Conservation and Sustainable Management of Traditional Ecosystems in Garhwal Himalaya, India

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Abstract: Forest and agricultural biodiversity play an important role in sustaining livelihood of local people in marginal land in Central Himalayan village ecosystems. These village communities have their own rules and regulations for conservation and management of agroecosystems as well as surrounding forest ecosystems. To assess the pattern of change in conservation and sustainable management of traditional agroecosystems, a participatory rural appraisal (PRA) was conducted and information collected from farmers. In the Study area traditional food crops and multipurpose agroforestry trees were replaced by cash crops during the recent past, due to the changes in the economic and political issues. These village ecosystems have become either degraded or less fertile ecosystems. The study focuses on the issues of conservation and sustainable development. [New York Science Journal. 2010;3(2):71-77]. (ISSN: 1554-0200).

Keywords: Conservation; Sustainable development; Traditional agroecosystem and Biodiversity

1. Introduction

The traditional Central Himalayan village ecosystems are more sustainable in ecological point of view. These areas in central region of Indian Himalaya are closely dependent on the surrounding forests for resources (Chandra, 2007; Nautiyal and Kaechele, 2007). The conservation of traditional agrobiodiversity is important for sustainability of the future landscape in mountains. Sustainable landscape is crucial all over, but in case of mountains, it requires additional attention as it also influences the landscape in plains. There is greater awareness for management of natural resources worldwide and suitable areas are protected in the form of sanctuary, national park and biosphere reserve particularly for achieving the goal of *in-situ* conservation of biological diversity. In this endeavor there are increasing interests for conservation and management of traditional crop diversity in natural conditions. Due to variations in climatic conditions, unavailability of reliable market, large family size, small fragmented farms on terraces on steep slopes led the farmers to adopt the subsistence farming systems in Himalaya. These subsistence farming systems are characterized by substantial diversity and also high degree of self-reliance (Maikhuri *et al*., 1996; Semwal and Maikhuri, 1996; Palni *et al*., 1998; Rao and Saxena, 1994; Ramakrishnan *et al*., 1994; Nautiyal *et al*., 1998, 2002, 2003).

In the Himalayan highlands of India, farmers predominantly practice traditional agriculture where it meets their needs (Chandra, 2007). Local communities in high Himalaya also possess a great deal of ethno-botanical knowledge related to traditional crops (Maikhuri *et al*., 1996). However, in the recent past, lot of erosion in the landrace diversity has been observed, mainly due to habitat degradation and shift to modern high yielding varieties (HYVs). In some areas, the traditional crop landraces are facing danger of complete extinction and consequently the ecological and economic security of the traditional farming systems of this region appears to be under threat (Maikhuri *et al*., 1997; Nautiyal *et al*., 2002). The maintenance of traditional varieties and landraces in their natural surrounding is an essential component of sustainable agricultural development by deploying more diversity in production systems. An empirical study was conducted with the objective to analyze the pattern of change in agrobiodiversity and its impact on Central Himalayan ecosystems.

2. Materials and Methods

The study was multidimensional, hence quantitative and qualitative information was obtained through literature review and available records in selected valley for understanding of conservation and sustainable development of traditional agroecosystem during April 2003 to May 2006. The primary data for the study was collected from the selected farmers of Langasu village by using participatory rural appraisal (PRA) method with the help of a structured schedule prepared for this purpose (Chamber, 1993; Borrini-Feyerband, 1996; Chandra, 2007).

3. Results and Discussion

3.1 General description of agroecosystem

Agricultural land use on terraced slopes is dispersed as patches in the matrix of forests. Cropping systems are built around two seasons, the kharif and the rabi. Agroecosystems are characterized by: (a) cultivation of three crops in two years; (b) a high level of crop diversity adapted to environmental heterogeneity and climatic uncertainty; (c) community decision on fallowing (a village is divided into two halves termed as Sar, each household owns at least one plot in each Sar, and a Sar is fallowed during one winter-crop season over a period of two years) but independent household decisions on choice of crop and management practices; (d) protection of naturally regenerating multipurpose trees and grasses on terrace margins; (e) use of organic manure derived from livestock excreta mixed with forest leaf litter; and (f) exchange of seeds without any monetary considerations.

3.2 Crop diversity of the region

Out of the 67 predominant food crop species of the central Himalaya, about 34 species (comprising of cereals, pseudocereals, millets, pulses, oil yielding crop and different kinds of vegetables) are grown in the traditional agroecosystems of Langasu village. The traditional crops are *Oryza sativa*, *Triticum aestivum*, *Hordeum vulgare*, *Eleusine coracana*, *Echinochloa frumentacea*, *Setaria italica*, *Panicum miliaceum*, *Amaranthus* spp., *Fagopyrum esculentum*, *F. tataricum*, *Phaseolus vulgaris*, *Vigna mungo*, *Macrotyloma uniflorum*, *Glysine max* (local black seeded types), *Brasscia compestris*, *Perilla frutescens*, *Sesamum indicum*, many local vegetables (cucurbits, *Trigonella* spp., *Beta* spp.) etc. Besides the improved types of some other crops viz., *Pisum sativum*, *Solanum tuberosum*, *Zea mays* etc. are also grown. Maximum area is covered by *O. sativa*, followed by *T. aesativum*, *S. tuberosum* and least by *S. indicum*.

3.3 Decline of genetic diversity

The detailed inventorisation of the landraces at three points of time (1970-1980; 1980-90 and 1990 onwards) was done. Before 1970ôs farmers of the valley were cultivating a total of 65 landraces of different crops. Eight landraces disappeared during a short span of time, and between 1980 and 1990, 57 landraces remained under cultivation. This declining trend further continued and a total of 18 landraces disappeared from the villages agroecosystems during 1980-90. After 1990ôs people are maintaining only 39 landraces for cultivation. The area under cultivation of many landraces of different traditional crops has been reduced to 80-85%. A decline in area is reported maximum for paddy landraces. Farmerôs preference for HYV and landraces introduced in the village from the neighboring areas is increasing for getting more output in the form of grain yield (Table 1). Studies have reported that the area under many of the traditional crops/landraces in this region is shrinking very fast due to replacement of traditional crop varieties by HYVs/modern variety or introduced crop (Maikhuri *et al*., 1997).

It has been observed that most of the traditional crop cultivars/landraces are in severe threat in the Central Himalayan region, where 30-75% area under cultivation has been replaced by the HYVs as these are preferred for obtaining more output in terms of grain yield and easy availability of their seeds through a formal seed distribution system. Unlike other areas of the Uttarakhand, farmers of the studied valley are still practicing traditional agriculture but, nonetheless, the genetic erosion has continued in the valley where the study village is located. Undoubtedly, the HYVs have made significant contribution in minimizing the problems of hunger in the wake of ever increasing demand for food world over. On the other hand, agricultural intensification with the use of HYVs and purchased inputs has many negative implications particularly for the unique agroecosystems of the Himalaya where farmers are dependent on local resources and locally developed technologies. Agricultural intensification has many long-term consequences and creates nutrient imbalances, soil and water erosion etc. (Maikhuri *et al*., 1997; Sen *et al*., 1997). Traditional agriculture, though suffered a major setback amidst a high cry of modern agriculture, still provides 20% of the world food supply (Trupp, 1996). The present study illustrated that the rate of loss of landrace diversity is an indication to the severe threat to crop diversity and sustainable agriculture.

3.4 High Yielding Varieties (HYVs) vs. traditional landraces

The distinction between the cultivation of landraces and high yielding varieties (HYVs)/modern varieties is one means of measuring diversity on a farm. HYVs/modern varieties are by definition uniform and stable, where as landrace cultivation are more volatile, encompassing a population of gene and alleles that are adaptable to natural and human selection pressure (Ceccarelli and Grando, 2002). The agroecosystem choice of cultivating a modern variety versus landrace for any one crop is driven by a set of supply and demand side factors. In the Central Himalaya these modern varieties that meet the production or consumption needs of farmers, do not exist due to tremendous variation in altitude, temperature, rainfall, soil type and ecological setting, as well as the diverse social and cultural condition together with different levels of market integration are some of the possible explanations for the existence of remarkable genetic variation of crop varieties in this region.

The production (grain yield q/ha) of high yielding varieties (HYVs) vs traditional landraces was compared. The HYVs gave 20-42 q/ha grain yield under improved agronomic management. However, among the landraces, the grain yield was between 20-35 q/ha, even under marginal conditions. There are substantial evidences that introduction of modern HYVs in agroecosystems have resulted in extinction of traditional landraces in the Himalayan region. A prominent scented paddy landrace, "Mukhmar" has become extinct because of the introduction of HYVs by government policy interventions in certain areas where traditional agriculture was once an integral component (Nautiyal *et al*., 2000). During 1980s a programme was launched by the government through watershed management project in the region and seeds of HYVs along with fertilizers at subsidized rate were provided to the local farmers. Farmers started cultivating a scented HYV rice variety in place of the local scented rice landrace. At initial stages the HYV showed high output in terms of grain yield under high agronomic management but later on its production declined when the government agencies stopped giving subsidy on fertilizers. Finally the traditional landrace Mukhmar has completely disappeared from the area now. Such state sponsored policies/ programmes have therefore negative implications on traditional knowledge-based agriculture.

3.5. Reasons behind land use change

This is an important aspect of study as farmers behaviour and driving forces which influence the value of the Himalayan agroecosystem is well known to the people living there (Figure 1). A framework to understand the complex interaction between human and the factors responsible for decline in traditional crop diversity/landraces (such as socio-economic, ecological and policy related issues, the main socio-economic factors responsible for erosion of traditional landraces) are presented in Table 2.

The sustainable development of landscape is dependent on the use and management of land resources. Himalayan agroecosystems are interlinked for agrodiversity management such as use of bullocks for drought power, human energy as labour, crop residues as animal feed and animal waste mixed with forest litter as organic inputs (Chandra, 2007), therefore the development of the agricultural land use directly influences the forest ecosystem services and other resources. This is the basic process for the landscape change in fragile Himalayan environment. The unsustainable land-use development in mountains accelerates erosion, which partly contributes to devastating floods in the plains (Ives and Messerli, 1989; Saxena *et al*., 2001, 2005).

4. Conclusions

The traditional crop diversity and their landraces in agricultural land use in Himalaya have great significance for long term sustainability of agroecosystems along with conservation and management surrounding landscape. Traditional land use in mountains is characterized by its dependence on local resources and locally developed technologies. In order to optimize food production in these low-input farming systems, farmers possess a considerable knowledge both of the nature and characteristics of the resources available, and of the methods suitable for sustainable crop production under conditions which are often marginal for agricultural productivity. Grain yield of traditional landraces of paddy was compared with the high yielding varieties. The output in terms of grain yield of the landraces is comparable with the grain yield of HYVs. It suggests that the hill agroecosystems with traditional crops are ecologically and economically viable and have the potential to support the food requirements in the Himalayan region. An institutional policy support is required for enhancing the value of the traditional crops including the promotion of elite landraces selected on the basis of urban consumption needs. Efforts are also needed to maintain and further develop the knowledge possessed by the traditional farming communities

Table 1: Replacement of some traditional crop varieties by High Yielding/ Introduced varieties in The Central Himalaya, India

Traditional crop	**Replacement crop**
Summer season crops	
Panicum miliaceum	High Yielding *Oryza sativa* varieties
Oryza sativa (Traditional landraces)	High Yielding *Oryza sativa* varieties
Avena sativa	*Solanum tuberosum*
Fagopyrum tataricum	*Solanum tuberosum* and *Phaseolus vulgaris*
F. esculentum	*Phaseolus vulgaris*
Parilla frutescense	*Glysine max*
Setaria italica	*Glysine max*
Eleusince coracana	*Glysine max* and *Amaranthus* spp.
Echinochloa frumentacea	*Cajanus cajan*
Macrotyloma uniflorum	*Glysine max* and *Amaranthus* spp.
Vigna spp.	*Cajanus cajan* and *Amaranthus* spp.
Winter season crops	
Triticum aestivum (traditional landraces) + *Brassica* spp.	High yielding *Triticum aestivum* varieties
Hordeum himalayens	*Solanum tuberosum*, *Amaranthus* spp. and *Phaseolus vulgaris*
Hordeum vulgare	Improved *Brasscia* varieties

Figure 1. Woman harvesting the pulses and other High yielding crops from their field

Table 2: Main socio-economic factors behind responsible for change in traditional crops/landraces/germplasm

1	Change in cropping patterns due to economic considerations	The farmers in the region are involved in diverse livelihood options as cultivation of crops, livestock, forestry, etc. Many of the traditional crops are grown under marginal conditions and often provide low yield and extremely low income, forcing the farmers to undertake other activities, for example, replacement of mixed cropping to monocropping, cultivation of improved strains bringing about more uniformity in crop species and switching over to cash crops. Monocropping and uniformity results in increased vulnerability to pest epidemics and consequent loss of biodiversity. Besides, a significant proportion of the traditional agricultural land has been brought under cash crops or off-season vegetables. This has adverse implications on traditional agro-ecosystems and traditional agrobiodiversity of the region has shrunk over time.
2	Loss/replacement of traditional multipurpose trees	The diversity of traditional multipurpose tree communities has been decimated because of promotion of apple plantations in the western Himalaya (Singh *et al.,* 1997), and plantation of *Alnus nepalensis* and *Albizia stipulata* in the eastern Himalaya during the last 50 years (Rai, 1995). While there are huge direct economic benefits from apple trees, *Alnus* and *Albizia* provide a microenvironment favoring higher profits from cardamom. Fodder available from pruning of these trees does not fully compensate for the reduction in palatable crop by-product production caused by the tree canopy. Manure is applied in larger quantities to the apple based systems as compared to the traditional multipurpose tree based ones. Thus, the changes in farm tree diversity have increased dependency of farming on forests and hence more threats to forest biodiversity and ecosystem functions. In order to promote apple based economy, the government granted price concessions on extraction of forest wood to be used for packing the product for marketing, further compounding the pressure on forests (Singh *et al.,* 1997).
3	Population growth and land fragmentation	The human population has increased over time. The land fragmentation and insufficient crop yield due to high land: man ratio and low output: input ratio of traditional crops compelled farmers to consider other options for livelihood.
4	Lack of traditional knowledge	Since there is no systematic documentation of ethnomedicinal uses of traditional landraces and the traditional underutilized crops, the younger generation is unaware about the distinctive properties of the landrace diversity. Lack of this knowledge often leads to discontinuation of cultivation of some of these landraces which are of high nutritional value to them. This kind of knowledge is, however, very much essential for value addition to local landrace diversity and also in Intellectual Property Rights (IPR) protection.
5	Out-migration:	Migration of people to plain areas for off.-farm jobs and reduced interest in traditional agriculture. In some villages, there has been a large-scale outmigration leading to abandonment of agricultural land. Slow natural regeneration in abandoned land is expected to cause severe site degradation. On a regional scale, however, the rate of agricultural expansion exceeds the rate of abandonment (Rao and Pant, 2001).
6	Change in food habits	Yield potential of most of the traditional crops has been stable for the last 2 -3 decades. The food shortage problem is because of population growth, change in food habits (increasing preference for wheat and rice as staples), reduction in crop diversity and net sown area.
7	Social values	Local socio-cultural integration has decreased. Social institutions such as community participation in natural resource management for agriculture, and seed and labour exchange systems are disappearing fast leading to weakening of agricultural management.

8	Livestock population	A trend of increase in livestock population and changes in composition of livestock population are common (Sharma and Shaw, 1993, Mishra, 1997). A change from preference of joint to nuclear families but persistence of the traditions of maintaining self-sufficiency in respect of cattle at household level and of considering sheep/goat/mule husbandry as an occupation of lower castes seems to have contributed to higher rate of increase in cattle population compared to other livestock types (Sen *et al*., 2002). An increase in livestock population but reduction in fodder production from farmland with changing cropping patterns implies more intensive grazing in forests. The government efforts to encourage husbandry of birds (poultry and duckery), rabbits yielding high quality wool, buffaloes and cross-breeds of sheep/goats have met limited success because of poor adaptation of these introduced animals to mountain terrain and locally available feed, and their unsuitability for the production of traditional farmyard manure.

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