Chapter 24

State of Underexploited Mountain Crops in the Indian Himalayas and Erosion Concerns

R. K. Maikhuri, R.S. Rao,
R.L. Semwal and K. G. Saxena

Introduction

Environmental, biological, and sociocultural-economic variations in the Himalayas led to evolution of diverse traditional farming systems. Slash and burn agricultural systems characterised by mixing cropping and linkages with detritus-based swine husbandry are the most extensive land use in the hot and humid climates of the north-eastern Himalayas dominated by tribal populations. In contrast, settled agriculture on terraced slopes with milch cattle, goat, and sheep husbandry predominates in the relatively cold and dry climates of the central and western Himalayas inhabited largely by non-tribal populations (Ramkrishnan et al. 1994). A variety of changes in traditional farming systems has emerged in response to population pressure, technological innovations, market forces and land tenure/ownership policies, economic growth, social welfare, and environmental conservation policies. Negative trends in mountain farming, such as declining crop yields, expansion of agriculture on to marginal land (Eckholm 1975; Toky & Ramkrishnan 1981; Whittaker 1984) forest degradation (Toky & Ramkrishnan 1983), weed infestation (Saxena & Ramkrishnan 1984), loss of crop Genetic Diversity (Maikhuri et al. 1991), soil erosion and hydrological imbalances (Validiya & Bartarya 1991), and soil disintegration (Ramkrishnan 1992) dominate the sustainable development debate on the Himalayas. Yet, looking over the diversity and complexity of farming systems, there are serious limitations to generalising the trends derived from one ecological situation to the other and in formulating sustainable development strategies based on generalisations (Thompson & Warburton 1985 ab; Rao & Saxena 1994).

The neglect of traditional mountain crops and cropping systems in agricultural research and development has been largely due to the minor role of mountain agriculture in the aggregate national economy and a smaller proportion of agricultural land in the mountains. Hardly 20 per cent of the geographical area of the Indian Himalayas is reported to be under cultivation, compared to 46 per cent as a national average. Yet, agriculture is crucial for the 51 million people living in the Himalayas; agriculture being the primary occupation of 92 per cent of the total population of the Indian Himalayas. The Himalayan mountains are a reservoir of large numbers of traditional crops of which the economic and ecological potentials are not yet fully exploited (Maikhuri et. al. 1991). This article deals with the extent of agricultural diversity in traditional settled agroecosystems of the central Himalayas, the impacts of external factors on agrobiodiversity, and ecological and economic opportunities for and constraints in promoting agriculture-based sustainable development in the region.

Farming System - The Ecological and Socioeconomic Setting

Land Holding

Settled agriculture in the central Himalayas (the hill area of Uttar Pradesh Province) is practised on privately-owned land; the ownership rights of which are inherited. The average size of land holding is 0.95 ha. Pressure on land in the Indian Central Himalayas is thus not as severe as in other comparable areas such as Nepal, Bhutan, and Afghanistan (0.13 ha, 0.10 ha and 0.53 ha, respectively).

Fragmentation of Holdings

Field scattering or field dispersion is a common feature of non-commercial agriculture in mountain regions. By planting several dispersed fields rather than a consolidated one, farmers tend to reduce the risks of environmental unpredictability and variability in the productive potential of the site. The degree of fragmentation is generally high on more heterogeneous sloping land (2-6 parcels of land owned by a family) than on homogeneous valley land (1-3 parcels of land owned by a family). Large holdings (1-5 ha) consist of three to seven dispersed fields compared to small holdings of less than one ha consisting of two to three dispersed fields. Fragmentation could be an efficient way of holding land at the cost of inefficiency, resulting from unproductive use of time and energy involved in travelling and transporting materials between distant fields. The degree of fragmentation in the Central Himalayas is much less than in other mountain regions where farmers may cultivate as many as nine-25 dispersed fields.

The most distant fields are often located far away on valley land at a distance of six to eight km from the dwelling in the uplands. Fields in the valley are so small that permanent stay there is not as advantageous as in the uplands where the fields are much larger. These circumstances force cooperation within a farming community. Farmers of a given social group from a hamlet share a common temporary house on valley land as and when needed. However, caste feeling is so strong and deep-rooted that the socially privileged (higher caste) and lower caste (scheduled castes) families never share a common house. Maintenance of irrigation canals is a responsibility assumed by the community. A couple of individuals capable of discharging these responsibilities are identified from a hamlet on a yearly rotation basis. These individuals, who suffer some loss on account of neglect of their upland fields, are compensated by contributions of food grains from each household during the year.

Efforts for consolidation of holdings by the Government were unsuccessful. The unifying government policy for consolidation is based on classification of cultivated land into four categories, viz., land producing rice only, land producing one crop a year other than rice, land producing two crops a year, land subject to fluvial action, and valuation of exchange ratio for conservation from one category to the other. Statutory provisions stipulate implementation of a consolidation package after it is accepted by the village community and not as an enforcement. Consolidation is not acceptable to the people by the village community and not as an enforcement. Consolidation is not acceptable to the people as they value the advantages of raising a variety of crops on fragmented holdings heterogeneous environmentally and, through that, achieving food security at household level, more than the advantage of saving time and energy in cultivating a consolidated holding.

Farm - Forest Linkage

Crop yields are sustained with nutrient, water, energy, and organic matter inputs from the surrounding forests. The farm output thus is a function of direct as well as indirect values of the forest (Rao & Saxena 1996). A sustained supply of nutrients in the agricultural land is managed through organic manure derived from leaf litter collected from the forest floor and excreta from the livestock. Livestock feed requirements are met partly from crop by-products and partly from grazing in the forests. Sustainable agriculture in traditional agriculture meant sustainable use of forest resources.

Farmers' concerns for forest conservation are also reflected in the maintenance of fuelwood and fodder-yielding trees on private farms, particularly in rainfed farming systems. The average density of trees in traditional agroforestry systems falls in the range of from 300 to 400 trees per ha. *Celtis australis* was found to provide the highest amount of green fodder, followed by *Boehmeria rugulosa* and *Grewia optiva*. The traditional value of farm-forest linkages eroded following denial of free access to the people of forests. At present, forests are owned by the Government/State and assertion of ownership rights by the government often leads to forest degradation/deforestation due to excessive biomass removal from the forests or encroachment on forest land by local communities.

Agricultural Development Interventions

Supply of inorganic fertilizers and high-yielding varieties of seeds of wheat/paddy at subsidised prices are the most prominent government-driven development interventions that have induced changes in the traditional agribiodiversity and crop management practices over the last couple of decades in the Himalayas. Absorption of these interventions into the traditional farming system is confined to the easily accessible areas with moderate climates. These interventions have reached high altitude areas characterised by extreme cool climates and high degrees of inaccessibility to a very limited extent.

Environmental Heterogeneity and Crop Diversity

Altitudinal Distribution

Some crops such as *Allium cepa*, *Zingiber officinale*, and *Vigna radiata* are grown at lower altitudes (up to 1,200 masl) characterised by warmer temperatures. The crops with distribution restricted to cool climates at high altitudes include *Chenopodium album*, *Fagopyrum tataricum*, *Fagopyrum esculentum*, and *Secale cereale*. *Triticum aestivum and Amaranthus oleracea* are crops that exhibit widest distribution range. The crop diversity, when considered at village or watershed levels, depends upon the altitudinal variation existing in the area under consideration (Table 24.1). In an area in which the altitude varies from 500 to 2,500 masl, one is likely to get about 40 crops.

Irrigation

Irrigation is practised up to an altitudinal limit of 1,800 m. Irrigated farming is largely confined to the valleys and covers only 11 per cent of the total net sown area. Rainfed agricultural practices thus dominate the area. Biodiversity, if looked at as the number of crops grown, is much higher in rainfed farming than in irrigated farming. Only four crops are grown in irrigated conditions, while 20-30 crops are grown under unirrigated conditions. Crops, such as *Oryza sativa* and *Panicum miliacium*, that are grown in both irrigated and rainfed conditions, have different cultivars adapted to two types of situation. On the other hand, the same cultivar is used for irrigated and unirrigated conditions in the case of a crop like *Setaria italica*.

Table 24.1: **Agricultural Crop Diversity Across an Altitudinal Gradient in the Central Himalaya**

Crop species	English name	Vernacular name	Altitudinal range (masl)
Allium cepa	Onion	*Pyaz*	500-1100
Amaranthus oleracea	Amaranth	*Chauli*	500-2500
Avena sativa	Oat	*Jail*	2000 - 2500
A. Frumentaceus	Amaranth	*Chuwa/Marcha*	1500 - 2500
Brassica compestris	Mustard	*Sarson*	500 - 2200
Brassica spp	Mustard	*Toriya*	500 - 2000
Cajanus cajan	Pigeon	*Tor*	500 - 1800
Canabis sativa	Hemp	*Bhang*	1500 - 2500
Chenopodium album	Pig-weed	*Bathuwa*	2000 - 2500
Cleome viscosa		*Jakhiya*	500 - 1500
Colocasia himalayensis		*Pindalu/Kuchain*	500 - 1500
Echinochloa frumentacea		*Barnyard millet (Jhangora)*	500 - 1800
Eleusine coracana	Finger millet	*Koda*	500 - 2000
Fagopyrum esculentum	Buckwheat	*Oggal*	1900 - 2500
Fagopyrum tataricum	Buckwheat	*Phaphar*	1900 - 2500
Glycine soja	Soybean	*Bhatt*	800 - 1800
Glycine spp	Soybean	*Kala bhatt*	1100 - 1800
Glycine max	Soybean	*Soybean*	500 - 1500
Hordeum himalayens	Naked barley	*O-wu-jau*	1500 - 2300
Hordeum vulgare	Barley	*Jau*	500 - 1500
Lens esculenta	Lentil	*Masoor*	500 - 2000
Macrotyloma uniflorum	Horsegram	*Gahat*	500 - 1800
Oryza sativa	Paddy	*Satti*	500 - 1800
Oryza sativa	Paddy	*Dhan*	500 - 1500
Panicum miliaceum	Hogmillet	*Cheena/Bhangna*	500 - 2000
Papaver somniferum	Poppy	*Post*	1200 - 2300
Perilla frutescense	Perilla	*Bajeera*	1000 - 1700
Phaseolus vulgaris	Kidney bean	*Razma*	1500 - 2500
Pisum sativum	Pea	*Matar*	500 - 1500
Sesamum indicum	Sesame	*Til*	500 - 1500
Setaria italica	Foxtail millet	*Kauni*	500 - 1800
Solanum tuberosum	Potato	*Alu*	1000 - 2500
Triticum aestivum	Wheat	*Gehun*	500 - 2500
Vigna aconitifolia	Mat bean	*Bhringa*	800 - 1600
V. angularis	Adjuki bean	*Rains*	900 - 2200
V. mungo	Black gram	*Urad*	500 - 1800
V. radiata	Green gram	*Mung*	500 - 1000
V. unguiculata	Cow pea	*Sonta*	500 - 1800
V. umbellata	Rice bean	*Bhotiya*	1500 - 2000
Zea mays	Maize	*Mungri*	500 - 1800
Zingiber officinale	Ginger	*Adrak*	500 - 1200

Cropping Seasons and Crop Rotations

Two crops in a year can be harvested up to an altitutde of 1,800 m. Farmers, however, take two harvests a year in irrigated conditions and three crops in two years in rainfed conditions. There are two growing seasons in the year - summer/

rainy season (April - October) and the winter season (October-April). Thus, rainfed agricultural land is fallowed in one growing season out of four available over a period of two years. Only one crop can be harvested in a year because of the longer maturity period in cool climate areas above 2,000 masl. Wheat in these areas takes 11-12 months to mature. The cold adapted high altitude cultivar of wheat is different from the one grown at warmer, lower altitudes. Agroecosystem diversity along an altitudinal gradie1nt is thus determined by the climatic constraints and farmers' needs.

Mixed and Monocropping

Food security can be achieved by growing a uniform mixture of crops all over the available land or by growing pure crops in small plots. The coexistence of these alternatives in settled farming in the Central Himalayas adds to the agroecosystem biodiversity and complexity. The factors that determine farmers' knowledge and decisions about the relative areas under mixed and monocropping, and the rationale behind making a choice of crops and their proportions in a mixture, need to be thoroughly investigated.

Genetic Erosion

Table 24.2 shows that the cultivation area for traditional crops declined tremendously during the last two decades (between 1970-74 and 1990-94). The area under *Panicum miliaceum* and *Setaria italica* decreased by 65 per cent. These crops were replaced by high-yielding rice varieties and cash crops such as soybean, the seeds of which are supplied by government agencies. In rainfed agroecosystems the area planted with traditional crops, such as *Avena sativa*, *Fagopyrum* spp, *Vigna* spp, *Hordeum* spp, *Hordeum* spp, and *Macrotyloma uniflorum*, has decreased by 72-95 per cent because of increasing emphasis on cash crops such as potato, soybean, *rajma* (broad beans), pigeon pea, mustard, and amaranth.

Although the area of irrigated and rainfed land under paddy has not changed, the traditional indigenous varieties have been almost completely replaced by the introduced high-yielding varieties China-4, Taichung, Govinda, and Seket-7. The same is true for wheat, traditional varieties have been replaced by high-yielding one. Crops such as *Parilla frutescense*, *Macrotyloma uniflorum*, and *Vigna* spp are now on the verge of extinction.

It is hard to say to what extent the genetic base has already been eroded, but the supply of inputs such as high-yielding varieties, inorganic fertilizers, pesticides, and irrigation facilities since the 1970s has encouraged replacement of native land races. In the Himalayan Gazettes of 1882, Atkinson listed 48

Table 24.2: **Area in ha/village under Different Traditional Crops in the Summer and Winter Seasons during 1970-74 and 1990-94 (average of about 150 villages in 11 valleys of the Central Himalayas)**

Crop/Cropping Season	Area in ha/village		Replaced by	Redu. in area, %
	1970-74	1990-94		
***Kharif** Season Crops**				
Panicum miliaceum	14.2	4.9	High-yielding rice varieties	65.5
Oryza sativa	14.2	14.2	Traditional rice varieties by HYV	-
Avena sativa	15.8	3.4	Potatoes	78.5
Fagopyrum tataricum	8.6	1.5	Potatoes and *rajma* (broad beans)	82.5
Fagopyrum esculentum	4.1	0.3	Rajma	92.7
Parilla frutescense	1.3	-	Soybeans	100.0
Setaria italica	2.3	0.8	Soybeans	65.2
Oryza sativa	11.2	11.2	Traditional rice varieties by HYV	-
Eleusine coracana	9.6	6.1	Soybeans and amaranth	36.5
Macrotyloma uniflorum	2.1	-	Soybeans and amaranth	100.0
Echinochloa frumentacea	2.5	0.7	Pigeon peas	72.0
Vigna spp	3.3	-	Pigeon peas and amaranth	100.0
***Rabi** Season Crops**				
T.aestivum+B.compestris	14.2	14.2	Traditional wheat varieties by HYV	-
Hordeum himalayens	17.1	4.7	Potato, amaranth and rajma	72.5
Hordeum vulgare	7.0	1.1	Improved mustard varieties	84.3
Brassica compestris	2.0	2.0	No change	-

(Source: Maikhuri et al. 1996)
**Kharif* = summer; *rabi* = winter

varieties of rice and stated that there were thousands of other nondescript varieties. Today only seven or eight of these varieties are cultivated, with only *Ramjawan, Thapachini, Lalmati, and Rikhva* on irrigated land and *Chiyasu* in rainfed areas. Wheat has also lost innumerable varieties and 90 per cent of the crop on irrigated land is planted at present with a single improved variety called *Sonalika*. This is one of the evident effects in cash crops and modern varieties of staple crops found in the study (Maikhuri et al. 1991; Shiva and Ram Prasad 1993; Kothari 1994).

Yield Potential

Fagopyrum + potatoes gave the highest yields followed by *Amaranthus* + *Phaseolus* spp. The monetary efficiency ratio was higher for mixed cropping than for monocropping. The combination of *Macrotyloma* and *Eleusine* (traditional crops) gave the highest yield of all the traditional *kharif* (rainy/summer) season crops at all altitudes. All the traditional crops, whether grown as pure or mixed crops, apart from the combination *Macrotyloma* + *Eleusine* practised at lower altitudes, exhibited a higher monetary efficiency than common crops of wheat and paddy.

Panicum miliacium (perso millet) is adapted to high altitudes and is cultivated exclusively on irrigated land. Its climatic and maturity requirements are such that it can be grown during the short fallow period between the major winter and summer growing seasons. It can be also be grown as a summer crop (Table 24.3).

Table 24.3: **Annual Yield of Grain and By-products (kg/ha/yr) and Monetary Input/Output (Rs/ha/yr) for *Panicum Miliaceum*, A Neglected Crop of the Central Himalayas**

Elevation	Yield (kg/ha/yr)		Monetary input/output per crop (IRS)		Efficiency ratio (IRs/ha/yr)
	Grain	By-products	Input	Output	Output:/input
High altitude (1800-2400 masl) *Panicum miliaceum**	1966	4476	1908	5310	2.8
Lower altitude (500-1000 masl) *Panicum miliaceum***	2102	5152	2303	7510	3.3

* Cultivated during *kharif* season (mid-June to mid-August)
** Intermediate crop grown between *rabi* and *kharif* seasons (May-June)

(Source: Semwal and Maikhuri 1996)

The yield trial experiments conducted by Shiva and Ram Prasad (1993) to compare traditional and modern varieties of paddy show that traditional varieties not only provide better grain yields than modern varieties, they also give better yields of crop by-products. Since crop by-products are used as livestock feed, higher biomass production by traditional crops should mean less pressure on forests to meet livestock fodder requirements. High livestock productivity also implies adequate organic manure and thereby maintenance of soil fertility, as well as provision of draught power in an area in which mechanisation is out of reach for a variety of reasons. These locally available inputs are critical for sustainable agriculture in the mountains where inaccessibility and economic marginality are the crucial problems. However, the superiority of local varieties over introduced breeds cannot be generalised upon broadly because of the fact that there are few comparative studies.

Food Security and Mountain Crops

Dependency on traditional crops is more prominent in high altitude than low altitude areas. Among the traditional crops, millets contribute more than pseudocereals and pulses in the local diet across an altitudinal gradient. The contribution of food energy and protein obtained from animal products (sheep, goats, and wild animals such as wild boar and deer) is much less than that of crops. People in high altitude villages even today are less dependent on markets for their supply of food grains. Purchase of grains is negligible.

Remoteness and isolation in the mountains fostered the evolution of cropping systems that provide variety and avoid risks. Such selective adaptation in land use helped develop self-reliance in respect of food security. The introduction of a public distribution system in the mid-sixties that provided staple food grains at subsidised prices led to a number of changes in traditional agriculture. There was a shift in attitude from considering agriculture as a means of subsistence to considering agriculture as an economic activity. Food habits also changed. So-called 'coarse' grains, such as finger millet (*Eleusine coracana*), *jhangora* (*Echinochloa colunun*), *chinna* (*Setaria italica*), and buckwheat (*Fagopyrum tataricum*), that were locally produced but not available through the public distribution system became of secondary importance. The habit of eating wheat and rice purchased from the market gradually became firmly established as a status symbol. All this led to a reduction in crop diversity, and a change from a system of food security based on local produce to a market dependent system of food security.

Market Economy

Many traditional crops are also exported every year by the locals of high and mid-Himalayan villages in order to earn cash to meet their other basic requirements (Table 24.4). *Amaranth*, kidney beans, and potatoes are the main crops exported. A traditional barter exchange system still operates but is on the wane. The inherent cultural value of the barter system was that food was regarded as the basic requirement for sustaining life, that should be available to all irrespective of their socioeconomic status. This idea is being eroded by the penetration of a monetary

Table 24.4: Export of Traditional and Other Cash Crops (per capita per yr) from Higher and Mid-Himalayan Villages Located between 1,200 and 2,400 masl in the Central Himalayas (prices in 1996)

Traditional and Other Cash Crops	Selling Price in Local Market (IRs/Kg)	Selling Price in Nearest Urban Centre (IRs/Kg)	Net Profit Gained by Middlemen Traders (IRs/Kg)
Amaranthus spp	8.0	15.0	7.0
Fagopyrum esculentum	9.0	18.0	9.0
Fagopyrum tataricum	8.0	15.0	7.0
Phaseolus vulgaris	10.0	15.0	5.0
Vigna angularis	8.0	12.0	4.0
Macrotyloma uniflorum	9.0	20.0	11.0
Cajanus cajan	12.0	25.0	13.0
Cleome viscosa	10.0	40.0	30.0
Solannnnum tuberosum	0.8	3.0	2.2

Source: Maikhuri et al. 1996

economy that has accompanied improvements in accessibility. Poor and uneducated farmers are often forced by powerful alien traders to exchange their high priced traditional crops for low-value crops. The natives of this region are badly exploited by middlemen who earn more than 50 per cent of the profits. Local communities are not sufficiently aware of the market prices and thus are unable to demand the full profit. If proper marketing policies were to be framed and implemented, the food security of mountain people could certainly be improved.

Value of Neglected Mountain Crops

Table 24.5 shows the per capita annual consumption of and amount of energy and protein provided by traditional crops and other foods at different altitudes in the Himalayas.

Table 24.5: **Per Capita Annual Consumption of Different Traditional Crops by the Local Population in Relation to Other Food Items at Different Altitudes in the Central Himalayas during 1990-94**

Food items	Lower altitudes (500-1000 masl)			Middle altitudes (1000-1800 masl)			High altitudes (2000-2500 masl)		
	QuaN. (Kg/lit)	Energy (MJ)	Protein (Kg)	Quan. (Kg/lit)	Energy (MJ)	Protein (Kg)	Quan. (Kg/lit)	Energy (MJ)	Protein (Kg)
Traditional crops	24.9	369.8	3.79	70.4	969.4	8.68	122.8	1730.2	15.7
Common crops	119.9	1942.5	11.7	103.7	1680.0	8.8	49.8	806.7	4.6
Imported/exchanged	68.7	1119.7	7.28	54.4	885.7	5.83	56.1	908.8	4.6
Animal products	50.5	152.7	2.66	74.2	227.8	3.9	102.3	323.6	6.4
Vegetables	20.5	318.8	1.7	26.5	412.5	1.9	40.6	631.3	3.5
Total	284.5	3903.5	27.13	329.2	4169.4	29.1	371.6	4361.6	34.8

(Source: Maikhuri et al. 1996)

The majority of traditional crops possess immense medicinal properties (Box 24.1). The grains of *Setaria italica, Panicum miliaceum,* and *Echinochloa frumentacea* are used to treat diarrhoea and other kinds of abdominal ailments. Soup made from *Macrotyloma uniflorum* is used to dissolve stones.

Traditional, settled mountain agriculture has a considerable potential for meeting local food requirements and also providing cash income for farmers. A variety of interventions is needed to improve the productivity and profitability of these systems and at the same time assure conservation of Genetic Diversity at the crop, cultivar, agroecosystem, and landscape levels. The strategic priorities should focus on the following.

- Improvement in scientific knowledge of the ecological and socioeconomic functions of agrobiodiversity

Box 24.1

List of Traditional Mountain Crops Having Medicinal Properties

Botanical Name	Vernacular Name	Medicinal Uses
Fagopyrum esculentum	*Oggal*	Grains are used to treat colic, choleraic diarrhoea, and all kinds of abdominal ailments
Fagopyrum tataricum	*Phaphar*	Grains are a good source of protein and used by diabetic patients
Macrotyloma uniflorum	*Gahat*	Soup from grains is used as a cure for kidney stones
Panicum miliaceum	*Chena*	Grains cooked with curd are given to patients suffering from jaundice
Avena sativa	Oats	Commercially exploited for ergot, used as a medicine
Setaria italica	*Kauni*	Cooked grains are known to be good for patients suffering from diseases such as typhoid fever and pneumonia.
Echinochloa frumentacea	*Jhangora*	Cooked grains are given to patients suffering from jaundice; grain husks are rubbed on the skin of patients suffering from the same diseases
Parilla frutescens	*Bangjeera*	Oil used to massage newborns

- Improvement of traditional agronomic practices and technologies for soil fertility management, rather than introduction of altogether new technologies
- Recognition of the special status of villages where traditional agrobiodiversity has eroded least
- Linking agrobiodiversity with biodiversity of natural ecosystems
- Establishment of 'crop parks' and 'gardens' analogous to national parks and botanical gardens
- Promotion of village marketing cooperatives through appropriate policies to avoid exploitation by middlemen
- Exploration of avenues for adding value to traditional crop produce and of potential market demand for such produce.

References

Eckholm, E., 1975. 'The Deterioration of Mountain Environments'. In *Science*, 139: 764-770.

Kothari, A., 1994. *Eco-regeneration "Hope for the Future" Survey of the Environment*. Madras, India: The Hindu Publication.

Maikhuri, R. K.; Nautiyal, M. C.; and Khali, M. P., 1991. 'Lessor Known Crops of Food Value in Garhwal Himalayaand a Strategy to Conserve them'. In *FAO/ IBPGR Plant Genetic Resources Newsletter*: 86: 33-36.

Maikhuri, R. K.; Rao, K. S.; and Saxena, K. G., 1996. 'Traditional Crop Diversity for Sustainable Development of Central Himalayan Agroecosystems'. In International Journal of Sustainable Development and World Ecology, *2: 1-24.*

Ramakrishnan, P. S., 1992. 'Shifting Agriculture and Sustainable Development - An Interdisciplinary Study from North-Eastern India'. In *Man and The Biosphere Series*, Vol. 10, UNESCO, Paris, 424 pp.

Ramakrishnan, P S.; Purohit, A. N.; Saxena, K. G.; and Rao, K. S., 1994. *Himalayan Environment and Sustainable Development*. INSA. New Delhi: Diamond Jubilee Publication.

Rao, K S.; and Saxena, K. G., 1996. *Sustainable Development and Rehabilitation of Degraded Village Lands in Himalaya*. Himavikas Publication No. 8. Dehradun: Bishen Singh Mahendra Pal Singh.

Saxena, K. G.; and Ramakrishnan, P. S., 1984. 'Herbaceous Vegetation Development and Weed Potential in Slash and Burn Agriculture (*Jhum*) in N. E. India'. In *Weed Res.*, 24: 135-142.

Semwal, R. L.; and Maikhuri, R. K., 1996. 'Agroecosystem Analysis of Garhwal Himalaya'. In *Biological Agriculture and Horticulture*, Vol. 13/3 (in press).

Shiva, V.; and Ram Prasad, 1993. 'Cultivating Diversity: Biodiversity Conservation and Seed Politics'. In *Research Foundation for Science Technology and Natural Resource Policy*. Dehradun: Natraj Publishers.

Thompson, M.; and Warburton, M., 1985a. 'Uncertainity on a Himalayan Scale'. In *Mountain Research and Development*, 5: 115-135.

Thompson, M.; and Warburton, M., 1985b. 'A Conceptual Framework for the Sustainable Development of the Himalaya'. In *Mountain Research and Development*, 5: 203-220.

Toky, O. P.; and Ramakrishnan, P. S., 1981. 'Cropping and Yields in Agricultural Systems of the North-Eastern Hill Region of India'. In *Agro-Ecosystem*, 7: 11-25.

Toky, O. P.; and Ramakrishnan, P. S., 1983. 'Secondary Succession Following Slash and Burn Agriculture in North-Eastern India'. I. Biomass, Litterfall and Productivity. In *J. Ecol.*, 72: 735-745.

Valdiya, K. S.; and Bartarya, S. K., 1991. 'Hydrological Studies of Springs in the Catchment of the Gaula River, Kumaon Lesser Himalaya, India'. In *Mountain Research and Development*, 11: 239-258.

Whittaker, W., 1984. 'Migration and Agrarian Change in Garhwal District, Uttar Pradesh'. In Bayliss-Smith, T. P. and Wanmali. S. (eds) *Undrstanding Green Revolutions: Agrarian Change and Development Planning in South-Asia*. Cambridge, UK.