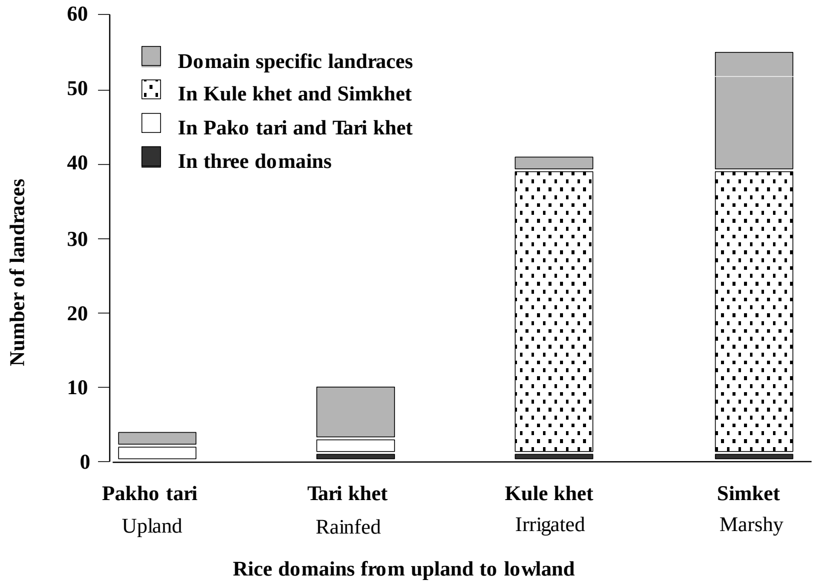
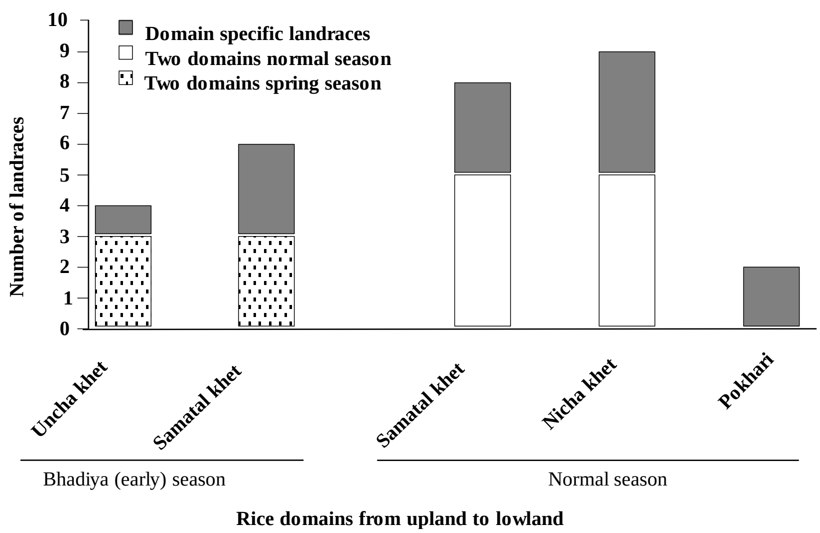


Fig. 4. Agro-ecological domains and rice diversity from upland to lowland in Bara: Bhadaiya (early) rice and Aghani (normal) rice plotted separately.



(a)

(b)