Chapter 35

Can On-Farm Conservation be Compatible with Agricultural Development? Some Policies and Issues

A. K. Vaidya

It is quite often assumed that the diversity of Nepal symbolises a challenge for development and a cost associated with the rugged terrain. But the rich biodiversity in the hills of Nepal reflects the needs of the people and represents a strategy for survival, it is the result of the cultural, socioeconomic, and biophysical diversity. Crop genetic resources are concentrated in some of the world's poorest farming systems (Brush 1995). The general hypothesis that crop diversity is associated with closed and subsistence farming systems, because of the diverse needs of the people, and declines with the increase in developmental opportunities and interventions, needs to be examined in a wider economic, sociocultural, and environmental contexts.

With the introduction of new high-yielding varieties and over-exploitation of natural resources, genetic erosion is taking place in Nepal. Genetic erosion is reported to be high in crops, fruits, and medicinal plants at both variety and species' levels. It is believed to be caused by social factors such as technology diffusion, commercialisation, changing preferences, over-exploitation, and government policy. In the late 1970s the international community became aware that the seemingly abundant Genetic Diversity of food and agriculture was eroding, just as our technical capacity to use and transform germplasm was increasing. Germplasm conservationists have not considered *in situ* conservation of germplasm justifiable. In their view, displacement of traditional land races is a necessary result of development programmes that promote improved varieties and/or different crops as a means of increasing agricultural production (Benz 1988). It is widely believed that the rate of genetic erosion increases with the introduction of improved seed and market incentives. The question whether *in situ* conservation of germplasm is incompatible with development programmes could be resolved if we can find a way of producing more without destroying the natural habitats of potentially useful germplasms. Brush (1995) has demonstrated that on-farm conservation of land races can be decoupled from national farming systems using three cases, one in Peru (potatoes), one in Mexico (maize), and one in Turkey (wheat), as examples. The three case studies demonstrated that farmers in regions of crop diversity maintain Genetic Diversity while adopting modern agricultural technology. The aim was to test the hypothesis of whether conservation can continue under conditions of agricultural modernisation or not. It is important to convince researchers that *in situ* conservation does not necessarily imply denial of opportunities to the farming community that is directly or indirectly responsible for creating and managing the system under which crop land races survive.

In the closed systems of the hills, the farming systems are traditional, characterised by land races, and deep-rooted economic and sociocultural specific preferences that influence genotypes and crop evolution in a given environment. Crop diversity is promoted by physical and economic isolation, dependence on local inputs, production for local consumption rather than for market, and the persistence of local knowledge systems (Friis-Hansen in Brush 1995). One may wonder whether biodiversity should serve as an indicator of backwardness. The rapid replacement of local cultivars by improved ones in North America and Northern Europe may not be relevant, considering the different and heterogeneous sociocultural and environmental settings in third world countries. Land races form the main basis of food security in the hills. The maintenance of a number of cultivars and types is commensurate with socio-economic status, land types, fertility status, and the needs of farmers in specific conditions. Inter and intraspecies' diversification is also a vital strategy in risk prone farming systems to safeguard against unfavourable factors and unforeseen breakdown of varieties as a result of diseases and pests. As a result, yield is by no means the most important criterion.

The hills have climatic, ethnic, cultural, and physiographic diversity, resulting in highly integrated farming systems that depend on livestock, forest, and crops to survive. Hill farming is characterised by a scarcity of arable land, diversified farming, few employment opportunities, marketing problems, weak institutional support, and poor financial ability to modernise agriculture. As a result, wide Genetic Diversity can be seen in food crops, vegetables, fruits, medicinal and ornamental plants, and forest. More than 7,000 species of flowering plants are estimated to grow in Nepal, 79 per cent of which have been collected, identified, and preserved in the National Herbarium and Plant Laboratories, Godawari (NAA 1995). Although no scientific studies on genetic erosion have been carried out in Nepal (Upadhyay and Sthapit 1995), there is a clear feeling that agricultural development processes, on the part of both agencies and clients, lack awareness of the importance and role of biodiversity. Abundant Genetic Diversity exists, for example, in rice, finger millet, barley, grain legumes, wild vegetables, and citrus.

The state of development in the hills of Nepal and the level of infrastructure present are strongly associated with road heads. The Research Impact Study done by LARC has shown that the level of adoption of improved varieties fades with distance from the intervention points or markets (Masdar and Oda 1995). This study also has showed the compatibility of on-farm conservation with the process of agricultural development and associated factors in the hills of Nepal.

Land-use Change

At least three distinct land types exist in the hills and this, together with the nature of kinship and inheritance, has resulted in considerable land fragmentation. This fragmentation poses a major obstacle to agricultural development in Nepal but is probably a blessing for Genetic Diversity. Hill farmers whose households possess land of *khet* (irrigated lowland rice field), *bari* (non-irrigated upland), and *tar* (non-irrigated river fan) types have to deal with diverse growing conditions that influence the types of crops grown and interact with household resource entitlements. The diversity in production results from the role of the different land types in the farming systems.

Generally, in the hills, a larger number of crop species is grown on dry land, often in mixed form. More than ten crops may be grown on the same terrace under rainfed conditions when it is near to a homestead. These terraces provide a variety of subsistence foods such as yam and colocasia; a range of local fruits and vegetables including potatoes; cereals such as maize, wheat, upland rice, finger millet barley, naked barley, and buckwheat; a variety of legumes; oil seeds; and some spices and condiments. More than 30 different crops can be seen growing on *bari* in the hill districts of the Western Development Region (WDR), but only some 16 crops on *khet* and 11 on *tar*.

Shifts in land use can be caused by macro-economic or market forces which lead to changes in the choice of crops, displacement of traditional crops, or use of land for non-agricultural purposes. Micro-irrigation projects in the hills have changed *bari* into *khet*, shifting the focus to rice-based cropping and threatening traditional diversity. *Yampaphant in Tanahun experienced a similar situation.*

Varietal Erosion

The adoption level of rice in the mid hills where most of the land races prevail has been very low (below 15%). Rice is grown as a normal (*Barkhe*), early season (*Chaite*), upland (*Ghaiya*), or high altitude crop. Research into these different types of rice culture has been limited, rice cultivation has complicated adoption criteria. On average, households in the hills maintain four cultivars, and sometimes as many as 20, each with a specific use and for a given condition (McNeely 1989). The number of cultivars reflects the diverse and complex environment, the different cultivars are used to maximise production in given micro-production environments.

Rice is grown widely in the *Terai* and river valleys and on hill slopes up to 1,500m, and the Genetic Diversity is evident. Not all types of aromatic rice are market oriented, but with the arrival of market forces the displacement of low-yielding varieties has been reported. *Jetho Budho* replaced other land races in Pokhara as a result of increasing demand, 47 local rice varieties have already disappeared from Pokhara Valley, 14 more are on the verge of extinction, and land races such as *Nathini, Khalte Kholo,* and *Biramphool* are believed to be under threat (Joshi *et al.* 1995).

Land races have evolved over generations to suit the local conditions of farms, they also closely reflect sociocultural preferences. In the case of rice, land races include varieties for different seasons, with different fertility, and for different conditions of water availability, aspect, and land type. There are different varieties for fertile soils and marginal soils. Fine type aromatic rice, noted for its low yield, is kept for festivals and guests. High-yielding but short varieties are rejected as they do not produce sufficient livestock feed. Varieties such as *Anadi* have medicinal use. The normal and staple varieties are well-adapted, giving stable yields under low input conditions with no fertilizer and very little or no manure. The filling content, swelling, and type of grain are important and desired characteristics that depend on socioeconomic conditions. These complex characteristics demanded by the social and biophysical environments promote on-farm conservation and often obstruct easy adoption of modern varieties. Even so, a recent study in the hills of Myagdi, Kaski, and Parbat indicated over 68 per cent of farmers grow improved varieties and the remaining local varieties are only conserved in the *bari* system (Vaidya and Gurung 1995a).

Genetic erosion of local varieties in wheat has also been strong as a result of the yield factor in a largely food deficit region. Anyway, hill people have no strong preference in wheat. But the low-yielding land races are believed to contain many useful traits that are desirable in modern agriculture, for example, *Paundur,* a local land race from Kaski district, showed a significant heritable trait against spike sterility (Joshi and Sthapit 1995). After research intervention at Reesing Patan, an off-station LARC research site for low altitude areas in Tanahun district, the number of improved varieties within the site increased from three to four to 10. Even so, the varietal diversity within households has dropped considerably, as a result of changing needs, and the fact that wheat is a relatively new food in the hills and is only used in a limited number of food dishes (Joshi *et al.* 1996).

The citrus decline in Pokhara Valley wiped out many land races of citrus, the disease was believed to be imported from outside during the process of development. Bacterial wilt (*Pseudomonas solanacearum*) disease has caused severe problems in the Western hills and was also believed to be introduced with 'improved' germplasms. This suggests that introduction of germplasm can be equally dangerous to land races.

Extent of Crop Diversity and Erosion in the Western Hills

A survey was carried out by LARC in nine hill districts of the WDR in 1995 (Vaidya 1996) to assess crop diversity and the extent of genetic erosion. Figure 35.1 shows the varietal diversity across altitude-based domains. Rice varietal diversity was greater in the low hills (600-1,000m), including areas under aromatic rice, followed by river basins (below 600m), mid-hills (1,000-1,700m), and high hills (1,700-2,300m). As many as 17 varieties were reported in river basin and low hill areas, where five varieties of rice are maintained on average by households, and 14 varieties in mid hills. A common pattern was observed for rice, maize, fruit, and vegetables of increasing crop diversity with decreasing altitude. But the reverse was sometimes true for temperate and winter crops, as for crops such as finger millet with specific sociocultural preferences.

Varietal erosion at village level varied with crops (Table 35.1). A greater varietal replacement was observed in the mid-hills for rice, fruit, and millet. There was a decline of wheat varieties in the river basins. Maize varieties had disappeared more from the high hills than from lower domains. Some 140 rice varieties are on the decline, the important ones including *Anga, Manamuri, Phulpata, Gauriya, Chote, Aapjhutte, Bangare, Sobhara* and *Tauli*. Farmers reported stopping using 103 varieties of maize, including *Seto, Pahele* and *Sathiya,* for reasons such as changes in cropping pattern and land-use system, and introduction of high-yielding varieties. *Mudulo* was the only local variety of wheat reported by 2.8 per cent of the respondents.

Ethnicity has some association with varietal maintenance, but this is not evident statistically in Table 35.1. *Brahmin*(s), as the dominant ethnic group in the hills,

Table 35.1: Number of Crops/Cultivars Reported to be in Decline by Different Ethnic Groups

Crop	Brahmin	Chhetri	Occupational castes	Gurung	Magar	Total
Rice	2.31±0.15	2.55±0.33	1.33±0.21	1.87±0.22	2.05±0.21	2.16±0.10
Maize	1.51±0.13	1.61±0.18	1.67±0.21	1.86±0.18	2.0±0.14	1.69±0.07
Fruit	1.67±0.33	2.33±0.88	1.0±0	-	1.5±0.50	1.75±0.28
Vegetables	1.25±0.16	1.25±0.25	1.5±0.50	1.0±0	1.6±0.24	1.32±0.10
Wheat	1.50±0.23	1.0±0	1.0±0	-	1.0±0	1.30±0.15
Millet	1.0±0	2.0±0	-	1.5±0.5	1.0±0	1.13±0.09

generally maintain a higher number of crop varieties. Figures 35.1 and 35.2 show the number of crop varieties or species maintained by the major ethnic groups in the WDR. *Brahmin*(s) maintain more diversity followed by *Chhetri*(s) and occupational castes regardless of crop species. The dominance of the *Gurung*(s), *Magar*(s), and mountain tribes increases with altitude, and crops such as finger millet and wheat varieties are important in their farming systems.

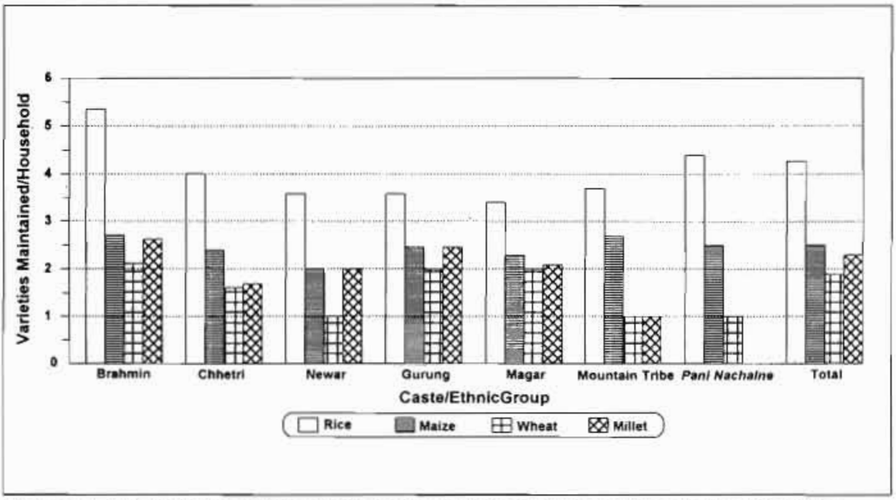

Figure 35.1: Food Crops Varietal Diversity Maintained by Each Household of Different Ethnic Communities in Nepal

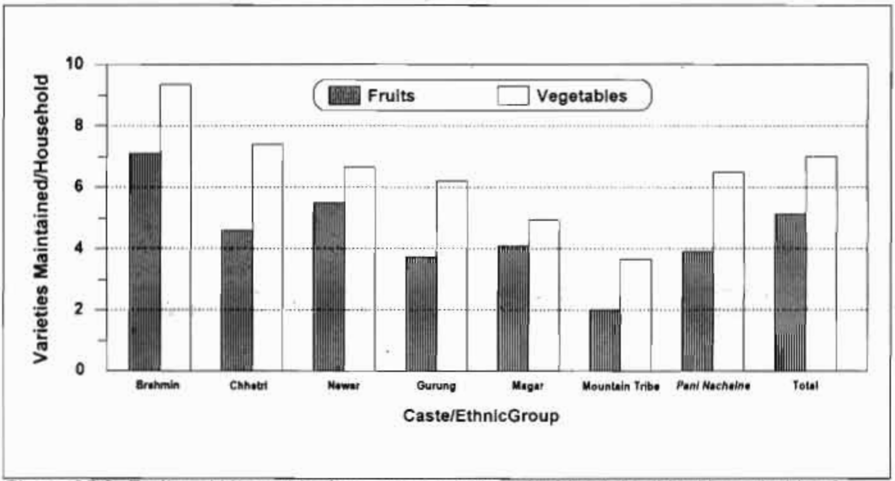

Figure 35.2: Fruit and Vegetable Crops Varietal Diversity Maintained by Households of Different Ethnic Communities in Nepal

The introduction of improved cultivars; market incentives; overexploitation of natural resources; social factors such as technology diffusion, commercialisation, and changing preferences; and government policy are often cited as reasons for genetic erosion. Most of these factors are believed to have a strong association with accessibility. But the study failed to establish any association between genetic erosion and factors such as distance from the road head, input levels, credit facilities, and altitude in the WDR (Table 35.2). Though in some cases diffusion studies in Lumle reported that the level of adoption of improved varieties drops away with distance from the road head.

Table 35.2: **The Correlation between Different Factors and the Genetic Erosion of Crops at Village Level in the WDR**

Crops	Distance	Input	Credit	Altitude
Rice	-0.067	-0.030	-0.070	-0.150
Maize	0.100	0.100	-0.020	0.120
Wheat	-0.180	0.100	0.180	-0.27
Finger Millet	-0.240	0.060	0.15	0.01
Fruit	-0.040	-0.220	-0.08	-0.06
Vegetables	0.140	-0.010	-0.13	0.12
All associations are statistically not significant at P ≤ 0.05				

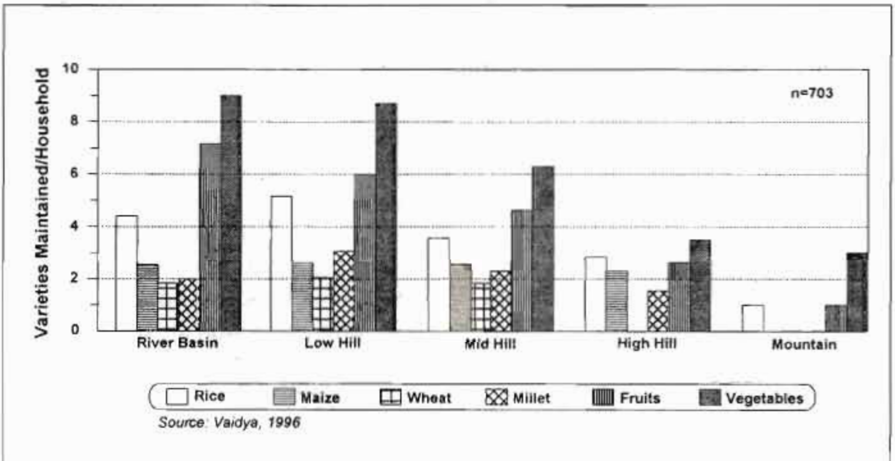

Figure 35.3: Household Crop Diversity Comparisons Among Five Agroclimatic Zones of Nepal

The Production Maximisation Approach

The green revolution in the tropics and subtropics during the mid-1960s helped to achieve incredible production of staple food, outpacing population growth, with the help of input responsive, carefully bred 'modern varieties'. However, it is felt increasingly that the revolution did not serve resource poor farmers, and widened inequality in the farming society. Extra 'entitlements' to food are now felt to be more important than increasing productivity (Sen 1981). The dependence on insecticides and fertilizers often resulted in the disappearance of beneficial insects, development of pest resistance, and deterioration in soil health. The modern varieties with genetic uniformity are designed to exploit productivity traits using external inputs. But now, the negative impact on the mountain environment, its resource poor farmers, and the political economy are being realised. New concepts such as a perspective for farming systems' research, client orientation, farmer participatory research, farmer first and last, and multidisciplinary participatory rural appraisal (PRA) and rapid rural appraisal (RRA) approaches are now being developed to counter the situation.

There has been an increase in adoption of improved varieties, improvements to road networks, input supply, and government extension and verification programmes, concomitant with the increase in population and the arrival of economic forces. However, farmers in the interior still conserve most hill and mountain land races *in situ*. But the block production programme run under the Department of Agriculture in Nepal, in which inputs, credits, and technology are supplied to maximise output, is often undermining on-farm biodiversity. These services involve government subsidies.

Farming Systems' Research Perspective

Agricultural development from the perspective of the existing farming systems has been tried in the western hills of Nepal and by Lumle Agricultural Research Centre (LARC). The aim was to address the problems of subsistence hill farming. The question of conserving biodiversity as a global concern was certainly not in the minds of the multidisciplinary researchers when the programme was conceived in the early eighties. The focus was more on the immediate and basic objectives of increasing the food security and income of hill farmers through the development of appropriate technologies. However, given the diverse and harsh environment the researchers did not take long to realise that use of local genetic resources was the key to addressing the problem. The approach adopted included emphasis on recommendation domains, identification of clients in a heterogeneous environment, and use of farmer participatory on-farm research, all taking socioeconomic diversity into full consideration. The multidisciplinary research teams worked together on prioritised farmers' problems using PRA techniques. They used eco-sites (off-station research (OSR) sites) to carry out farmer participatory on-farm activities and evolve a series of innovative approaches. The experience suggests that working on farmers' priorities with their active participation not only contributes to conserving on-farm diversity but may even enhance it further. The OSR sites' case studies showed that there was a significant increase in interspecies' diversity and no significant disruption to intraspecies' diversity (Vaidya and Gibbon 1991). This resulted in significant changes with higher farm income and increased food security. The cropping pattern achieved at Tapu during 1985-1991 was maintained after the site was closed in 1991, apart from the use of *Sesbania spp* for green manuring of *khet*. The on-farm and participatory approach helped promote the adoption by farmers of *Khari* and *Aule* goats because local selections were evaluated and found to be better than exotic ones at serving local needs and conditions.

Development with Conservation

There are several examples documented that suggest that on-farm conservation and development can proceed together. Some of these are listed below.

1. Maize (Plan Peubla, Mexico) (CIMMYT 1974)
2. Potatoes (Tulumayo and Paucartambo, Peru) (Brush 1995)
3. Wheat (Eskiseher and Kutahaya & Usak, Turkey) (Brush 1995)
4. Maize (Vicente Guerrero, Mexico) (Brush 1995)
5. Staple crops and vegetables (Western Development Region (WDR), Nepal) (Lohar and Rana 1996)
6. Early rice (WDR, Nepal) (Joshi et al. 1995)
7. Green manuring (WDR, Nepal) (Sthapit et al. 1988, 1989)
8. High altitude rice (Kaski, WDR, Nepal) (Sthapit et al.1996).
9. Mid-hill rice (Pokhara Valley, WDR, Nepal) (Sthapit et al. 1996)
10. Summer maize (WDR, Nepal) (Vaidya and Gurung 1995b)
11. Wheat (Tanahun, WDR, Nepal) (Joshi et al. 1995)

Some Issues

While this paper does not intend to draw conclusions, it attempts to raise some of the issues to be considered in local contexts. Attention to these issues should contribute to sustainable development of traditional farming in Nepal, as well as promoting and maintaining genetic resources 'on-farm'.

- The credit and subsidies given by the state favour improved technology to increase productivity, and thus conflict with on-farm conservation of agrobiodiversity and need careful revision. The concept of the Block Production Programme implemented under the Department of Agriculture has forced whole communities to exploit the genetic potential of selected improved varieties. The ambitious Agricultural Perspective Plan aimed at accelerating growth rate through fairly input intensive mechanisms does not consider adequately the impact on on-farm biodiversity; the consequences should be assessed. The activities of most national programmes, if successful, may in fact become the main cause for the loss of agrobiodiversity (Roder 1995).

- How would a farmer know he owns a threatened species and/or valuable gene? Identification of valuable germplasms and creating awareness will result in effective conservation. Awareness about the issue is desirable at all levels of society, from farmers, through grassroots' workers, researchers, and government line agencies, to policy formulators, all of whom play important roles.

- Farmer participatory, multidisciplinary, and on-farm approaches with a farming system perspective are likely to favour on-farm diversity. The formal development approaches lack this perspective.

- Land-use changes in the process of development can pose an important threat to conservation of agrobiodiversity. Land-use systems, such as *bari* in stress environments, conserve more on-farm biodiversity.

- The dilemma between development and biodiversity conservation needs to be analysed in terms of social, cultural, and economical rationales in a given farming system, and this is a dynamic process. Although diversity in species and variety levels in a locality is observed and reported, the understanding of the household dynamics influencing biodiversity needs to be strengthened. Studies should quantify the extent of genetic erosion and efficacy of farmer-based conservation and explore the possibility of community-based gene banking.

- Farmers cannot be persuaded to maintain a species on farm without need, use, or incentive. This may require marketing promotion for land races and elevating species' prestige at fairs and expositions (Brush 1995).

- In the face of the process of development, in whose interest is it to conserve agrobiodiversity? How can farmers be compensated and what are their rights to the germplasm they have preserved for generations? The cost of conservation for a country like Nepal is difficult to imagine in view of its pay-off at the present level of technological knowhow. The issue of resource availability to developing countries for ensuring *in situ* conservation is still unclear.

References

Benz, B.F., 1988. '*In situ* Conservation of the Genus Zea in the Sierra de Manantlan Biosphere Reserve'. In *Recent Advances in the Conservation and Utilisation of Genetic Resources*. Proceedings of the Global Maize Germplasm Workshop at CIMMYT, Mexico, 6-12 March. Mexico: INIFAP/CIMMYT/CTA/IPGRI/ Pioneer Hi-Bred International and UNDP.

Bush, S.B., 1995. '*In situ* Conservation of Landraces in Centres of Crop Diversity'. In *Crop Science,* 35:346-354.

Joshi, K.D., Rana, R.B., Subedi, M., Kadayat, K.D., 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*. Koski, Pokhara: Lumle Agricultural Research Centre.

Joshi, K.D., Sthapit, B.R., Kadayat, K.B. and Vaidya, A., 1996. 'Problems and Potentials of Aromatic and Fine Rice in Nepal'. LARC Seminar Paper (in press).

Joshi, K.D, Rana, R.B., GC, Y.D. and Gurung, H., 1996. In *Prabhidi Sangalo,* Year 10, Vol. 34).

Joshi and Sthapit, 1995. 'Genetics of Wheat Sterility and Possibility of Making Genetic Gains through Breeding'. Seminar Paper presented at NRIP.

McNeeley, J., 1989. 'Conserving Genetic Resources at Farm Level'. In *ILEIA Newsletter*, Vol. 5. No. 2.

Roder, W., 1995. *On Farm Management of Biodiversity and Genetic Resources*. ICIMOD Discussion Paper Series No. MFS 95/3. Kathmandu, Nepal: ICIMOD.

Sen, A.K., 1981. *Poverty and Famines*. Oxford: Clarendon Press.

Sthapit, B.R., Joshi, K.D., Witcombe, J.R., 1995. *Farmer Participatory High Altitude Rice Breeding in Nepal: Providing Choice and Utilising Farmers' Expertise*. Kaski, Pokhara: Lumle Agricultural Research Centre.

Sthapit, B.R. and Gautam, M., Ghale, N., Gurung, D., Gurung, K.J., Paudel, D.R.S. and Subedi, K.D., 1988. *The Results of Soil Fertility Thrust Samuhik Bhraman: Traditional Method of Sustaining Crop Production in the Lower Hills (300-700m), The Problems and Potentials*. Technical Paper No. 87/16. Nepal: Lumle Agricultural Research Centre.

Sthapit, B.R., 1989. *Comparative Performance of Indigenous Green Manuring Species on Yields of Rice*, Technical Paper No. 23/89, Pokhara, Nepal: LAC.

MASDAR and ODA, 1995. *The Social and Economic Impact of Research Done at Lumle and Pakhribas Agricultural Centres in Nepal*, Main Report. Pokhara: LAC.

NAA, 1995. *Plant Genetic Resources Profile Study*. Kathmandu, Nepal: Nepal Agricultural Association.

Tobey, J.A., 1993. 'Towards a Global Effort to Protect the Earth's Biological Diversity'. In *World Development*,Vol. 21. No. 12, pp 1931-1945.

Upadhyay and Sthapit, B.R. 1995. 'Plant Genetic Resource Conservation Programmes in Nepal: Some Proposals for Scientific Basis of *In situ* Conservation of Agro-Biodiversity'. Paper Prepared for Participants' Conference on Strengthening the Scientific Basis of *In situ* Conservation of Crop Genepools, IPGRI, Rome.

Vaidya, A.K.,and Gibbon, D.,1994. 'Survival and Sustainability in the Mid-Western Hills of Nepal'. In *Journal of Farming Systems Research-Extension*, pp 75-91, Volume 4, No. 3.

Vaidya, A.K.,and Gurung, H.B., 1995a. *Yield Estimation and Farm Management Study of Wheat in the Extension Command Area*. LARC Working Paper 95/23. Pokhara; LARC.

Vaidya, A.K, and Gurung, H.B., 1995b, *Yield Estimation and Production Systems Analysis of Summer Maize with Reference to Adoption and Farm Management Issues in the Extension Command Area*, LARC Working Paper No. 95/71. Pokhara: LARC