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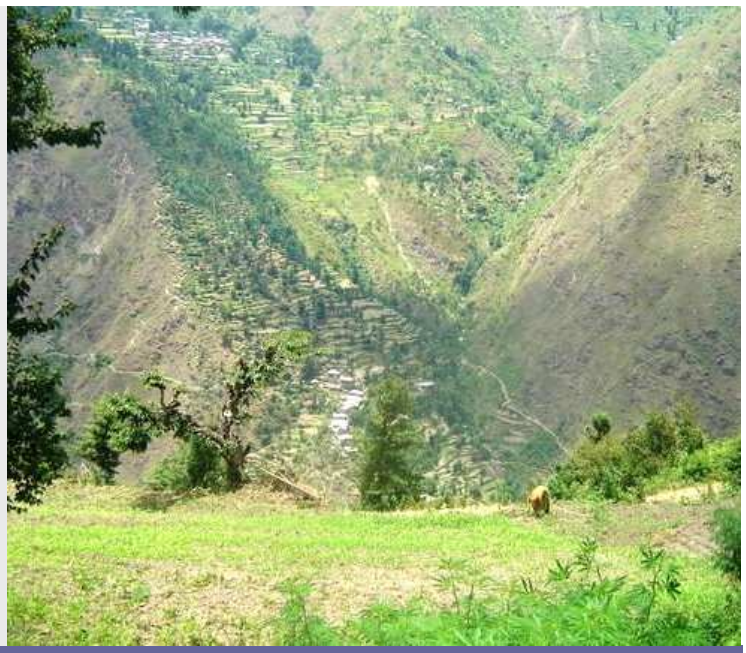

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Agrobiodiversity in Great Himalayan National Park: Challenges for Conservation

ABSTRACT

Great Himalayan National Park (GHNP), situated in Kullu district of Himachal Pradesh, India, is home to huge diversity of fauna and flora. Having rich bio-cultural traditions the farmer communities residing in buffer zone of GHNP Conservation Area (GHNPCA) have developed multitude of indigenous on-farm techniques (the methods by which inputs are powered) and technologies (the application of knowledge to the production system) for optimal production. Appreciable diversity of agriculture has been maintained through a variety of crop compositions, cropping patterns and crop rotations. Grassroots Institute undertook the mapping and documentation of *in situ* agrobiodiversity in 2007-10, followed by promotion of on-farm conservation and organic farming practices. Farmers practice polyculture by growing multiple traditional cultivars of millets, pulses, beans, barley, pea, buckwheat, horse gram, maize, wheat, potato and soybean. About 45 traditional cultivars of 15 different crops are being cultivated by the mountain farmers in 2 gram panchayats covering 20 villages in Tirthan Valley of GHNPCA. Results of the study revealed that these traditional cultivars are far superior in characteristics than their counterpart modern or hybrid varieties. However, the old agronomic practices and poor market rates have ever discouraged the farmers to continue growing the traditional cultivars of these crops, and the farmers were forced to adopt hybrid seeds and monoculture. Abundance and sown area of various cultivars also decreased over past three decades. Grassroots Institute addressed the two-fold challenge: one, preservation and re-introduction of traditional cultivars *in situ* coupled with improvement in agronomic methods of farmers for enhancing the yield; and two, linking the organic produce of the traditional crops with innovative post-harvest techniques and better market opportunities. Challenge ahead lies in engaging large number of farmers in cultivation of genetically-superior traditional cultivars, and in value addition, processing and marketing of organic produce of these crops, so that the livelihood of marginal and poor farmers, which is relatively based on bioresources of national park, can be diversified/diverted and the overall goal of biodiversity conservation is fully achieved.

KEY WORDS

Agrobiodiversity; Biodiversity; Polyculture; Monoculture; Agro-ecosystem: Erosion; Great Himalayan National Park; Conservation; Agronomic Practices; Agriculture; Sustainability; Mountain; Traditional Cultivar; Landrace

Introduction

Himachal Pradesh is the home for world famous Great Himalayan National Park (GHNP) where varied types of forests, from dry scrub forests at lower altitudes to alpine pastures at higher altitudes, do exist. Other distinct vegetation zones such as mixed deciduous forests, bamboo, chil, oaks, deodar, kail, fir and spruce are also found depending on the altitude. The temperate forest flora-fauna of GHNP Conservation Area (GHNPCA) represents the western most extension of the Sino-Japanese Region. The high altitude ecosystem of the Northwest Himalaya has common plant elements with the adjacent Western and Central Asiatic region. As a result of its 4,100 m elevation range the GHNPCA has a diversity of zones with their representative flora and fauna, such as alpine, glacial, temperate, and sub-tropical forests (GHNP, 2012). Hundred of traditional villages are situated in GHNPCA from elevation of 1400m to 2800m. Having rich bio-cultural traditions the farmer communities residing in GHNPCA have developed multitude of indigenous on-farm techniques (the methods by which inputs are powered) and technologies (the application of knowledge to the production system) for optimal production. The mountainous environment has shaped the evolution of traditional agricultural practices in GHNPCA. Most of the farmers engage in mixed crop-livestock agriculture cultivated in rainfed terraced fields. Appreciable diversity of agriculture has been maintained through a variety of crop compositions, cropping patterns and crop rotations in agro-ecosystems of the mountains. These traditional cultivars are far superior in characteristics than their counterpart modern or hybrid varieties (high yielding varieties or HYVs). However, over a period of 5-6 years the Grassroots Institute has observed the declining trends in traditional agronomic practices causing the loss of agrobiodiversity. Challenge lies in conserving the biological diversity, including the diversity of agro-ecosystems, of GHNPCA in changing climates both for sustaining the livelihoods of farming communities as well as fulfilling conservation goals of protected area i.e. Great Himalayan National Park (GHNP).

When any species or cultivar is lost the centuries old traditional knowledge about the same also disappear. It disbalances the mountain agro-ecosystem, farm sustainability and food security.

Methodology

The agrobiodiversity is an extremely difficult concept to measure (Maikhuri, Rao and Semwal, 2001). Its complexity exists within temporal and spatial scales and encompasses biophysical, socio-economic and cultural factors (Brookfield *et al.,* 2002). Pioneering the agrobiodiversity research and conservation in Himachal Pradesh, the Grassroots Institute undertook the mapping and documentation of *in situ* agro-biodiversity during 2007-10 in 10 villages of Nohanda gram panchayat and 10 villages of Tung gram panchayat of Tirthan Valley of GHNPCA. Both the gram panchayats and villages were selected using non-probabilistic judgment and purposive sampling strategy (Laws *et al.,* 2003). For conducting field research work, two distinct sampling strategies were employed in sampling the farmer families. Initially a convenience sampling strategy (Laws *et al.,* 2003) was used. This entailed interviewing farmers who were available within the village at that particular time. Snowballing strategy (Laws *et al.,* 2003) was then used to further interview other farmers. It involved requesting the farmers to inform other farmers and households about the research and hence encourage their participation. For each cultivar of the crop, the abundance (percentage of farmers cultivating), sown area and yield were studied. However, the analysis in this paper is based on only *the abundance* of various crops and its cultivars being grown by the farmers in both the sampled gram panchayats. The assessment of the decline of abundance and diversity on-farm has been made from the data of abundance as well as the direct field observations during Grassroots Institute's interventions (based on awareness-raising and training of farmers) made for *in situ* conservation of agrobiodiversity from 2007 till the date.

Mapping and Assessment of Agrobiodiversity

Farmers practice polyculture by growing multiple traditional cultivars of millets, pulses, beans, barley, pea, buckwheat, horse gram, maize, wheat, potato and soybean. About 45 traditional cultivars of 15 different crops are being cultivated by the mountain farmers in sampled 20 villages. Farmers of Tung gram panchayat were reported cultivating 19 different cultivars of various crops, as opposed to 42 cultivars being cultivated by farmers of Nohanda gram panchayat (Table.1). Most prevalent crop for both gram panchayats is maize (*Zea mays*) which is grown by 100% of the respondents in Tung gram panchayat, followed closely by respondents of Nohanda gram panchayat. Wheat (*Triticum aestivum*), barley (*Hordeum vulgare*), beans (*Phaseolus vulgaris*) and pea (*Pisum sativum*) are commonly grown in both gram panchayats with over 70% of the respondents.

Table.1: Names of Crops & its Cultivars with Percentage of Farmers Cultivating (Abundance), 2010

Category or Name of Crop(s) (with Botanical Name)	Vernacular/English/Botanical Name of Cultivar	Percentage of Respondent Farmers Cultivating the Crop/Cultivar	
		Nohanda GP	Tung GP
Millets	French White (*Panicum milliaceum*)	24.0	5.0
	Ragi or Red Millet (*Echinochloa utilis*)	10.0	-
	Red Jhalli (*Oplismenus frumentaceus*)	1.5	-
	Finger Millet (*Eleusine coracana*)	2.0	-
	Finger White (*Echinochloa utilis*)	1.5	-
Pulses	Black Gram (ma`ash) (*Phaseolus mungo*)	4.9	2.6
	Totru	4.9	-
	Maser (*Lens culinaris*)	2.1	-
	Chana (*Cicer aietenum*)	0.8	-
	Kohl	0.8	-
Beans (*Phaseolus vulgaris*)	Chittera (Urad)	3.0	-
	White Chittera (Safed Urad)	46.0	-
	Red Chittera (Laal Urad)	35.0	98.3
	Kidney Bean (Rajma)	30.0	-
	White Bean (Safed Rajma)	3.0	-
	Kohal	3.0	-
	Unidentified Local	5.0	-
Barley (*Hordeum vulgare*)	Gundev	49.2	86.0
	Shalai	1.9	-
	Naked Barley (*Hordeum himalayens*)	23	-
Pea (*Pisum sativum*)	Farsi or Kinnauri	0.8	0.8
	Lincon	0.7	0.7
	Aurcul	0.7	0.7
	HYV/ Azazd P.1	-	1.2
	Unidentified Local	5.6	2.6
	HYV (unidentified)	4.2	-
Common Buckwheat (*Fagopyrum esculentum*)	Kathu	2.5	-
Maize (*Zea mays*)	HYV/ Kunchun	88.1	97.4
	Shatu	25.0	-
	Chuhedani	-	3.0
	Duani	19.8	5.1
	HYV (unidentified)	17.2	-
Wheat (*Triticum aestivum*)	Siraji	58.1	29.0
	Kinouri	4.8	-
	Unidentified Local	12.0	-
	HYV/ PBW343	10.0	2.5
	HYV/ HPW89	2.1	-
	HYV/ HPW42	29.0	40.0
	HYV (unidentified)	11.8	-
Horse Gram (*Macrotyloma uniflorum*)	Kulth	2.5	-
Potato (*Solanum tuberosum*)	Dhankhri	30.0	-
	Chandermukhi	-	2.6
	Uptodate	1.2	-
	HYV/ Kufri Jyoti	8.0	60.0
Soybean (*Glycine max*)	HYV	1.0	0.2
Garlic (*Allium sativum*)	HYV/ Agrofound Parvati	20.0	51.0
Onion (*Allium cepa*)	HYV	-	1.8
Cabbage (*Brassica oleracia*)	HYV	2.0	1.8
Cauliflower (*Brassica oleracia botrylis*)	HYV	7.0	4.5

Wheat is second most grown crop of India used in multiple byproducts with straw as good source of cattle feed (Singh, 1984). Siraji cultivar is most preferred variety being grown in both gram panchayats. Though high yielding varieties (HVYs) are adopted most in wheat as compared to other crops; but all HYVs have shown lower yields than Siraji cultivar because of low adaptability of former in tedious agro-climatic conditions. Siraji is as widespread as most common HYV/HPW42, simply because it survives best at high altitudes having high rainfall and low temperature. Unlike wheat, not many HYVs are introduced or adopted of the maize, as the HYVs tend to collapse in harsh environments at high altitudes. Kunchun (HYV) of maize has been most popular in both the gram panchayats, followed by Duani cultivar. Reportedly, the Kunchun variety gives higher yield in lower altitudes as compared to quite low yields in high altitude villages where geo-climatic conditions are harsh. Barley is an important *rabi* (winter) season crop and is preferred by farmers due to its low input requirements and lower cost of cultivation (Bala, Verma & Deor, 2006), and is fairly resistant to high rainfalls at high altitudes. No HYV of barley was reported having been cultivated in both the gram panchayats, with Gundev cultivar as most popular, followed by naked barley (*Hordeum himalayens*). HYVs of barley tend to be predated by birds as their seed husk has no needles; they also ripe late thus preventing the double cropping, and their grains are easily spoiled by heavy rainfalls (Cooper, 2007).

Bean (*Phaseolus vulgaris*) is intercropped in kharif (monsoon) season. Kidney bean and Chittera beans are most commonly cultivated varieties. Red Chittera and kidney bean have better taste and higher market prices. Beans are excellent source of fibre, protein and essential amino acids. Among the pulses, the ma`ash (*Phaseolus mungo*) is cultivated more by the farmers. Being leguminous crops the beans and pulses are highly adapted to mountain environments. Notably, the farmers of both the gram panchayats have not yet adopted any HYV of bean or pulses. Some farmers grow kathu (common buckwheat: *Fagopyrum esculentum*) and kulth (Horse Gram: *Macrotyloma uniflorum*), which are eaten as pulses and have medicinal properties.

Intercropping and storey-cultivation are very common in the villages of Tirthan valley of GHNPCA. Most of the cultivars of maize are sown separately; however, 21% farmers in Nohanda gram panchayat and 1.3% farmers in Tung grow more than one cultivar mixed together. Likewise, 17.2% of farmers of Nohanda gram panchayat mix the wheat with other crops. Cultivation of bean cultivars has revealed strong tradition of intercropping and polyculture. Approximately, 70% of farmers in Nohanda gram panchayat intercrop kidney bean and white Chittera with maize, while 100% farmers of Tung gram panchayat mix Red Chittera with maize (Table.2). All farmers in Nohanda and Tung gram panchayats grow white bean and Kohal cultivars with maize.

Table.2: Number of Farmers intercropping the Bean with Maize, 2010

Cultivar of Bean (*Phaseolus vulgaris*)	Nohanda Gram Panchayat			Tung Gram Panchayat		
	Respondent Farmers (n)	%age of Farmers intercrop with Maize	%age of Farmers who cultivate separately	Respondent Farmers (n)	%age of Farmers intercrop with Maize	%age of Farmers who cultivate separately
Chittera (Urad)	2	100	-	-	-	-
White Chittera (Safed Urad)	65	69.2	36.9	-	-	-
Red Chittera (Laal Urad)	47	21.3	78.7	77	100	-
Kidney Bean (Rajma)	43	68.9	31.1	-	-	-
White Bean (Safed Rajma)	3	100	-	-	-	-
Kohal	3	100	-	-	-	-
Unidentified Local	7	85.7	14.3	-	-	-

The Erosion of Agrobiodiversity

Since traditional agricultural systems were finely interwoven with the social and cultural fabric of villages, they could not withstand the far-reaching changes in landuse, dramatic changes in Indian agriculture, inputs of chemical fertilizers and pesticides, and promotion of cash crops. Inter-cropping is replaced by monocropping, a wide diversity of cultivars is replaced by a handful of profitable ones, and genetic diversity within the same crop species is replaced by a narrow genetic range of financially lucrative varieties. Thousands of varieties of cereals (rice, wheat, etc.), cotton, minor millets, pulses, and other crops are no longer in use on farms (Dharampal, 1983).

Data in Table.1 shows that the traditional cultivars of various crops are grown more in Nohanda gram panchayat than in Tung gram panchayat. There are 25% more farmers cultivating millets in Nohanda gram panchayat than in Tung gram panchayat. Prominent reason behind zero or less abundance of traditional cultivars in Tung gram panchayat is that the villages of this gram panchayat are accessed by motor road connecting Bathad valley. On the contrary, villages of Nohanda gram panchayat mostly lie on the ridge and have no motor road connectivity. The villages of Tung gram panchayat are more exposed to penetration of market culture, market-dependent food chain, modern system of agriculture (increasingly monoculture), communication-induced socio-economic changes, and promotion of HYVs by extensionists of Himachal Pradesh Agriculture University and Himachal Pradesh Department of Agriculture. Main vehicle behind these socio-economic, bio-cultural and environmental changes in the villages of Tung gram panchayat is the motor road connectivity. As a result, the shift of farmers from polyculture to monoculture causing erosion of *in situ* agrobiodiversity (except pea crop) is clearly visible from the data of abundance in Table.1. Cash crop of garlic's Agrobound Parvati (HYV) has spread to the fields of half of the farmers of Tung gram panchayat, causing remarkable erosion of the diversity on-farm. Introduced in 1997 in Tirthan valley, the garlic took over majority of other crops till 2006; and crash of export market for garlic pushed the farmers back to look for alternative economically-viable crops. But this phenomenon of monoculture has made irreparable damage to the erstwhile sustained agro-ecosystems. Similarly, the Kufri Jyoti (HYV) of potato has been receiving popularity among farmers of Tung gram panchayat. However, this modern variety is unable to cope with difficult environmental conditions at high altitudes, as its yield is very low (62-352 kg per bigha) as compared to the national average yield (672 kg per bigha) of potato (Shailbala *et al*., 2004). In Nohanda gram panchayat, on the contrary, the traditional Dhankhri cultivar of potato is yielding (48-200 kg per bigha) almost at par with HYV/ Kufri Jyoti. HYVs of wheat (PBW343, HPW89, HPW42, Raj78) have also tried to replace 2-3 traditional varieties like Kinnouri, Siraji. Incidentally, due to superior traits and resistance possessed by traditional cultivars, the Siraji cultivar is grown by 58% farmers in both the gram panchayats. However, Kinnouri and other local cultivar are grown by 5-12% farmers only.

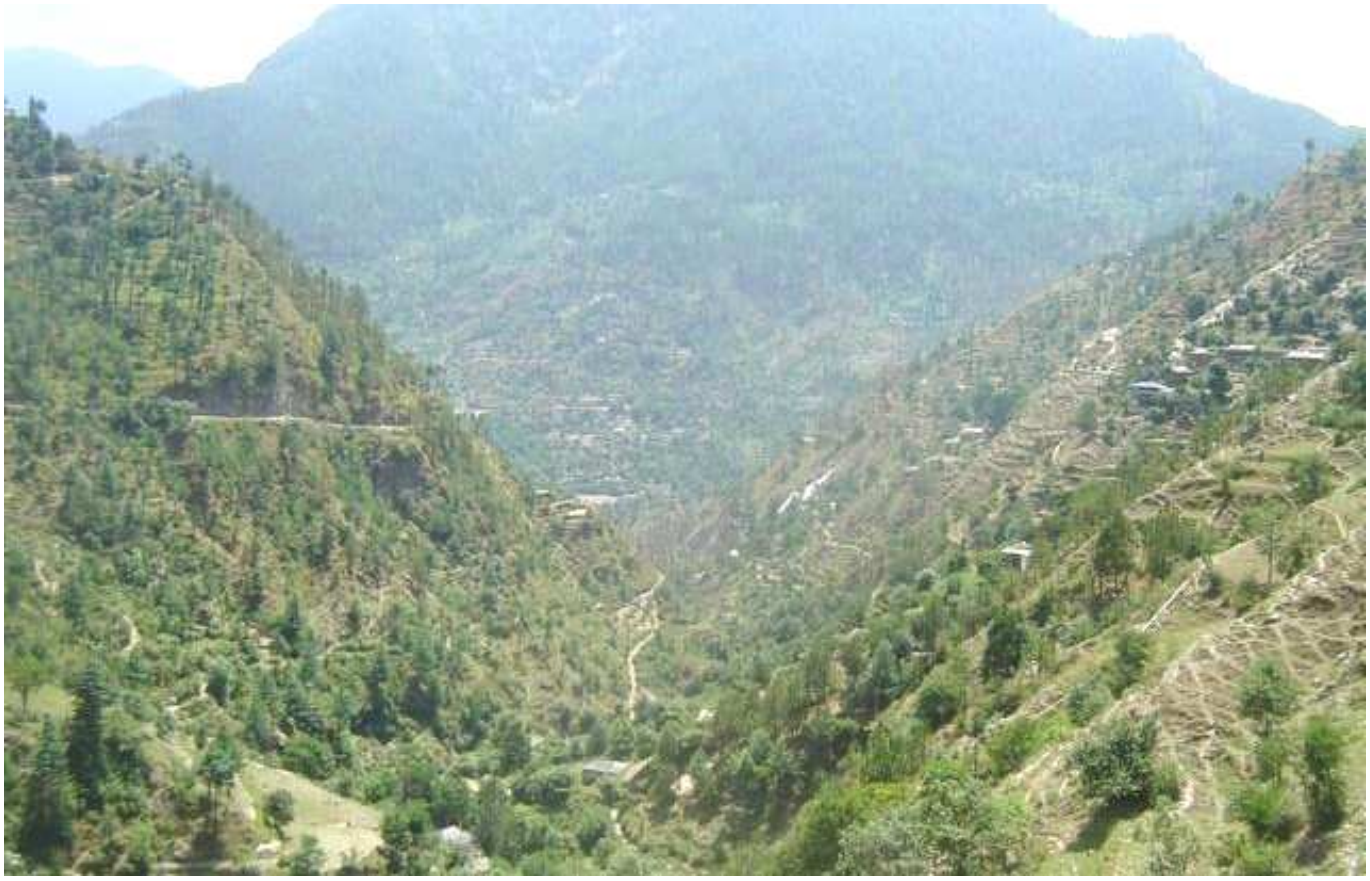
Millet was once widely produced, but now has superseded by other crops. Having immense diversity, the millets have faced sharpest erosion of genetic pool and abundance. White millet (*Panicum miliaceum*) is being grown by only 25% farmers in Nohanda gram panchayat followed by red millet (*Echinochloa utilis*) being grown by merely 10% farmers. Finger millet (*Eleusine coracana*) is recoded as being grown by very few farmers in Nohanda gram panchayat. Tung gram panchayat exists with only white millet (*Panicum milliaceum*), that too in small acreage. As the yield of millets uses to be low and no agronomic interventions are made to improve its yield, the farmers have no incentive to continue growing the millets. Limited number of farmers cultivates the millets only for home consumption. One farmer is documented as growing millets to make sweet pudding being consumed on religious festivities.

This loss of agrobiodiversity not only affects the loss of traditional practices but diminishes the abundance of biodiversity within the natural environment encompassing the agro-ecosystems. Biological diversity has a vital role in agro-ecosystems: it provides food, performs nutrient cycling, regulates the microclimate, suppresses undesirable organisms and detoxifies noxious chemicals (Brookfield *et al*., 2002). The decrease in biodiversity within natural or agricultural ecosystem is an indicator of severe environmental degradation. Repercussions of this degradation are the loss of genetic and productive resources for future generations and the demise of sustainable traditional practices of local farmer community (Arjjumend and Lal, 2010a).

Interventions on Agrobiodiversity Conservation

A small-scale model of agrobiodiversity conservation through linking the farm produce with market was implemented in the sample 20 villages between 2007 and 2010. Participatory development processes with the farmer communities generated causative understandings about farmer's attitudes and internal-external forces responsible for the decline of agricultural biodiversity. First observation was the old agronomic practices, which have ever discouraged the farmers to continue growing the traditional cultivars of various crops. The farmers developed multitude of indigenous on-farm techniques (the methods by which inputs are powered) and technologies (the application of knowledge to the production system) for optimal production. Despite the agronomic practices of traditional farmers are organic by-default, the traditional cultivars and landraces give low yields. During colonial era and post-colonial times there has not been any significant investment in improving the agronomic systems of traditional crops and its diverse cultivars. Hence the farmers see the traditional crops economically unviable.

Secondly, the market forces and agriculture policies have transformed the local agricultural practices and, as a result, the farmers are forced to adopt hybrid seeds and monoculture, which are prone to changing climatic conditions and poor market prices. Consequently, instead of cultivating a variety of environmentally-adapted traditional crops, the farmers prefer growing wheat, maize, garlic and vegetables. Actually, the cultivation of HYVs within rainfed, marginal and fragile agro-ecosystem is a risky strategy for poor farmers. HYVs require consistent irrigation water and chemical-based nutrients (fertilizers). Therefore, loss of traditional practices and declining agrobiodiversity tend to expose the farmers to risks and their livelihoods are bound to face an uncertain future if unsustainable agriculture practices persist and no favorable policy measure is taken in time.



Grassroots Institute addressed the two-fold challenge: one, preservation and re-introduction of traditional cultivars *in situ* coupled with improvement in agronomic methods of farmers for enhancing the yield; and two, linking the organic produce of the traditional crops with innovative post-harvest techniques and better market opportunities. The technical interventions included the following:

- Formation of Farmers' Committees at gram panchayat level
- Promotion of exchange of seeds of traditional cultivars
- On-farm Training & Counseling of farmers on Organic Production of traditional crops
- Exposure of farmers to organic farming site
- On-farm Training of farmers on Quality Control and Post-Harvest Storage
- Providing on-field technical inputs of organic cultivation, such as -
  - manipulations in humus levels according to soil types
  - testing of nutrients in the soil and balancing them
  - planning the crop rotation and crop cycle
  - assistance in planning intercropping, storey culture and cover crops
  - use of compost, manure and bio-fertilizers
  - compost making and vermicompost
  - water harvesting and soil conservation
  - treatment, storage and selection of seeds of traditional cultivars
  - biological weed control, and bio-pesticides
  - other necessary technical inputs

Coupled with agronomic and post-harvest improvements, the linking of farm produce with ensured market opportunities is always a challenge. On experiment basis, a post-harvest processing and marketing of product were administered. Food grains of barley, beans, wheat, maize, millets, horse

gram and soybean were processed/grinded in a specific proportion on traditional water mill (*gharaat*) to make *6-grain aatta* (flour) to supply in domestic market. The market linkages thus provided the growers of organic commodities (of traditional varieties of superior traits) offered premium prices for their produce and hence they were encouraged to continue organic cultivation of traditional crops in fragile agro-ecosystems of high altitude mountains (Arjjumend and Lal, 2010b). However, the participatory action with the mountain farmers of studied 20 villages underwent several socio-technical barriers that generated significant learning for further improvement and inclusive planning.

Future Course of Action and Challenges for Conservation

Small scale pilot project established the need of pursuing research with broad framework and spelt out the urgency of taking planned action of conservation. To further the exploratory and empirical research on agricultural biodiversity in Great Himalayan National Park Conservation Area, the Grassroots Institute intends to study the following:

- Cultivation history
- Bio-physical characteristics
- Ethnobiology
- Economics
- Agronomic practices
- Characterization of cultivars (such as size/color/taste of the seed/fruit/tuber, nutrition value, and resistance to pests/insects/pathogens/water stress).

Conservation strategies related to sustainability of the indigenous farming systems are needed for overall environmental, economic and social development through adopting the traditional and appropriate modern techniques and technologies. One of the main solutions is to preserve and or re-introduce traditional cultivars, and to increase the number of cultivars on-farm. Increasing crop diversity will enhance food security, reduce farmer's vulnerability to market uncertainties, and also preserve genetic resources. But the real challenge ahead lies in engaging large number of farmers in cultivation of genetically-superior traditional cultivars, because the farmers need to be made part of conservation process at large scale. Grassroots Institute intends, with the partnership/cooperation of authorities of Great Himalayan National Park (GHNP), the extension of agrobiodiversity conservation initiative into Tirthan, Sainj and Jibhi valleys covering at least 50 villages.

Furthermore, sustaining the cultivation of traditional cultivars on farmers' lands is possible through improving the farmers' access to national/ international market for gaining adequate prices of their farm produce of traditional crops. So developing linkages and supply chain is also essential, apart from post-harvest processing of organic produce of traditional crops. Impediment of the low yield of traditional

varieties can be removed through organic cultivation and agronomic interventions.

This component of improving and diversifying the farm-based livelihood system of marginal and poor farmers is also essential from viewpoint of reducing the dependence of majority of these farmers on bioresources of national park. About 16,000 people, mostly marginal farmers, live in nearly 130 villages in GHNPCA (GHNP, 2012). The marginal and poor farmers look at forest produce to augment their income. There are a sizeable number of herb collectors and sheep herders, who exert biotic pressure on natural resources of the national park. Therefore, development of alternative livelihood on-farm for such farmers would definitely reduce their frequency and volume of harvesting of the forest produce, herbs and other natural resources. It would help achieving the overall goal of biodiversity conservation in GHNPCA.

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For further information, please contact

Chuni Lal, *Head of Operations* | head@grassrootsinstitute.in

PO Building, Banjar – 175 123 District Kullu (HP)
Tel: 01903-200202, 09418133427 Fax: +91-01903-222257
E-mail: info@grassrootsinstitute.in
Website: www.grassrootsinstitute.in

Authors & Speakers:
Hasrat Arjjumend, *Senior Fellow* | Chuni Lal, *Head of Operations*
GRASSROOTS INSTITUTE | Banjar – 175 123 Distt. Kullu, Himachal Pradesh (India) | Fax: +91-01903-222257
Tel: 01903-200202, 09418133427, 09910188948 | E-mail: info@grassrootsinstitute.in | Website: www.grassrootsinstitute.in

Co-Organizer of COP.11 Side Event:
Ajay Srivastav, IFS, *CCF Wildlife & Director* | GREAT HIMALAYAN NATIONAL PARK | Shamshi – 125126 Distt. Kullu (HP)
Tel: 01902-265320, 09418462618 | E-mail: dirghnp@gmail.com | Website: www.greathimalayannationalpark.com