Chapter 19

Factors and Processes behind the Erosion of Crop Genetic Diversity in Nepal

K.D. Joshi, M. Subedi,
K. B. Kadayat and B. R. Sthapit

Nepal, with the great mountain chain of the Himalayas and its associated hill tracts and wide socioeconomic variation, is rich in plant genetic resources of crop species. Nepal lies along the southern slopes of the Himalayas between 80° and 88° E and 26° and 30°N. The altitude range within which crop production takes place is from 70m to as high as 4,000m. The altitude variation has created diverse climatic conditions. Almost all the climatic conditions of the earth are represented within a small geographical distance (Pandey 1987). The diversity in the agroclimatic and sociocultural setting has given rise to a large number of land races of major crops. The existence of oriental and occidental types of barley in the foothills of the Himalayas, of wild relatives of rice at Ajigara lake in Kapilvastu district, and of thousands of local land races of different crop species are evidence of the Genetic Diversity in Nepal (Vavilov 1926; Takahashi et al. 1968, Gupta et al. 1996). Apart from rice and barley, finger millet, grain legumes, and minor crops also have great Genetic Diversity (Upadhyay and Sthapit 1995).

In Nepal 81 per cent of the population still depend on agriculture for their livelihood. The majority are subsistence farmers, practising mixed farming with a range of crops, livestock, and forestry-related production systems. The strategy of traditional farmers centres on harvest security. This itself signifies the importance of agriculture and agricultural biodiversity for farmers in Nepal.

A lot of genetic erosion of biological diversity appears to be taking place in Nepal, and there are reports that extinctions are not only taking place at the variety level but also at the species' level. Over-exploitation of natural habitats, overgrazing, clearing of natural forest in the *Terai*, introduction of new crop varieties, commercialisation of agriculture, and government policies are held responsible for the replacement and/or erosion of indigenous land races in Nepal. However, there are no scientific studies quantifying the extent of genetic erosion *per se*. This paper highlights the processes influencing agrobiodiversity.

Genetic Diversity and Erosion: Some Examples

Rice (Oryza sativa L.)

In Nepal, rice is grown in all agro-ecological zones from the *Terai* (100-300m), through the valleys and foothills (100-1000m), to the high mountains (2,600m). Double cropping of rice ceases at around 900m, and rice reaches its altitudinal limit at 2,600m. Few countries have such a diversity of both cultivated and wild relatives of rice. Nearly 2,500 land races have been identified in Nepal, although some may be duplicates, and many more are yet to be collected (Gupta et al. 1996).

Four wild *oryza* species, namely, *O. nivara, O. rufipogon, O. officinalis,* and *O. granulata*, and two wild relatives of rice, *Leersia hexandra* and *Hygrorrhiza aristata*, have been reported in 13 districts in the *Terai* from the far west to east

Table 19.1: Distribution of Known Aromatic Rice Varieties in Nepal

S. No	Name of the best aromatic rice variety	District	Altitude range (masl)
1.	*Achhame masino*	Chitin	200-800
2.	*Kalo nimak*	Chitin, Rupendehi, Nawalparasi, Bardia	200-400
3.	*Jogini*	Chitwan	200
4.	*Tulsi Prasad*	Nawalparasi	200-1400
5.	*Basmati*	12 districts	200-800
6.	*Manabhog*	Kailali, Dhading, Rasuwa	200-600
7.	*Hans Raj*	Darchula, Bajhang	600-1100
8.	*Pran Piuli*	Sallyan	1200-1400
9.	*Jhinuwa*	Baglung, Parbat, Kaski, Syangja	400-800
10.	*Pahenli*	Sindhupalchok, Ilam, Kaski, Gorkha, Lamjung, Palpa, Bardiya	600-800
11.	*Jetho budho*	Kaski	600-800
12.	*Pokhreli masino*	Solukhumbu, Sankhuwasabha	200-1400
13.	*Kariya kamod*	Saptari, Morang, Dhanusa	<200
14.	*Gauria*	Myagdi, Sankhuwasabha	800-1400
15.	*Kasturi*	Parsa	<200
16.	*Tulsi Prasad*	Parsa, Dhanusa	<200
17.	*Jirasari*	Panchthar	400-600
18.	*Ram Tulsi*	Panchthar	400-600
19.	*Biramphool*	Morang, Kaski	200-800
20.	*Rajbhog*	Kailali	<200
21.	*Chirakhe*	Dhankuta	<1800

(Source: ADO offices)

Nepal (Shrestha and Vaughan 1989). Anonymous (1991) reported that Genetic Diversity has been maintained in the Karnali area because of the specificity of the land races, undisturbed agriculture, and remoteness; whereas the level of genetic erosion was highest in the Kapilvastu and Banke districts.

Five different types of rice culture method are prevalent that are associated with the food culture of local ethnic groups in Nepal. They are early rice, main season rice, high altitude rice, upland rice, and deep water rice. A few case studies of upland, fine grain and aromatic rice are described in the following passages.

Fine Grain and Aromatic Rice

There is a considerable diversity in varieties of aromatic and fine grain rice in Nepal. These types of rice are grown up to 1,850m, but the majority are distributed below 1400m. A total of 102 different rice varieties has been reported by the District Agricultural Development Offices (DADOs) in different districts. Varieties such as *Basmati, Jhinuwa, Jerneli, Kala nimak, Acchame masino, Atemarsi, Kariya kamod, Kalo masino, Gauria, Pokhreli masino, Rajbhog, Tulsiphool, Ekle masino, Kalo masino, Jeerasari, Biramphool, Barhmukhe, Bange, Anami masino,* and *Anadi* were reported from more than one district indicating their wider adaptation.

Joshi et al. (1996) estimated that 57 per cent of aromatic rice land races are of local origin and 29 per cent are improved; 14 per cent were not defined. This study also indicated that some varieties were introduced from Assam, India. A list of the best local rice varieties in Nepal is presented in Table 19.1. Pokhara Valley is known for many high quality rice varieties such as *Pahenle, Jetho Budho, Ramani, Ekle, Biramphool, Jarneli, Manamuri, Rato Anadi, Seto Anadi, Gurdi, Ruduwa, Tulasi, Mansara, Aapjhutte, Jyagdikhole, Bayarni, Gurdi, Khalte Kholo, Nathani/ Bhangere Tauli, Anga, Marshi, Lamjunge Kalo, Masino, Lahare tulsi, Chhote, Gorkhali, Samundraphinj,* and *Jhinuwa*. Even so, the number of farmers reporting varieties of high quality and fine grain rice other than *Jetho Budho, Pahenle,* and *Gurdi* in Pokhara is very low, and the rate of genetic erosion is increasing with the expansion of *Jetho Budho* and with increasing commercial planting of vegetables. Varieties such as *Samundraphinj, Biramphool, Jhinuwa, Bayarni,* and *Ramani* produce high quality aromatic rice but have poor yields, and these are also gradually being replaced by *Masuli, Jetho Budho, or Pahenle* which have higher yields. *Masuli* is exotic and *Pahenle* and *Jetho Budho* are productive local land races. It is commonly thought that exotic varieties tend to replace local varieties. However, the evidence from Pokhara Valley indicates that the best land races will also replace other local varieties. Some land races, such as *Nathani, Khalte Kholo,* and *Biramphool,* could not be found even through *ex situ* conservation at the International Rice Research Institute (IRRI), and they are now believed to be on the verge of extinction. The Genetic Diversity of rice at both household and community levels seems to be decreasing in comparison with the past two to three decades.

Ghaiya

Ghaiya (upland rice) is grown for both grain and straw as the main staple crop on *tars* (ancient river tan); terraced *bari*[1], and newly cleared forest areas in the hills, mainly as a means of subsistence. This crop is important for those farmers of the *Kumal, Darai, Bote, Gurung, Magar, Damai, Kami,* and *Brahmin/ Chhetri* ethnic groups who have little or no *khet* (bounded irrigated land) where paddy rice can be grown. A great diversity of varieties was observed in *Ghaiya* land races, with the level of diversification varying between locations (Subedi et al. 1993). *Ghaiya* is grown in highly stressed environments where rainfall is low and unpredictable. Farmers use totally traditional husbandry practices to grow this crop. Under such conditions, farmers use more varieties as an insurance against natural risks.

The varietal diversity of *Ghaiya* is concentrated on *tar* land at an altitude ranging between 400 and 500m (Figure 19.1). The *tar* land system, in general, maintains more diversity of *ghaiya* varieties than the *bari* system. The reasons are clear. *Bari* can be used to grow other crops, whereas people with *tar* land depend almost totally on *Ghaiya* for their survival. Indigenous groups, such as the *Darai*

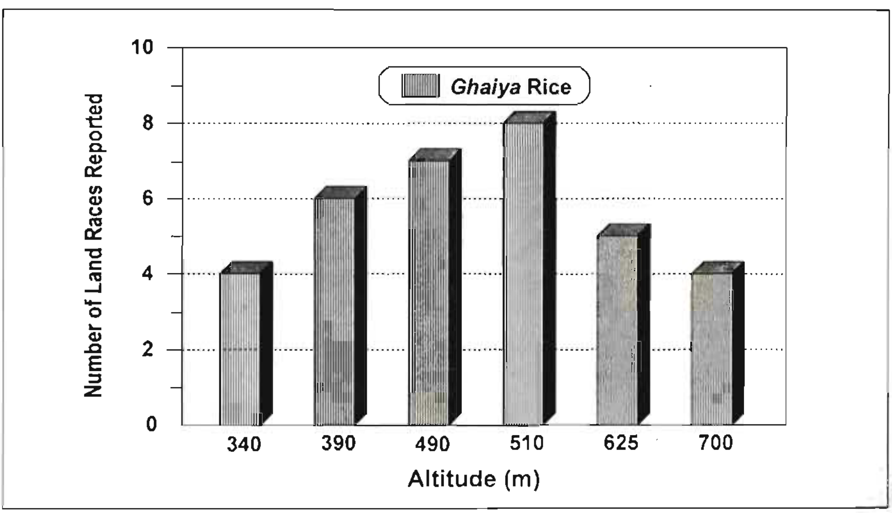

Figure 19.1: Number of Land Races Reported for Ghaiya Rice in the Western Development Region (Source: Subedi et al. 1993)

1 *Upland terraced fields with rainfed irrigation management.*

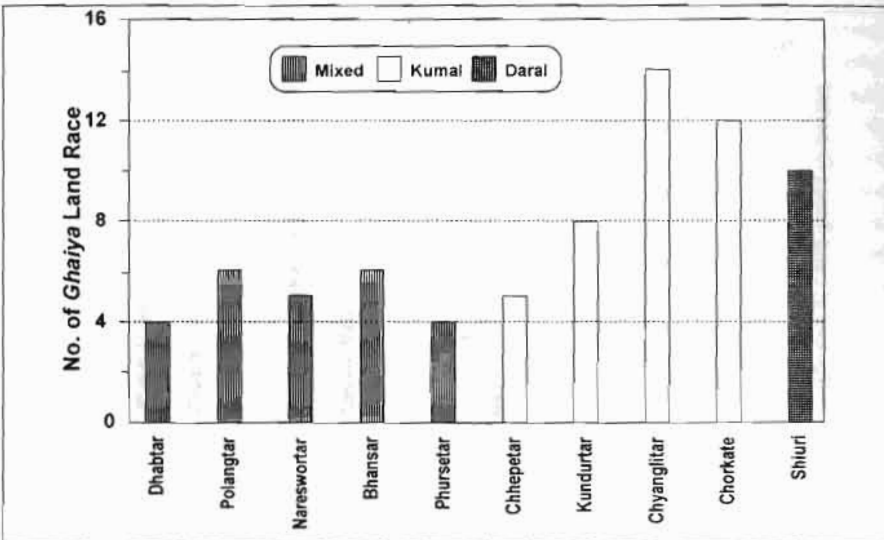

Figure 19.2: Diversity of Ghaiya Rice Maintained by Different Ethnic Groups in the Tar Land-use System of the Western Development Region

and *Kumal,* maintain more land races than mixed communities (Figure 19.2). The majority of farmers maintain at least two varieties with different types of maturity, yield potential, yield stability, adaptation to low fertility, or other important qualities to meet their different needs (Subedi et al. 1993). Some *ghaiya* land races, such as *Pahenle Ghaiya, Bichare, Basmati, Dudhe Marange, Pakhe Masino, Sinduli, Pakhe Sali langre, Jabaka,* and *Charinangre,* have either fine grain or aromatic quality but are low yielding. Because of this farmers are replacing these with high-yielding genotypes.

Barley (Hordeum vulgare L.)

Nepalese barley displays a great variation in qualitative traits. It is argued that a species within its centre of diversity is only highly variable for conspicuous qualitative characteristics, the variation of which is not limited by natural selection (Witcombe and Gilani 1979). The maximum variation is found in awns; ranging from hooded awns, through awnless, to different orientation of awns (Pradhanang and Joshi 1993). Vast areas of traditional land races of barley were replaced by the two-row hulled barley cv. Bonus after its introduction from Sweden in 1975. Though farmers still maintain two land races to avoid risk, varietal diversity is decreasing in several areas in which Bonus is grown. The diversity of covered barley is currently higher than the diversity of naked barley (Figure 19.3).

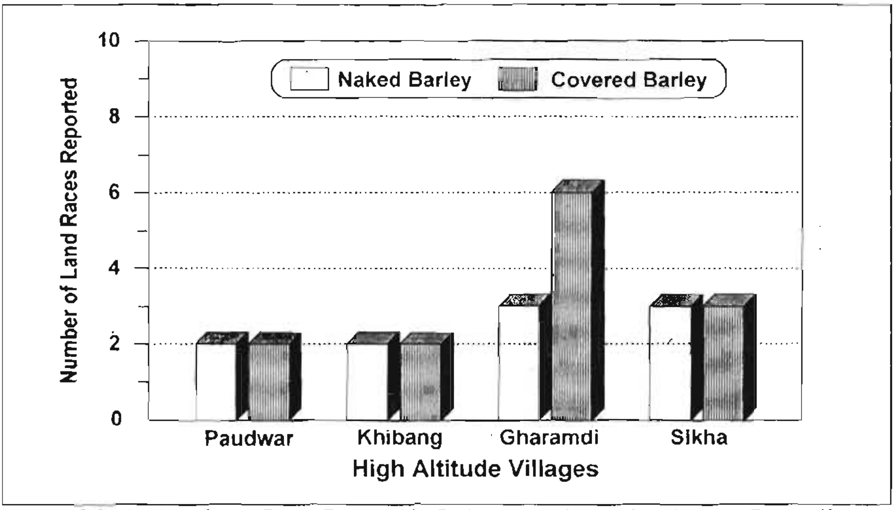

Figure 19.3: Number of Land Races Reported for Barley in the Western Development Region (Source: Pradhanang and Joshi 1993)

Grain Legumes

Traditionally several grain legume species, such as soyabean, black gram, cowpea, pea, common beans, horse gram, faba bean, and rice bean, are grown in hill and mountain farming systems, mainly as a mixed or relay crops, and to some extent on rice bunds.

There is a great variation in varieties, adaptation, growth habit, phonology, productivity, and uses of legume crops. Some legume crops are particularly adapted to low elevations, for example pigeon peas and cowpeas, whereas some, such as common beans, are adapted to higher elevations. However, the majority of legume crops can be grown at different altitudes. There is a diversity among legume crops in terms of photosensitivity. Some varieties of crops are photo-sensitive, whereas others are photo-period neutral. There is a further great diversity in the use of legume crops. Some crops, such as pigeon peas, lentils, and black gram, are grown for the dry bean, while others, such as cowpeas, common beans, and peas, can be grown for both the green pod and the dry bean. Moreover, some legume crops, such as rice beans, soyabeans, and *sesbania*, are also used for manuring fields. But because of the low yield potential and/or poor insect resistance some legume varieties are being lost.

In this paper we present the case of black gram (*Phaseolus mungo*) as an example. Black gram provides the preferred *dal* (curry) of hill people and is the most important grain legume in the *tar* land-use system. Although vernacular names for black gram vary with the location and colour of the grain, the genetic diversity of this crop is limited. It is grown as a secondary crop on marginal lands using residual moisture and fertility and with a minimum of intercultural operations. Therefore, the yield potential of the crop is constrained by environmental stress. The crop is greatly influenced by weather conditions and per unit economic returns are quite low (Sthapit 1990). In recent years the area under black gram has decreased, for two reasons mainly. The first is that, with improvements in irrigation facilities, areas formerly under black gram are taken over by rice or vegetables. The second is that, in unirrigated areas, cowpeas are replacing the black gram crop because farmers can grow a third crop of oil seed rape as a break crop with cowpeas. This is one example in which one species is replacing another for obvious reasons. Replacement of traditionally grown black gram by cowpeas in some parts of the lower hills is an example in which a transformation process is accelerating genetic erosion at the species' level.

Finger millet (Eleusine coracana L. Gaertn)

Finger millet is the fourth major cereal crop in Nepal, but it is considered as *Kuanna* (a low status cereal). It has been grown in highly diverse conditions across Nepal for centuries, and as a result there is a wide variability in the Nepalese finger millet gene pool. The diversity is more concentrated between 900 and 2,400m where over 50 different types of germplasm have been reported, and greater diversity is found in the western to mid-western region of Nepal (Baniya et al. 1992). Rapid Rural Appraisal carried out in a few sites recorded between five and nine different finger millet land races per location.

Nepalese farmers maintain more than two varieties of finger millet for various reasons — including:

- to confer greater yield stability on overall farm production,
- to diversify fodder and food availability,
- to use different varieties for different production systems,
- to adapt to specific edaphic or climatic conditions, and
- because different varieties have different tastes and uses (Subedi 1990).

In the lower hills (300-1000m), late maturing millet, such as Chitwan Local and *Bikase Nala*, is commonly relayed with a long duration improved maize variety. In the middle hills (1,001-2,000m), a number of local millet genotypes are relayed with various maize varieties. They include *Bhalu Kodo, Okhale-1, Kalo Bhunde, Dalle, Nala, Kanchhi Kodo, Bikase Nala, Archaure, Seto Jhapre, Mangsire Urchho, Kirante Kodo, Chitreli Dalle, Deupure Dalle, Bajunge, Bhalu Nala, Seto Urchho, Bhachuwa, Sano Bhachuwa, Mirshali Kodo, Malae Kodo*, and *Juwai or Samdi* Kodo (White). These millet varieties are grown in association with more than ten different maize genotypes (Subedi 1990).

In the higher hills (>2000 masl), millet is rotated in a two-year cycle, and varietal diversity is relatively limited. Land races such as *Dalle, Sano Bhanchuwa, Thulo Bhanchuwa, Bhalu, Chitre Kren, Nala, Okhale-1, Ramcheli, Sano Kodo, Thulo Kodo,* and *Tarali* are some of the millets commonly grown at high altitude.

Green Manure Crops

It is traditional practice in Nepal to use green leaves, twigs, and succulent parts of wild plants as green manure in vegetable and rice nurseries, submerged paddy fields, and as a mulch for potato, turmeric, ginger, and garlic crops. There is no systematic study that documents the number of different plant species that have value as green manure. Eighteen species of plants, most of them wild, are used as green manure in several districts of Nepal's Western Development Region (Sthapit et al. 1988).

Green manures have an increasing appeal as a means of maintaining the level of soil organic matter and reducing soil compaction and erosion while still maintaining economic returns. These factors are vital, particularly in the context of declining soil fertility in the mountain areas of Nepal on both arable land and in fruit orchards (Sthapit et al. 1988, Subedi et al. 1989, Joshi et al. 1994 and 1995). Laboratory analyses and crop performance tests have shown that incorporation of 10 t/ha of biomass of green manure species such as *asuro* (*Adhatoda vasica*) can increase rice yield by nine per cent compared to farmers' normal practices and by 14-49 per cent compared with 60:30:30 N2, P_2O_5 and K_2O/ha. (Sthapit 1990). This implies that farmers' normal practices are also better than NPK fertilizer. These investigations have established the real worth of these organic manures in mountain farming systems. Resource-poor farmers maintain these species with great care.

Farming communities, researchers, and development workers are all aware of the value of these indigenous plant species as green manure, but even so the use of green manure in mountain agriculture is declining. The main constraint to the use of green manure is the scarcity of these species (Joshi et al. 1994).

In the past, when the forest was not too degraded, preferred green manures, such as *ankhitare* (*Walsura trijuga*) and *siplikan* (*Euphorbia royleana*), could be collected from the nearby forest for incorporating in rice fields (Sthapit et al. 1988). Now these resources are so degraded that farmers have to walk a long distance to collect biomass even for nursery beds. Loss of indigenous knowledge about these resources is a serious concern, younger generations cannot even recognise species such as *ankhitare* as the plant has become so rare.

There is a need to promote the growth of these valuable plant species in and around farmlands in order to meet fertility demands. The green manure *asuro* (*Adhatoda vesica*) can be used as a hedge plant and has several other uses apart from being a valuable green manuring plant. There are a few examples in which *asuro* has been planted in mandarin plantations to support orchard fertility.

Causes of Genetic Erosion

No one single cause can be held responsible for genetic erosion. A number of factors independently or in combination may be acting in this process, and variety replacement or erosion is a dynamic process in itself.

Joshi et al. (1995) listed a total of 77 rice varieties grown in the Pokhara Valley until recently. At present only 65 varieties are grown, of which 53 are local and 12 improved varieties. Reports show that 47 local rice varieties have already disappeared from the Pokhara Valley and 14 more are on the verge of extinction (Figure 19.4).

The main reason cited for the disappearance of rice genotypes is the introduction of high-yielding varieties (HYVs), with low shattering, disease resistance, non-lodging, and early maturity, that compare favourably with land races with low yield and late maturity. Some land races have been replaced because they produce poor grain or grain with poor cooking quality, or because they are not suitable for three crop seasons. In many instances, high quality local varieties, such as *Pahenle*

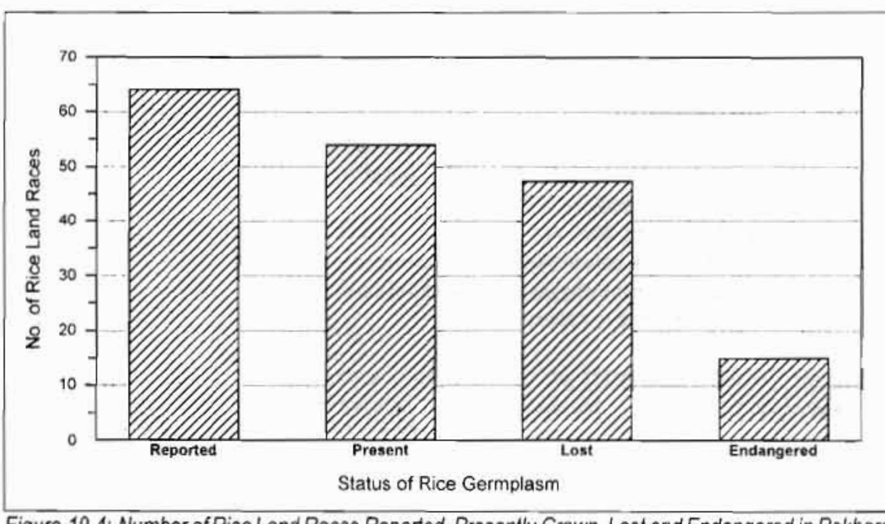

Figure 19.4: Number of Rice Land Races Reported, Presently Grown, Lost and Endangered in Pokhara Valley, 1996

and *Jetho Budho*, are also replacing other high yielding but poor grain quality rices, because they have a higher market price (Joshi et al. 1995). Varietal erosion is also taking place because of the disappearance of specific habitats, for example the marshy areas (*dhab*) needed for *Samundraphinj*, or because of lack of market promotion for high-quality but low-yielding varieties. At present only one farmer is maintaining the *Samundraphinj* variety.

In the past, farmers grew a specific mixture of varieties, known locally as *kaude*, a practice aimed at minimising risk. *Kaude* can be composed of *Aapjhutte* + *Mansara*, *Mansara* + *Tulasi*, *Bhangere* + *Mansara*, or *Jetho Budho* + *Ghaiya*. These varietal mixtures maintained varietal diversity. The farmers found that *kaude* gave better results in marginal conditions. Moreover, *kaude* suffers less infestation of grain moth during storage. The practice was used mainly on marginal land

Box 19.1

Lessons from the Loss of Citrus Land Races of Pokhara Valley, Nepal

Pokhara Valley lies in the middle hills of Nepal in the Western Development Region of the country. The valley was once very famous in Nepal for citrus fruit quality and production, e.g., mandarin, *chaksi*, and, *narayani* (different citrus fruits). In the late sixties, disease killed thousands of citrus trees and resulted in the disappearance of the citrus industry from the valley.

Among the many reasons for the decline of the citrus industry in the Pokhara Valley, the root cause was the mass introduction of citrus planting materials from India in 1960. At that time there were no quarantine regulations in Nepal and many diseases were introduced with this material. The main diseases that caused tree decline were citrus greening disease (CGD), virus and virus like diseases, and fungal diseases (such as foot rot gummosis, root rot, and pink disease). CGD with its active vector citrus psylla (*Diaphorina citri*) devastated the citrus orchards. By the late sixties once highly-valued fruits, such as mandarins, *chaksi*, and *narayani*, had disappeared from the valley.

The disappearance of the citrus industry from Pokhara valley taught a very valuable lesson, that free movement of planting materials could be disastrous and lead to the destruction of valuable indigenous plant genetic resources. In 1972 the Quarantine Act came into force in Nepal. However, this regulation is not strong enough to prevent the transfer of citrus diseases within Nepal and safeguard the livelihood of people dependent on citrus. The main reasons why the regulation is ineffective is that farmers in the villages are not aware of the problem, and local level citrus nurseries are not technically equipped to address it.

Improving local-level awareness and strengthening local citrus nurseries can help to prevent the spread of citrus diseases from one area to another. There is a wide variation in citrus characteristics in Nepal, and the use of local planting materials would also help to conserve these important citrus genetic resources. Local organizations can be given a role to play in this important work. This would help save time and effort in the government sector.

Source: Lama et al. 1996

without irrigation facilities, an environment that is decreasing or disappearing with the improvement in irrigation facilities (Joshi et al. 1996).

The number of land races of *Ghaiya* varieties maintained on-farm is affected not only by the physical environment but also by the sociocultural setting. Aromatic *ghaiya* varieties are no longer grown because of their low-yield potential and lesser tolerance to environmental stress. Such varieties are being replaced by high-yielding local varieties. For example, *ghaiya* varieties, such as *Sindhuli, Charinagre, Pakhe Jhinuwa, and Basmati,* are reported to be disappearing (some may even have become extinct) and the area formally under these varieties is now planted with more widely adopted varieties such as *Chobo, Tauli*, and *Chiuri*.

Local land races of barley are being replaced in areas where Bonus is grown because of the high yield potential, non-lodging, and relatively rust resistant properties of Bonus. In some instances, in recent years, barley has also been replaced by wheat. Local land races are barely used in crop improvement programmes at present.

There is very little research into millet at present, and no adequate efforts aimed at collection, evaluation, or utilisation of local germplasm. Thus the yield potential of finger millet has not been improved in the same way as for other major cereals such as rice, wheat, and maize. One of the main reasons for the erosion of genetic resources of finger millet is its low economic return, which results from the low productivity and high labour requirements. Farmers prefer cultivating rice once irrigation facilities have been established in an area, or they choose cash crops, such as vegetables, which can be marketed.

The Future Implications of On-going Genetic Erosion

Genetic Diversity is important to agriculture for both present and future generations. Farmers are the end users of these diversities. The main concerns of the ordinary farmer are traits of economic importance such as yield and quality. Not all land races are of equal importance to farming communities. Land races deficient in traits of agronomic importance are less likely to be accepted in the community, and farmers may therefore not be interested in maintaining such germplasm as it does not offer them any obvious benefit.

Another issue, which is important, is that the needs of future generations are unpredictable, and conserving Genetic Diversity is necessary. If the immediate needs of farmers are not addressed there will be further erosion or replacement of valuable high quality local land races by medium quality exotic varieties for economic reasons, and the future potential for developing farmer preferred varieties of different crops will be lost for ever. There is a danger that local food security will worsen if these issues are not addressed properly and in time. Often the topics of agrobiodiversity and food security are taken to be opposed to each other. However, in Nepal, most agriculture is still subsistence agriculture, and land races are still used widely. Thus even a small effort made to improve local land races by incorporating at least a few important traits could lead to an increase in output and improve the value of such varieties to the farming community. In this way improvements in food security could be combined with maintaining agrobiodiversity in the form of local land races. In fact there are many such cases (Green 1987; Sthapit et al. 1996), but they need to be studied to demonstrate the economic and social impacts. The need of the hour is to identify some ways and means by which the role of the farming community in conservation and utilisation of agricultural biodiversity can be consolidated. Following the Convention on Biological Diversity of 1992, there is a growing interest among national and international organizations in involving local people in the conservation and utilisation of plant genetic resources. This is one positive step in the process of recognising the role of the community, however, it is not very clear what the best way is of addressing this issue and how the local communities can best be motivated and benefitted. The best approach still needs to be worked out.

While long-term programmes and policies are being developed, there is a need for some immediate action-oriented activities. The first and foremost should be creating awareness among farmers about the situation of our germplasm through such activities as campaigns, meetings, and workshops, and letting farmers know about the present and future importance of plant genetic resources. Traditional land races usually differ in morphological characteristics, and in many cases names of varieties are often related either to the place of origin or the name of the person who made the introduction. The real worth of land races that are known by several different names has not been assessed. It is essential that the real worth of different crop varieties is studied so that their value can be identified and the local community made aware of the importance of such resources. This would be a logical option for making conservation and the use of plant genetic resources attractive to the farming community. Crop varieties that are on the verge of extinction should be collected, rejuvenated, multiplied, and reintroduced into the farming system. Promotion of highly valuable green manure species, such as *asuro*, at the farm level is one of the types of activity needing the attention of organizations at the grassroots' level. Conservation and development-oriented agencies in the country should set a priority agenda for developing an operational framework and calculating resource needs so that these activities can be carried out.

Conclusion

The real worth of agrobiodiversity cannot be realised by the farming community unless such biowealth is converted into income-generating enterprises by identifying and adding value. The potential benefit from these resources has not been exploited in Nepal because of the lack of institutional and financial capabilities. However, there is continuing erosion of genetic resources in the country which will have serious implications for both present and future agricultural productivity unless it is attended to properly in time. There is a need to understand local farming systems, the needs and aspirations of farmers, and the value of biowealth for improving such things as yield and product quality. Consolidating the role of farmers in the conservation and utilisation of plant genetic resources seems to be the most appropriate and sustainable way of managing these resources.

References

Anonymous, 1991. Annual Report of Central Plant Breeding and Biotechnology Division, Khumaltar, Nepal.

Baniya, B.K., Riley, K.W., Dangol, D.M.S., and Sherchand, K., 1992. *Characterisation of Nepalese Hill Crop Land Races (barley, buckwheat, finger millet, grain amaranth, foxtail, proso and barnyard millets)*. National Hill Crops Research Programme, NARC, IBPGR.

Green, T., 1987. *Farmer-to-Farmer Seed Exchange in the Eastern Hills of Nepal: The Case of Pokhreli Masino Rice*. PAC Working Paper 5/87. Dhankuta, Nepal: Pakhribas Agricultural Centre.

Gupta, S.R., Upadhyay, M.P. and Katsumoto, T., 1996. 'Status of Plant Genetic Resources in Nepal'. Paper presented at the 19th Summer Crops Workshop, held at National Rice Research Programme, Parwanipur, Bara, Nepal from 27-29 February, 1996.

Joshi, K.D., Kadayat, K.B. and Choi, K.R., 1995. Trip report. Germplasm Collection Trip to Pokhara Valley, 9-15 November, 1995.

Joshi, K.D., Sthapit, B.R., Kadayat, K.B. and Vaidya, A., 1996. 'Problems and Potentials of Aromatic and Fine Grain Rice in Nepal'. Paper presented for Summer Crops Workshop held at National Rice Research Programme, Parwanipur, Bara, Nepal from 27-29 February 1996.

Joshi, K.D., Vaidya, A., Subedi, P.P., Bhattarai, S.P., Subedi, K.D., Rasali, D.P., Suwal, M.R.S., Tuladhar, J.K., Phuyal, U. and Floyd, C.N., 1994. *Soil Fertility Systems Analysis in Relation to Temperate Fruit Crops in High Hills and Inner Himalayan Region of Western Nepal*. LARC Working Paper No. 94/50. Kaski Nepal: Lumle Agricultural Research Centre.

Joshi, K.D., Rana, R.B., Subedi, M., Kadayat, K.B. and Sthapit, B.R., 1995. 'Addressing Diversity through Farmer Participatory Variety Testing and Dissemination Approach: A Case Study of *Chaite* Rice in the Western Hills of Nepal'. In Sperling, L. and Loevinsohn, M.L. (eds) *Proceedings of Conference on Using Diversity and Maintaining Genetic Resources on Farm, New Delhi, June 19-21, 1995*. New Delhi: International Development Research Centre.

Lama, T. K., Lohar, D. P. and Shrestha, P. K., 1996. 'Lessons from Disappearance of Citrus Industry from Pokhara Valley: Role of Community Level *In Situ* Conservation and Quarantine'. Paper Presented in the National Workshop on Mountain Agrobiodiversity and Management Issues in Nepal. Organized by Local Initiatives for Biodiversity, Research and Development (LiBIRD) Pokhara, Nepal, March 15-26.

Pandey, R. K., 1987. *Altitude Geography; Effects of Altitude on the Geography of Nepal*. Lalitpur, Nepal: Centre for Altitude Geography.

Padoch, C. and Jong, W. de, 1991. 'The Home gardens of Santa Rosa: Diversity and Variability in an Amazonian Agricultural Systems'. In *Economic Botany*, 42(2): 166-175.

Pradhanang, P.M. and Joshi, K.D. (eds), 1993. *Barley Production Systems in Western Hills of Nepal: A Samuhik Bhraman Report*. Working paper No. 93/40. Kaski, Nepal: Lumle Agricultural Research Centre.

Shrestha, G.L. and Vaughan, D.A., 1989. 'The Wild Relatives of Rice in Nepal'. In Iyama, S. and Takeda, G. (eds) *Proc. of the 6th International Congress of SABRAO. Proc I.* from August 21-25, 1989, Tsukuba, Japan.

Sthapit, B.R., 1990. 'Comparative Performance of Indigenous Green Manuring Species on Yields of Rice'. In *J. Inst. Agric. Anim. Sci*. Vol II: 9-14.

Sthapit, B.R. (Ed), 1990. *Problems of Traditional Practices of Blackgram Production in Tanahun and Gorkha Districts: The Results of a Topical Samuhik Bhraman*. Working Paper No. 19. Kaski Nepal: Lumle Agricultural Research Centre.

Sthapit, B.R., Gautam, M., Ghale, N., Gurung, D., Gurung, G., Gurung, J., Gurung, K.J., Paudel, D.R.S., and Subedi, K.D., 1988. *The Results of a Soil Fertility Thrust Samuhik Bhraman: Traditional Methods of Sustaining Crop Productivity in the Lower Hills (300-700m), The Problems and Potentials*. Technical Paper 1988/19. Kaski Nepal: Lumle Agricultural Centre.

Sthapit, B.R., Joshi, K.D. and Witcombe, J.R., 1996. 'Farmer Participatory Crop Improvement. III. Participatory Plant Breeding. A Case Study of Rice in Nepal. In *Experimental Agriculture, 32: 479-496.*

Subedi, K.D., Gurung, G.B., Paudel, D.R.S., Gurung, K.J., Gurung, D.B. and Gurung, J.B., 1989. *Traditional Methods of Maintaining Soil Fertility in the Mid and High Hills (1,200-2,100m) of the Western Development Region of Nepal (Kaski, and Lamjung Districts) Problems and Potentials.* Working Paper No. 3. Kaski Nepal: Lumle Agricultural Centre.

Subedi, K.D., Sthapit, B.R., Joshi, K.D., Floyd, C.N., Pandey, R.R. and Rana, R.B. (1993). 'Indigenous *Ghaiya* (upland rice) Culture in the Western Hills of Nepal: Contribution of Farmers' Knowledge in Rainfed Farming'. In *Proceedings of the International Symposium and IInd National Meting on Sustainable Agriculture: Importance and Contribution of Traditional Agriculture,* 1993. CEICADAR, MEXICO.

Subedi, M., 1990. *The Findings of Finger Millet Samuhik Bhraman: Dangsing, Ghandruk, Lumle and Dhikurpokhari Areas of Kaski District.* Working Paper No. 1/91. Kaski, Nepal. Lumle Agricultural Research Centre.

Takahashi, R., Hayashi, J., Hiura, U. and Yasuda, S., 1968. *A Study of Cultivated Barely from Nepal and North India with Special Reference to Their Phylogenic Differentiation.* Ber. Ohara Inst. Landwirtsch. Biol., Okayama University 14, 85-122.

Upadhyay, M.P. and Sthapit, B.R., 1995. 'Plant Genetic Resource Conservation Programmes in Nepal: Some Proposals for Scientific Basis of *in situ* Conservation of Agrobiodiversity'. Paper Presented on the Strengthening the Scientific Basis of *In situ* Conservation of Crop Genepools, from 17 to 19 July 1995 in Rome, Italy, IPGRI.

Vavrilov, N.I., 1926. Centres of Origin of Cultivated Plants. Bulletin of applied Botany and Plant Breeding Leningrad, 16, 139-248.

Witcombe, J.R. and Gilani, M.M., 1979. 'Variation in Cereals from the Himalayas and the Optimum Strategy for Sampling Plant Germplasm'. In *Journal of Applied Ecology*, 16, 633-640.