Traditional crop diversity needs institutional and policy support for their conservation and sustainable land use development in Himalayas of India

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Abstract
The traditional agroecosystems are characterized by their dependence on local resources and locally developed technologies in Himalayas of India. The land use system is closely linked to surrounding forests for the sustenance. For the sustainable landscape development the on-farm conservation of traditional crop diversity is urgently needed. An empirical study was undertaken for inventorisation of traditional crop resources in the region. Traditional landraces of different crops and trend of genetic resource erosion was documented in detail. The land use land cover map was developed in view to observe the process of the landscape change trend in the region. An institutional and policy support needs to conserve traditional crop diversity to encourage enhancing their utilization for economic incentives of local farmers and management of the ecosystem services on the other.

Introduction
Study reports the importance of conservation of traditional agrobiodiversity for sustainable development 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. An empirical study was done to understand the cause and consequences of declining the traditional agro-biodiversity and implications in Himalayas of India. There is greater awareness now for management of natural resources worldwide and specific areas are protected in the form of sanctuary, national parks and biosphere reserves 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 condition. On-farm conservation is "the conservation and management of cultivated species in the surrounding environment where they have developed their distinctive properties" (Maxted et al., 1997). On-farm conservation is considered to be the sustainable management of genetic diversity of locally developed traditional agricultural, horticultural and agri-silvicultural cultivation systems. In the Himalayan highlands of India, farmers predominantly practice traditional agriculture where it meets their needs. Local communities also possess a great deal of ethno-botanical knowledge related to traditional crops (Maikhuri et al., 1996). The traditional agricultural system is characterized by their dependence on local resources and locally developed technologies. 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 in jeopardy (Maikhuri et al., 1997; Nautiyal, 2002). Sustainable agricultural development will involve the strengthening and improvement of some of these traditional systems rather than their replacement with alternative high input farming systems. The maintenance of traditional varieties and landraces in their natural surrounding can be an essential

component of sustainable agricultural development by deploying more diversity in production systems. Recognition of situations where maintenance of traditional varieties or landraces is a component of an appropriate development strategy is likely to provide a more secure political and social basis for conservation activities and to strengthen their long-term viability. An empirical study is done to analyze the land use under different traditional crops and erosion of traditional landraces (genetic diversity) of crops grown in a part of Indian Himalayan region.

Study area and climate

The study area is located in mid high altitude of Central Himalaya (30^{o}32’18”N and 79^{o}28’02”E) was selected for the present study as a representative site of traditional landrace-based cultivation in the region. The altitudinal limits ranged between 1500 and 2000m asl. The year consists of three distinct seasons: summer (April – June), rainy (July – September) and winter (October- March). Average rainfall is about 925mm, of which about 51% is received in a short period of two months (July – August) featuring a strong monsoonic influence. Monthly maximum and minimum temperatures range between 28^{o}C to 16^{o}C, and 9.5^{o}C to 5.0^{o}C, respectively.

Average land holding size is <1.0ha per household. Besides traditional agricultural crops, a variety of fruit trees (apple, apricot and walnut etc.) are planted on the margins of the rainfed terraces. Seasonal and off-season vegetables such as, cucurbits, ginger, cabbage, green vegetables, etc., are cultivated in the kitchen gardens. The average area under kitchen garden is about 0.012 ha/household.

General description of agroecosystems and cropping patterns

In the studied Valley, the rainfed agriculture on steep terraces is the predominant form of land use. About 8.5% of the total cultivated land is irrigated. All the households were involved in agriculture. The rainfed agriculture in all the villages is practiced on almost two equal halves of agricultural land locally called as ‘sari’ with different crop compositions. To maintain soil fertility, the tradition is to keep one half of the land fallow during winter season alternately over a period of two years. Therefore three major crops can be harvested biannually from rainfed agriculture. In irrigated land, two crops, a summer crop and a winter crop, were harvested in a year. The crop rotations, cropping patterns and crop composition, practiced in studied Valley have been presented in Fig 1.

Materials and methods

Study was carried out in all the villages of the studied Valley during October 2000 to October 2002. All the households were surveyed to determine average land holding size, area under different crops, crop compositions, cropping patterns and crop rotations. The information was collected through informal discussions with knowledgeable members of the households. To gather the above information, each household was visited at least 5-6 times during the study period. It is very difficult to measure diversity of agricultural crops and ranking them in order of rarity, endangered or extinct on one hand and prejudged the farmers’ behaviours and their thinking on the other. But we can measure and investigate farmer behaviour through long term observations, inquiries and socioeconomic survey methods (Bailey, 1987; Maxim, 1999; Pischke and Cashmore, 2006). Using the satellite data the land use land cover map was developed to understand the pattern and process of landscape change in mountains. The methodology pertaining to remote sensing image analysis was followed by Nautiyal and Kaechele (2006).

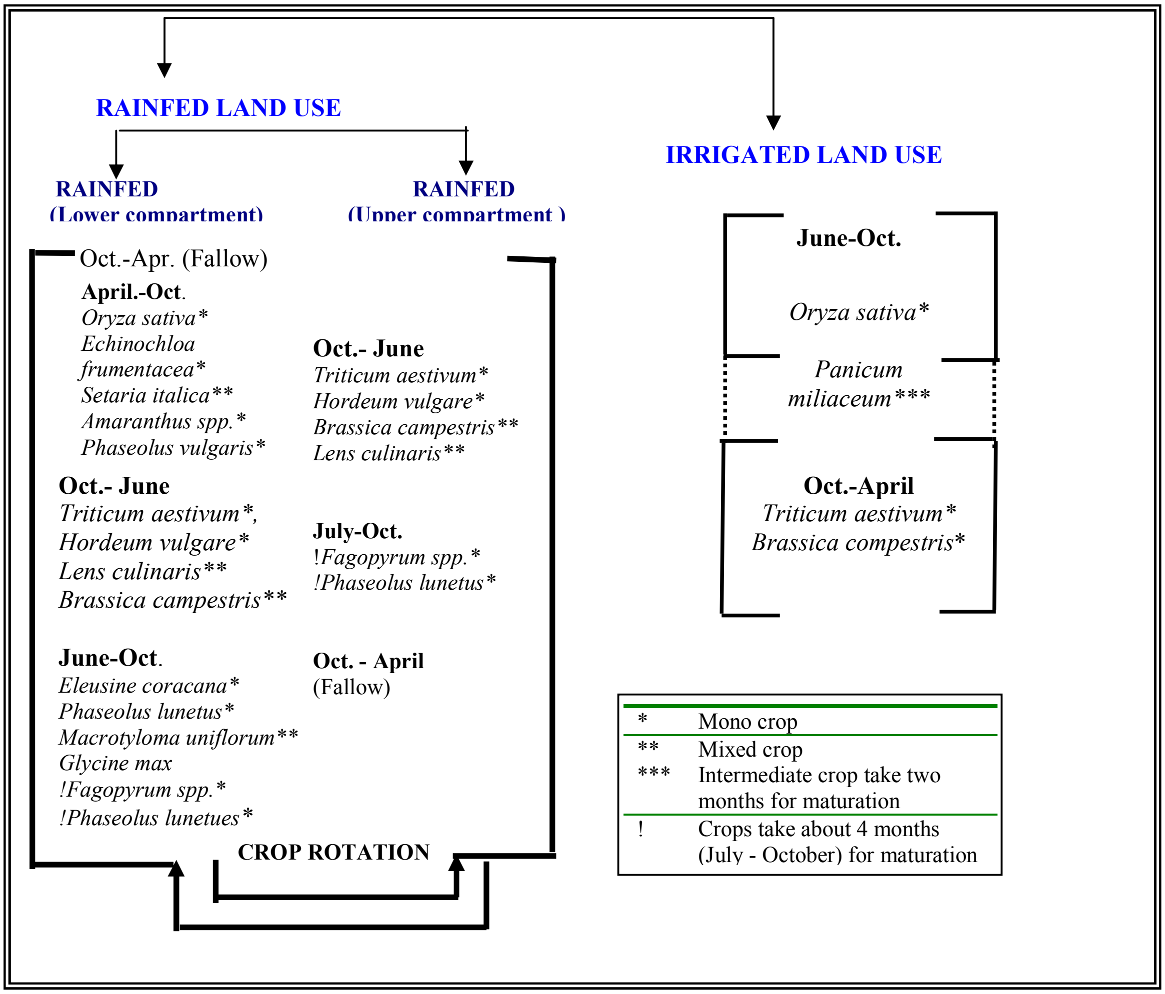

Figure 1. General cropping pattern, crop composition and crop rotation in studied valley

Results and Discussion

a). Crop diversity of the region

Out of the 67 predominant food crop species of the Uttaranchal 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 the Valley. The traditional crops of the valley 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* (53 ha), followed by *T. aesativum* (49 ha), *S. tuberosum* (30 ha) and least by *S. indicum* (2 ha).

b) 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 1970 farmers of the valley were cultivating a total of 65 landraces of different crops cultivated in the valley. The eight landraces disappeared during a short span of time form the valley, and between 1980 and 1990, 57 landraces remained under cultivation. Declining trend further continued and a total of eighteen landraces disappeared from the valley during 1980-90. After 1990 people are maintaining only thirty nine landraces for cultivation. The area under cultivation of many landraces of different traditional crops has been reduced to 8-85% between 1980 and 1990. Decline in area is reported maximum in paddy landraces. Farmers' preference for the landraces is increasing which have been introduced in the valley from the neighboring areas for getting more output in the form of grain yield.

Similar information on genetic erosion is reported by 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 formal seed distribution system. Unlike other areas of the Uttaranchal, farmers of the studied Valley are still practicing traditional agriculture but, nonetheless, the genetic erosion has continued in the valley. Undoubtedly, the HYVs has made significant contribution in minimizing the problems of hunger in the wake of over increasing demand for food world over. But agricultural intensification with use of HYVs and purchased inputs has many negative implications particularly for the unique agroecosystems of the Himalayas where farmers are dependent on local resources and locally developed technologies. Agricultural intensification has many long-term consequences and create 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). In the present study, not a single landrace of paddy was replaced by the HYVs but still the rate of loss of landrace diversity is an indication to the severe threat to crop diversity and sustainable agriculture. Policy makers should not only promote planning to increase consumption of traditional crops as human and animal food but should also support research that will enhance their utilization.

c) Yield potential of HYVs *vs* traditional landraces

The production (grain yield q/ha) of high yielding varieties (HYVs) *vs* traditional landraces was compared. In this endeavor grain yield of six landraces of paddy from the study area was compared with the six high yielding varieties of paddy. The productivity of HYVs was collected from secondary sources whereas for traditional landraces the data were collected from farmers' field based on personal observations. The HYVs gives 20-42 q/ha grain yield under improved agronomic management. However, among the landraces, the grain yield was reported between 20 and 35 q/ha, even under farmers' marginal conditions. We have found that the grain yield of HYVs and traditional landraces of paddy is relatively comparable (R^2=0.7476).

There are substantial evidences that introduction of modern HYVs in agroecosystems have resulted in extinction of traditional landraces in the in the Himalayan region. A recent study conducted by Nautiyal et al. (2000) in the Uttaranchal Himalaya showed that 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. 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 of rice 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. 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.

d) Land use land cover change detection in the region

The overall system analysis concluded that the study of spatial and temporal distribution of land-use and land-cover change is important. This is important to understand the change in human behaviour due to variety of factors and consequences to this how land landscape is changing. For landscape change analysis data from remote sensing is helpful to monitor the current state and changes to the land-use land-cover in the fragile Himalayan environment. Using the satellite data available, we have developed the land-use land-cover map and studied the land-use cover change. In this endeavor, remote sensing imagery from seventies, at a decade interval were used to analyse the major land use cover categories. For the present study, the land-use cover map of the area for the period of 1979 and 2002 is depicted in Figure 2 a&b. Based on satellite data interpretation and visual observation, we found that the agricultural land use is getting expansion and consequences to this the forest cover is narrowing. The trend of expansion in agricultural lands and narrowing the forest cover is a common trend in the Himalayas of India (Sen, et. al., 2002; Semwal et.al., 2004) and other mountainous regions in developing countries (Fox et.al., 1995; Jianchu, et.al., 2005. Thongmanivong et.al., 2005).

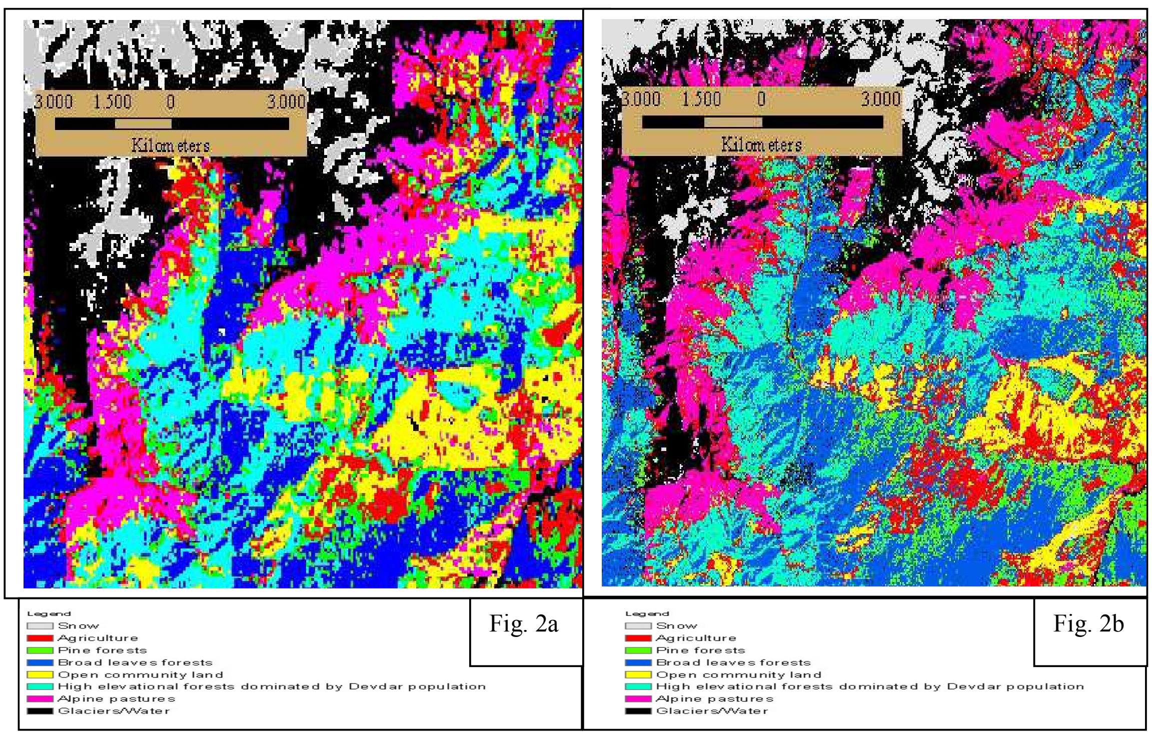

Figure 2a & 2b. Showing the Land use land cover view of the study area for the period of 1979 and 2002 respectively

e) Reason behind land use change

This is an important aspect to study the farmer behaviour and driving forces which influence his activity. A framework to understand the complex interaction between human and resources is depicted in Figure 3. The sustainable development of landscape is depends on the use and management of land resources. In Himalayas of India all the branches of ecosystem are interlinked. The agriculture which is main stay of the people of the region is directly linked to the surrounding ecosystems and 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 sustainable land use development is a very crucial issue all over the world. But in the mountains it need a bit more attention as it affects equally the sustainable landscape development in the plains. 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; Saxena et al., 2005). In mountains of Indian Himalaya efforts have been made to analyze changes in broad land-use/land-cover types (Schweik et al., 1997; Rao and Pant, 2001). Yet, knowledge on changes in spatial patterns of agricultural land-use, declining of traditional agro-biodiversity, driving factors, and their implications within the context of sustainable landscape development is limited. Therefore, in depth study while studying the complexity of all land use types will be very helpful in designing and developing the strategies for conservation of genetic resources and sustainable development of Himalayan landscape.

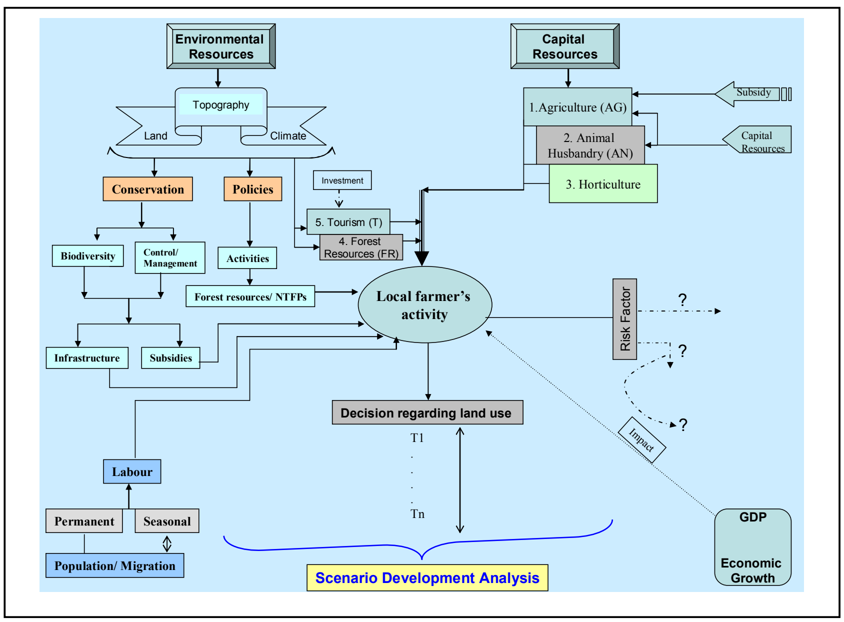

Figure 3. Framework depicting the influences of the driving forces on the activities of farmer in Himalayas of India

Conclusion

The traditional crop diversity and their landraces in agricultural land use in Himalayas have great significance for long term sustainability of agroecosystems along with conservation and management surrounding landscape. As 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.

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