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Traditional Crop-Diversity Based Nutrition & the Prospects for Sustainable Rural Development in the Central Himalaya

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Unsustainable resource-use in both developed and developing countries and rapidly-decreasing food security in the latter has been a source of concern for researchers and policy-makers because of the skewing of conservation priorities between national and regional levels. However the traditional cropping and land-use patterns evolved by farmers through trial and error over centuries continue to suit local climatic conditions and can provide food security and nutrition. The study from central Himalayan villages across an elevation gradient reports the problems now being encountered in sustaining traditional agriculture. Revival of traditional agrosystems is deemed essential for sustainable development.

Crop-Diversity *versus* Monoculture

Food security has been defined by the FAO Committee on World Food Security as economic and physical access to food, for all people, at all times. The green revolution was extremely significant in many developing countries in providing food security for millions in their fast increasing populations. Certain environmental/ ecological costs had however to be borne in order to achieve this, among which reduction in the diversity of crops under cultivation, and increased use of fossil fuels triggering environmental imbalances *etc*., are of major concern. While it has obviously been imperative to increase production to meet growing food demands, little ethical justification exists for the promotion of monocroping of a few selected species in replacement of all others without actually analysing the potential of crops traditionally cultivated in localised regions. Such traditional crop varieties have not only met regional food demands but have also met environmental concerns by requiring lower resource application as compared to improved high HYV crop varieties. Nevertheless large scale replacement of traditional cropping by cashoriented cultivation continues to occur through the Himalaya. The present study confronts this problem in the central Himalayan region.

Traditional Agroecosystems in the Central Himalaya

The Central Himalaya in the context of the study comprises the hill districts of the province of Uttar Pradesh in India. The region is separated to the west from Himachal Pradesh by Tons river and to the East from Nepal by the Eastern Ramganga river, while snow clad peaks to the North separate it from Tibet (China). To the South, the region extends into the upland plains. The area thus demarcated is predominantly rural, with as much as 98 percent of its population residing in villages. Agriculture thus constitutes the primary occupation for this population and engages 90 percent of the workforce.

Traditional agroecosystems in the central Himalaya exhibits a great deal of variation in crop diversity, crop composition, crop rotation, *etc*., along an altitudinal transect because of corresponding variations in a number of factors which influence agricultural practices. The region may therefore be divided into three major agroclimatic zones along the elevation gradient (vertical zone), which are namely

i) lower zone (500-1000 m);
ii) middle zone (1000-1800 m); and
iii) higher zone (1800-2600 m).

Both rainfed and irrigated agriculture are important agricultural land use systems occurring in the region, the latter being restricted to valleys in the lower and middle zones, while the former accounts for around 89 percent of cultivated land in the region. While the energy intensive HYV based monocropping is preferred in irrigated areas, the mixed/monocropping sequences involving traditional crop varieties and use of organic inputs prevail in the rainfed agriculture of the region. Cropping patterns upto 1800 m and occasionally up to 2000 m are built around the two cropping seasons of kharif (summer:April-October) and rabi (winter:October-April), with 10-12 crop varieties being brought into cultivation either as a varying mixture or as monocrops, to meet food requirements. Most of these crop varieties are traditional and conprise *Amaranthus frumentaceus; A. oleracea; Hordeum himalayens; H. vulgare; Eleusine coracana; Fagopyrum esculentum; F. tataricum; Setaria italica; Echinocloa frumentacea; Macrotyloma uniflorum; Vigna umbellata; Parilla frutescense; etc.*, (see Table 1). It is interesting to note that the ecological amplitude (expressed as the altitudinal breadth or distribution) is limited for most varieties except the Amaranths and wheat. These two latter crops are cultivated across all elevations and are also major economic and food crops of the region at present. The standard cropping practice followed in the region involves either three crops over two years in rainfed conditions, with a brief fallow period, or two crops in a year in irrigated conditions, without an intervening fallow period. However, in some pockets at lower elevations, *Panicum miliacium* is also cultivated as a third crop between April to June in irrigated conditions, followed by two cereal crops. One interesting feature of agriculture under rainfed conditions is that the entire cultivated area of a village is divided into two nearly equal parts, locally known as Sar, which are then used in synchronous rotation with only one part being under short fallow over the winter cropping season. Thus during the summer cropping season, the entire rainfed agricultural land of the village is under crops, except when the land has been abandoned.

The usage of bullocks for draught power, of human energy as labour, of crop residues as animal feed, and of animal wastes mixed with forest litter as organic inputs in order to maintain soil fertility levels are important characteristics of regional agroecosystems. Human labour is drawn mainly from women, except when ploughing or threshing grain. Crop rotation is an important feature within the system which preserves the diversity of species grown and the distribution of crops over growing periods, while also managing soil fertility. Such rotations are however not possible at elevations above 2000 m due to shorter growing seasons and the crop response to prevailing environmental conditions. Thus there are pockets in the region where a single crop conprising a traditional wheat variety can take almost twelve months (September-August) to mature.

Average per capita landholding in the region is reported to be only 0.19 ha (Swarup, 1993), with marked variation along the elevation gradient. The general rule is that the higher the elevation, the larger the average per capita landholding, mainly because of lower settlement density at higher elevations.

Green Revolution Impacts on Crop Diversity

The central Himalaya had previously been identified as a center of crop diversity in India (Jain & Sastry, 1978; Arora, 1980; Maikhuri *et al.*, 1991; Khoshoo, 1992). Such diversity came into existence because of the influence of

Table 1: Crop diversity across an elevation gradient in Central Himalaya

Crop Species	Vernacular Name	Major Uses	Ecological amplitude
Allium cepa	Pyaz, Onion	Vegetable (both leaf and tuber)	500-1100 m
Amaranthus frumentaceus	Chuwa, Marcha, Ramdana	Seed used as food	1500-2500 m
A. Oleracea	Chaulai	Leafy vegetable	500-2000 m
Brassica sps.	Toriya	Leafy vegetable	500-2000 m
B. compestris	Sarson	Oil from seed is cooking medium	500-2200 m
Cajanus cajan	Tor	Major pulse	500-1800 m
Canabis sativa	Bhang	Seed used as condiment & fiber for domestic rope making	1500-2500 m
Chenopodium album	Bathuwa	Leafy vegetable	2000-2500 m
Cleome viscosa	Jakhiya	Seed used as condiment	500-1500 m
Colocasia himalayensis	Pinalu, Kuchain	Tuber and leaf used as vegetable	500-1500 m
Echinochloa frumentacea	Jhangora	Seed used as food	500-1800 m
Eleusine coracana	Koda	Seed used as food	500-2000 m
Fagopyrum esculentum	Oggal	Seed used as food	1900-2500 m
F. tataricum	Phaphar	Seed used as food	1900-2500 m
Glycine spp.	Kalabhatt	Major pulse	1000-1800 m
G. soja	Bhatt	Major pulse	800-1800 m
G. max	Soyabean	Major pulse	500-1400 m
Hordeum himalayens	Owa-jau	Seed used as food	1500-2300 m
H. vulgare	Jau	Seed used as food	500-2000 m
Lens esculenta	Masoor	Major pulse	500-2000 m
Macrotyloma uniflorum	Gahat	Major pulse	500-1800 m
Oryza sativa	Satti (Glutinous rice)	Major food	500-1800 m
O. sativa	Dhan	Major food	500-1500 m
Panicum miliaceum	Cheena, Bhangna	Seed used as food	500-2000 m
Papaver somniferum	Post	Seed used as condiment	1200-2300 m
Parilla frutescense	Bhangeera	Seed oil is cooking medium	1000-1800 m
Phaseolus vulgaris	Razma	Major pulse	1500-2500 m
Pisum sativum	Matar	Major pulse	500-1500 m
Secale cereale	Jai	Seed used as food and animal feed	2000-2500 m
Sesamum indicum	Til	Seed oil is cooking medium	500-1500 m
Setaria italica	Kauni	Seed used as food	500-1800 m
Solanum tuberosum	Alu	Tuber is vegetable	1000-2500 m
Triticum aestivum	Gehun	Major food	500-2500 m
Vigna aconitifolia	Bhringa	Pulse	800-1600 m
V. angularis	Rains	Pulse	900-2200 m
V. mungo	Urad	Major pulse	500-1800 m
V. radiata	Mung	Pulse	500-1000 m
V. unguiculata	Sonta	Pulse	500-1800 m
V. umbellata	Bhotiya	Pulse	1500-2200 m
Zea mays	Mungri	Food	500-1800 m
Zingiber officinale	Adrak	Tuber used as condiment	500-1200 m

heterogeneous environments and spatial isolation in inducing farmers to become more subsistent. Different crop varieties were introduced to the region by early migrants. Varied edaphic, topographic and climatic factors, coupled also with the varied selection pressure of centuries of cultivation, have resulted in immense variation (Arora and Nayar, 1984) in the indigenous crop varieties that are adapted to a particular area. These varieties have withstood the rigors of time, escaped the attack of insects, disease and pests, and have tolerated adverse climatic conditions. They possess also the desired agronomic and genetic traits needed to develop resistant varieties (Altieri, 1991; Anonymous, 1989; McNeely *et al.*, 1990).

The present study of villages in the central Himalaya indicates that cropping intensities and areas of several traditional crop varieties have decreased drastically between 1970-74 to 1990-94 (see Table 2). Both *Panicum miliaceum* (irrigated) and *Setaria italica* (rainfed) which are short duration crops maturing over 50-60 days, have been replaced by HYV rice and soyabean, with acreage reduction of more than 65 percent over the assessment period. Acreage reduction ranged between 72-95 percent for crops such as *Avena sativa; Fagopyrum* sps.; *Vigna* sps.; *Hordeum* sps.; *Macrotyloma uniflorum; etc*., which have been replaced by HYV potato, soyabean, kidneybean, pigeonpea, mustard and amaranth. While no marked change had taken place in the acreages under rice and wheat, replacement of traditional varieties by HYVs was observed under both irrigated and rainfed conditions. Among the traditional crops now exhibiting negligible acreages in the region, *Parilla frutescense; Macrotyloma uniflorum; Vigna* spp. and *Hordeum himalayens* appear the most threatened by current lack of interest.

The introduction of modern seed varieties which has marked the green revolution has had similar perilious impacts in other developing countries, measurable in acreage changes in major crops. Within the first 15 years of their release, modern HYVs were adopted on 40 percent of Asian rice farms, the extent of adoption crossing 80 percent in the Philippines and Indonesia (Reid & Miller, 1989; McNeely *et al*., 1990; Anonymous, 1992). In India, of the 3000 varieties of rice that were being cultivated before the green revolution, only 50 are found now (Shiva & Ram Prasad, 1993). The other major impact of the green revolution has been reduction in the number of crops cultivated and in their marketability. Among the traditional crops, *Amaranthus frumentaceus* has shown significant acreage increas at higher elevations following increased marketability (see Table 2). *Solanum tuberosum*, which used to be cultivated as a traditional vegetable for home consumption, has became a cash crop and the acreage under it has grown manifold following the introduction of HYVs. *Phaseolus vulgaris* which was a traditional high value crop in the past has grown in importance with the development of road networks and its acreage has also increased commensurately. The traditional media for cooking used to be drawn from diverse cultivated sources such *as Parilla frutescense, Sesamum indicum* and *Brassica compestris, and Princepia utilis* in the wild. These sources have become of minimal importance now, the major source now being HYV *Brassica compestris* or imports from outside. Even the animal fat-based products such as 'Ghee' have become marketable products and export

Table 2: Acreage reduction in certain traditional crop varieties in the Central Himalaya 1970-74 to 1990-94 (Data from 150 villages over 11 valleys)

Crop	Acreage (ha/village) 1970-74	1990-94	Replacement crop	% decline in traditional crop acreage
A. Summer crops				
Avena sativa	15.8	3.4	*Solanum tuberosum*	78.5
Echinochloa frumentacea	2.5	0.7	*Cajanus cajan*	72.0
Eleusine coracana	9.6	6.1	*Glycine max* (upto 1400 m) + *Amaranthusfrumentaceus* (above 1400 m)	36.5
Fagopyrum esculentum	4.1	0.3	*Phaseolus vulgaris*	92.7
F. tataricum	8.6	1.5	*Solanum tuberosum* and *Phaseolus vulgaris*	82.5
Macrotyloma uniflorum	2.1	0.0	*Glycine max* (upto 1400 m) and *Amaranthus frumentaceus* (above 1400 m)	100.0
Oryza sativa#				
Satti (Glutinous rice)	14.2	0.0	HYV rice	100.0
Dhan (Rice)	11.2	0.0	HYV rice	100.0
Panicum miliaceum	14.2	4.9	HYV rice	65.5
Parilla frutescense	1.3	0.0	*Phaseolus vulgaris*	100.0
Setaria italica	2.3	0.8	*Phaseolus vulgaris*	65.2
Vigna spp.	3.3	0.0	*Cajanus cajan* (upto 1800 m) + *Amaranthus frumentaceus* (above 1800 m)	100.0
B. Winter crops				
Hordeum himalayens	17.1	4.7	*Solanum tuberosum, + Amaranthus frumentaceus + Phaseolus vulgaris*	72.5
H. vulgare	7.0	1.1	*Brassica* spp. (HYVs)	84.3
Triticum aestivum# + *Brassica* spp.	14.2	0.0	HYV wheat + *Brassica* spp.	100.0

While no acreage changes for rice and wheat occurred, traditional varieties were replaced by HYVs thus the change was presumed to be 100%.

of them outside has decreased fat sources for local consumption (Maikhuri *et al*., 1998).

Yield Potential of Traditional Crops

Traditional societies have depended both for foodgrains and fodder on traditional crops. The green revolution has however created an imbalance in resource availability by tilting the balance towards maximum grain output and minimal by-products. Coupled with increasing animal populations, this has put enormous pressure on other fodder sources. While studying the yield potentials of traditional land use patterns and crop varieties under cultivation in the region, it was found however that all such mono or mixed cropping systems showed good agronomic and better efficiency (economic output:input) rates (see Table 3). Along the elevation gradient considered mixed cropping of wheat and mustard at lower elevations produced the highest agronomic yields, followed by monocropped wheat at middle and upper elevations. Yields for *Panicum miliaceum* were better at lower elevations where it was cultivated as a third crop on irrigated fields than that at higher elevations where it was cultivated as kharif (summer) crop. Increased *P. miliaceum* yields at lower elevations might also derive mainly from better management practices being followed. In general, the traditional crops under a system of mixed cropping showed better agronomic returns in comparison to monocropping systems, mainly due to the better land equivalency ratios in mixed cropping, where multilayer canopy crops use available resources to the optimum.

Investment efficiency in traditional crops was also generally higher under mixed cropping than under monocropping. The only exceptions found in the study were for *Macrotyloma uniflorum* under monocropping at all elevations in comparison to *M. uniflorum* with *Eleusine coracana* under mixed farming (Table 2). Mixed cropping with a legume proved to be more efficient in economic terms than non-legumenous mixtures. Investment efficiencies were highest (5.5) for *Parilla frutescense* + *Vigna mungoo* at middle elevations, and least (1.2) for *Hordeum vulgare* at middle elevations and for *Macrotyloma uniflorum* + *Eleusine coracana* at lower elevations.

Shiva & Prasad (1993), while comparing the yields of traditional and HYV rice, concluded that at existing technology and resource input levels, traditional crop varieties provide better agronomic and biological returns. In any subsistence farming system where crop byproducts are used as animal feed, biological yields have importance. While traditional crop varieties were cultivated on terraces occupied also by many fodder yielding trees, improved HYV crop varieties require more light forcing farmers to remove the trees to ensure better crop yields. Semwal & Maikhuri (1996), while studying the agroecosystems of Dalimsain and Hathnur villages in Central Himalaya, has recorded a density of 334-418 individual fodder trees per ha on agricultural fields under traditional cultivation, which met fodder requirements over the entire lean season. Among the

Table 3. Crop yield & monetary investmentefficiency of traditional crops in the Central Himalaya

Crops	Yield in kg/ha/yr Grain	By-product	Investment efficiency (Output: input ratio)
Lower elevation zone (500 - 1000 m)			
A. Traditional crops			
Macrotyloma uniflorum 868	784	3.3	
Macrotyloma uniflorum 1502 + *Eleusine coracana*	3727	1.2	
B. Common food crops			
Brassica compestris	837	1350	3.8
Oryza sativa	1806	3215	1.7
Triticum aestivum + *Brassica* spp.	2931	4387	2.0
Middle elevation zone (1000-1800 m)			
A. Traditional crops			
Parilla frutescense	612	1357	4.9
Parilla frutescense + *Vigna mungo*	962	1208	5.5
Macrotyloma uniflorum 624	764	2.7	
Macrotyloma uniflorum 1306 + *Eleusine coracana*	3734	2.3	
B. Common food crops			
Hordeum vulgare	805	1500	1.2
Oryza sativa	2270	3969	2.4
Triticum aestivum	713	1400	1.3
Upper elevation zone (1800-2500 m)			
A. Traditional crops			
Parilla frutescense	444	1214	3.3
Parilla frutescense + *Amaranthus* frumentaceus + Eleusine coracana	934	1980	2.3
Macrotyloma uniflorum 1180	840	4.7	
Macrotyloma uniflorum 1844 + *Eleusine coracana*	4481	3.2	
B. Common food crops			
Brassica compestris	1083	2475	2.1
Oryza sativa	3004	5160	2.7
Triticum aestivum	1315	4393	1.8

species recorded were *Celtis australis*, *Boehmeria rugulosa*, *Grewia optiva, etc.*, which produce highly nutritious green fodder. Such trees were totally absent in irrigated areas under HYV cultivation. Such observations suggest that traditional crop based agroecosystems are viable both ecologically and economically, and have further potential for yield improvements that support growing food requirements, while meeting fodder demands to a large extent.

Restoring Traditional Cropping Systems

The population through most parts of the Himalaya lives in small highly dispersed hamlets and villages and practises subsistence farming. Among the main crops grown for domestic consumption are millets, pseudomillets and cereals, which have negligible market value in the locality off the village. The attention of policy makers has therefore not fallen upon these traditional crops; which do not have palatability similar to that of fine grains such as wheat, rice and maize. For this reason, the yield improvement and palatability improvement of policy makers and researchers have focused on only a few selected grains. Improved varieties developing out of this focus were relied upon for raising agricultural yields in the Tarai-Bhabar (foothill) regions. The green revolution, coupled with increased accessibility through improved roads and exposure of traditional hill societies to those residing in the plains, has changed food preferences from coarse local grains towards newly introduced fine grains. The changing food preferences have also changed the cropping emphasis towards cultivation of fine grains. Unfortunately, the unreliable monsoon conditions of the region have never been suited to these newly introduced crop varieties which tend to fail at the slightest alteration in weather, where traditional varieties withstood these climatic fluctuations better and provided subsistence yields.

Low soil fertility and erosion are major constraints on food production in the region. With increasing population density, expansion of agricultural activity has taken place on marginal lands otherwise not suitableto cultivation. Sen *et al*., (1997), while comparing soil losses between traditional and introduced crops, found that soil erosion was higher for the introduced cash crop oriented cropping systems than for traditional cropping systems over all slope categories. Similarly, the soil fertility management practices were in tune with available resources under traditional cropping systems, the introduced crop varieties and species much more soil management and inputs to provide economic returns, thus adding to the pressures to support systems which are already under encroachment because of the expansion of agriculture, increased grazing pressures and increased production and conservation requirements (Ramakrishnan *et al*., 1994; Rao & Saxena, 1994).

With the increase in population pressures, land fragmentation has been rapid in the region. The highly dissected plots make agricultural operations cumbersome for the farmer. The need to increase food production has however forced farmers to reduce the durationof the fallow period to avail of the maximum land for cultivation,

Table 4: Variations in per capita consumption of various food items in the Central Himalaya

Food items	Lower elevation zone			Middle elevation zone			Upper elevation zone		
	Quantity Kg or l	Energy MJ	Protein Kg	Quantity Kg or l	Energy MJ	Protein Kg	Quantity Kg or l	Energy MJ	Protein Kg
1970-74									
Traditional crops	86.4	1170.4	9.35	90.4	1252.6	10.86	150.6	2085.0	17.7
Common crops	105.0	1637.6	12.00	92.0	1441.0	10.00	58.0	903.0	7.7
Imported/exchanged	3.0	51.4	0.70	-	-	-	-	-	-
Animal products	97.2	295.3	4.90	127.2	384.3	6.20	206.8	627.0	10.5
Vegetables	16.0	248.8	1.32	26.0	404.3	2.15	85.0	1321.8	7.0
Total	**307.6**	**3403.5**	**28.30**	**335.6**	**3482.2**	**29.20**	**500.4**	**5437.2**	**42.9**
1990-94									
Traditional crops	24.9	369.8	3.79	70.4	963.4	8.68	122.8	1730.2	15.7
Common crops	119.9	1942.5	11.70	103.7	1680.0	8.80	49.8	806.7	4.6
Imported/exchanged	68.7	1119.7	7.28	54.4	885.1	5.83	56.1	908.8	4.6
Animal products	50.5	152.7	2.66	74.2	227.8	3.90	102.3	323.6	6.4
Vegetables	20.5	318.8	1.70	26.5	412.5	1.90	40.6	631.3	3.5
Total	**284.5**	**3903.5**	**27.13**	**329.2**	**4168.8**	**29.10**	**371.6**	**4400.6**	**34.8**

Table 5: Nutritive value of certain traditional and common crops of the central Himalaya (Content per 100 g of edible portion)

Crop species	Moisture (g)	Calorific value (cal)	Protein (g)	Carbohydrate (g)	Fat (g)	Fiber (g)	Minerals (g)
Amaranthus spp.	10.0	320	15.5	60.1	1.9	9.0	3.5
Echinochloa frumentacea	11.9	307	6.2	65.5	2.2	8.3	4.4
Eleusine coracana	12.4	332	7.1	72.5	1.5	3.7	2.8
Fagopyrum esculentum	11.3	323	10.3	65.5	2.4	8.6	2.3
F. tataricum	13.2	349	9.2	63.2	2.0	-	-
Hordeum himalayens	10.8	351	13.1	62.3	1.2	4.2	2.7
H. vulgare	11.0	336	12.6	66.8	2.0	5.0	2.6
Macrotyloma uniflorum	11.8	321	22.0	57.2	0.5	5.3	3.2
Oryza sativa	12.5	346	6.9	77.1	1.1	0.5	1.9
Panicum miliaceum	11.9	341	12.5	70.5	1.1	2.2	1.9
Setaria italica	11.2	331	12.3	60.9	4.3	8.0	3.3
Triticum aestivum	12.6	346	12.0	71.2	1.5	1.2	1.5
Vigna angularis	13.4	323	24.1	54.5	1.0	3.8	3.2

Source: Gopalan *et al*., 1978, except for calorific values. Calorific values were estimated by us.

consequesnly reducing the period of time set by for restoring soil fertility. While traditional mixed cropping systems used available family labour more effectively by dispersed requirements throughout the year, the introduced monocropping systems require highly concentrated short term labour inputs, forcing the farmer to deploy agricultural labour and bear additional economic pressures for the same.

Traditional crops provide higher energy equivalents in comparison to improved crop varieties on unit basis, and consumption of traditional crop products has helped in meeting the high energy requirements of human labour in the region. During the present study, it was noted that traditional food sources provided higher energy and protein equivalents to the diet with increase in elevation gradients, while the status of improved varieties and exchanged foods (through marketimportation) increased in importance with a decline in elevations (see Table 4), probably due to the increased accessibility of imported items at lower elevations. Among traditional food crops, millets and minor grains constituted major portions of the diet at all elevations,while consumption of pseudomillets and pulses rose significantly in the upper elevation zone. Higher values were found at upper elevations, even for consumption of protein sources of animal origin and vegetable, than at middle and lower elevations, reflecting lower involvement of market forces and the need to be self sufficient at such environments. Market or cash based procuration of food grains is almost nonexistent in the region. Most requirements of local residents that can not be met from their own produce are procured through barter. The traditional crops are secured and collected by middlemen in exchange against cheaper fine grains, and are then sold at a premium in the plains where a market exists for them. Among local produce, amaranth, kidney bean and potato currently constitute the major portion of items exchanged and exported.

In the nutritional terms, traditional crops are rich in proteins, dietary fats, carbohydrates and fiber (Table 5). Content of dietary fats which contributes the highest energy on per unit basis is high in traditional crops such as *Setaria italica* and *Fagopyrum* sps., which are consumed in large quantities by people residing at upper elevations to meet their high energy demand. Unlike the common carbohydrate-plus-protein based diets of people residing in the plains, the rich diversity of of the diet based on traditional grains of the region meets energy and nutrition requirements more optimally. Several traditional crop varieties also have medicinal value (Table 6) and are used in treatment. The tendency towards reduction in the traditional content of diets has therefore created health and dietary imbalance and energy insufficiency.

For HYV crops on the other hand, performance risks are high. Several studies (Tatum, 1971, Plucknett *et al*., 1987; Anonymous, 1972) indicate that HYVs are susceptible to climatic vagaries, pest infection and yield fluctuations which could be catastrophic in subsistence farming areas with poor communication and transport linkages.

Table 6: Medicinal value of traditional crops from the central Himalay

Crop	Vernacular Name	Medicinal Uses
Avena sativa	Oat	For commercial growing of medicinal ergot moulds
Echinochloa frumentacea	Jhangora	Cooked grain administered and husk rubbed on to the skin in case of jaundice
Fagopyrum esculentum	Oggal	Grain administered in cases colic, choleraic diarrhoea & other abdominal ailments
Fagopyrum tataricum	Phaphar	Good medicinal source of rutine, a flavonol glucoside having the ability to reduce capillary fragility in cases of hypertension
Macrotyloma uniflorum	Gahat	Grain soup administered as a cure for kidney stones
Panicum miliaceum	Chena	Cooked grain administered with curd in case of jaundice
Parilla frutescens	Bhangjeera	Seed oil used for the massaging new born infants

Thus continuation of traditional landuse in the Himalaya is more appropriate for food security. Most of the traditional seed varieties are also required for the future improvement of existing HYVs and thus their continuance *in situ* is well-advised in order to maintain sufficient variety in the germplasm.

Considering these observations and the points raised, it can be concluded that crop diversity plays a significant role in maintaining the long-term stability of traditional agroecosystems in a variety of ways. Among these, it helps to

(i) minimise crop loss to insect pest attacks
(ii) minimise crop losses from plant diseases and nematodes
(iii) improve soil fertility by incorporating legumes into the crop mix
(iv) inhibit or suppress weed growth
(v) increase productivity per unit area
(vi) provide variety to diets
(vii) conserve soil on steep slopes against erosion
(viii) insure against crop failure, by improving the chances of success of at least some crops in the cropping mixture

Such conclusions are also supported in studies conducted by Toky & Ramakrishnan (1981), Ramakrishnan (1992) and Altieri (1991) in other parts of Himalaya and elsewhere.

While it is agreed that the green revolution approach had positive impact on food production, the approach firstly failed to recognise the value of mixed cropping as a system of risk avoidance, and secondly the difficulty of providing the inputs required by the HYVs under subsistence cropping systems. It is also unfortunate that the green revolution has totally displaced traditional seed-varieties with singular character and their characteristics are thus lost forever (Anonymous, 1975; Altieri & Merrick, 1987; McNeely *et al*., 1990; Anonymous, 1994). To sustain what had been developed after centuries of trials by our farmers in to posterity, conservation and/or restoration of traditional crop based cultivation is necessary, at the least in regions where climatic conditions suit these crops and the germplasm still exists.

Prospects for Sustainable Development based on Traditional Crop Diversity

Various ideas have been broached by researchers and policy-makers on how to conserve crop diversity, especially of crop varieties which are either rare and on the brink of extinction, or else are threatened or otherwise endangered. Both *ex-situ* and *in-situ* measures are proposed. Thus conservation in small pockest (*in-situ* conservation) in the region ensures the continuance of these varieties and crop types. The lack of economic incentives in traditional crop cultivation seems to have been a major reason for the shifting emphasis towards a limited number o HYVs/traditional crop varieties. Using existing knowledge itself, traditional crops could be promoted as health foods and organic produce in order to capture growing niche markets. Value addition to traditional crops is an important and appropriate strategy to revive the interest and to increase the market potential for these crops. If consumption is revived to acceptable levels, cultivation of these crops would be restored immediately. As their agroclimatic suitability is high in the central Himalaya, revived cultivation of these crops in a new scenario of improving market positions, would see economic benefits flow back into the region with environmental benefits also accruing. this is bound to render development in the region sustainable.

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