Chapter 1

The Challenges of Managing the Agrobiodiversity of the Hindu Kush-Himalayan Region: An Overview of Issues

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Focussing on Mountain Agrobiodiversity

Over one hundred and forty million people inhabit the Hindu Kush-Himalayan region today, and ninety per cent of them depend on farming for their livelihoods. The diversity of their agricultural systems, farming cultures, agroclimatic regimes, crops, and livestock makes the Hindu Kush-Himalayan (HKH) region rich in agrobiodiversity. Through the ages, the mountain farming communities of the HKH region have evolved strategies for harnessing local agrobiodiversity for food security as well as to improve their livelihoods. This richness of agrobiodiversity is, therefore, the result of ages of experimentation, by selection and by experience, by mountain farming communities.

However, in recent decades, population growth has compelled farmers to extend their operations into forests and on to pastures, rangelands, and marginal habitats – changing the land-use systems and altering the agrobiodiversity of the region. Faced with the vicious cycle of 'resource scarcity-food insecurity-poverty-resource degradation', for many mountain farmers in the HKH region, agrobiodiversity provides the hope of a strong base for developing their agricultural systems in sustainable ways. Governments in the region are attempting to transform subsistence agricultural systems, mostly by introducing new technologies and crops from outside. Economic improvements are visible in some areas (Sharma 1996), but there are also indications that these changes have a negative impact on local agrobiodiversity.

Today, farmers of the HKH region are faced with a dilemma, increased population and economic needs have made their traditional methods of farming economically unsustainable and, therefore, changes are needed. Yet, at the same

BOX 1.1
Biodiversity and Agrobiodiversity

Biodiversity includes all species of plants, animals, and micro-organisms, together with the agroecosystems and ecological processes of which they are a part . It covers both natural and people-managed habitats, including forests, rangelands, agricultural systems, deserts, plains, and mountains. Since most of the world's biodiversity exists in people-managed or modified systems and land-use patterns, it is necessary to integrate conservation of biodiversity of natural habitats with that of agricultural systems. However, agriculture is generally seen as the enemy of biodiversity rather than as part of it. This perception arises because raising livestock and crops inevitably alters natural systems. Population growth has compelled farmers to use forests, pastures, rangelands, and marginal habitats (Srivastava et al. 1996). The effects can be both positive and negative. Some land-use systems have helped enhance biodiversity, while others have degraded it. The natural linkage between biodiversity and agrobiodiversity is unique, the habitat gains for agrobiodiversity are generally at the expense of natural biodiversity. **Agrobiodiversity** is the subset of biological resources that support the agricultural production systems of every farming culture; the crops and livestock and the agroecological processes of which they are a part. The diversity of agroecosystems is enriched by the variety of farming cultures and agro-climates. These components are physical manifestations of agrobiodiversity. The environmental setting, population and social organization, modern technologies, capital investments, and other kinds of interventions can enhance or deplete agrobiodiversity. Thus it can actually be managed, destroyed, or replenished. It is often assumed that any form of agrobiodiversity will be of importance to agriculture, because diversity causes, enhances, or otherwise contributes to stability in systems. This view is too simplified, unlike in natural systems, increasing the species' and Genetic Diversity of an agricultural system will not always improve its sustainability because both ecological and economic viability need to be considered. The new view of agrobiodiversity in agriculture distinguishes between the biodiversity of natural systems and planned diversity within agroecosystems. Therefore, agricultural systems cannot be made more stable simply by increasing their complexity. With the present level of knowledge it is difficult to assess what level of agrobiodiversity is needed to maintain the sustainability of agricultural systems. But what can be said is that agrobiodiversity is necessary for the long-term sustainability of farming systems. It remains a challenge, though, to qualify and quantify the need for agrobiodiversity. Biodiversity and agrobiodiversity are like two sides of the same coin. The one with the national emblem represents biodiversity, because natural biodiversity is a human heritage of local communities and society as a whole and is not generally priced. The face of the coin showing the value represents agrobiodiversity, since agrobiodiversity provides livelihoods for human societies and its value can be assessed in terms of who depends on it and to what extent. Agrobiodiversity, however, is of more fundamental importance than the agricultural resources recognised conventionally and falls outside of a purely utilitarian or economic calculation. Agrobiodiversity provides the fundamental base for agriculture and the overall economic system. It is the source of resiliency and regeneration and necessary for the sustainability of agricultural systems (Dahlberg 1987). Agrobiodiversity is the ultimate basis for local self sufficiency, as well as being a global asset, and benefits people materially in more ways than we realise. The boundaries between biodiversity and agrobiodiversity are not clearly demarcated. All biodiversity is potentially of use to agriculture (Srivastava at al. 1996). Agriculture is dynamic and the interface between domesticated plants and animals and wild species is constantly shifting. Biodiversity conservation is not only a matter of conserving natural habitats and the wild plants and animals therein but also the different kinds of agricultural system.

time, transforming traditional farming using conventional strategies may cause loss of agrobiodiversity. In fact, there are reports that agrobiodiversity has already started to decline in parts of the HKH region (Sharma 1996, Pei 1995). So far, we are not in a position to assess this loss to a precise degree in terms of Himalayan agriculture - whether for agroecosystems or all species or sub-species' levels. As yet, the potentials, in terms of ecological and economic values of mountain agrobiodiversity, for the people living in the region and for global food security as an important source of crop genetic resources, have not been understood. Our understanding of the spectrum of issues confronting mountain agrobiodiversity is also limited and little is known about the impact of the changing demands of mountain societies on diversity. The lack of precise information concerns not only crops and animals, but also knowledge about the diversity of unique ethnic mountain communities and the dynamics of their agroecosystems. Efforts have been made by certain communities, NGOs, and other conservation-oriented agencies to conserve native crop/ animal genetic resources at farm level. Similarly, attempts at *ex situ* conservation have been made by National Agricultural Research Systems (NARS). But are these adequate or is something more needed?

To answer these questions and to highlight other issues related to agrobiodiversity and mountain farming, a series of studies was commissioned in the Hindu Kush-Himalayan region. The reviews and studies were discussed in follow-up national expert meetings on mountain agrobiodiversity in China, India, Nepal, and Pakistan. The reviews, studies, and discussions are presented in the chapters of this book. They are grouped loosely according to seven central themes that emerged during discussions. Each chapter presents different perspectives and new concerns are identified.

This chapter is an attempt at an overall synthesis of the issues treated in other chapters. In seven parts, the issues range from contributions of ethnic cultures to mountain agrobiodiversity; agricultural transformation processes and their impact on agrobiodiversity ; traditional seed supply systems; state of crop genetic resources' diversity and risks to it in the HKH; concerns related to unique gene pools; neglected potentials of livestock diversity; farmer-led conservation and management of crop Genetic Diversity; and the need for institutional innovations for sustainable management of mountain agrobiodiversity. In addition to the broad spectrum on agrobiodiversity loss and conservation in mountain areas, some thoughts about how to manage agrobiodiversity in the mountain areas are also presented in the chapter.

Management Perspective and Framework

From the farmer's perspective, mountain agriculture includes all land-based activities such as cropping, horticulture[1], animal husbandry, forestry, and the

1 *Horticulture as used in this document refers to the understanding of the word as defining vegetable and fruit farming, primarily as cash crops, and not gardening per se.*

linkages of these and is the prime source of sustenance. The sustainability of this life support system (farming) is, however, dependent on the agrobiodiversity of the region. In fact, it is not the overall diversity of crops and animals found in the mountains that make various mountain agricultural systems sustainable; but rather the species and genetic resources' diversity within each farming system that make them stable. The human factor is most important in terms of maintaining diversity of species and genetic resources within the farming systems. Therefore, in the management approach to agrobiodiversity, the most dynamic factor is the livelihood needs of mountain farmers - the key stakeholders within mountain agricultural systems. The genetic complexity of their subsistence farming systems may be ecologically stable, but this does not ensure economic sustainability. It triggers a process of transformation that may result in loss of agrobiodiversity.

Classification of Mountain Agrobiodiversity for Management Purposes

Agrobiodiversity management is possible only if specific information is made available about it and factors influencing it. General inventories of crops, animals, and their genetic resources may not be of much use. In this respect. The Mountain Perspective Framework developed by ICIMOD (Jodha 1990, 1992) serves as a useful tool suggesting ways to generate forms of mountain agrobiodiversity for management purposes. The mountain perspective framework groups diverse mountain conditions into six key categories called mountain specificities (Jodha 1990). The framework can be used to define various types of mountain agrobiodiversity, which may be useful from the management point of view (Partap 1992). These forms of agrobiodiversity are, in fact, the sum result of the influence of the physical and socioeconomic dimensions of mountain specificities. Table 1 provides details of these and provides guidelines for identifying forms of mountain agrobiodiversity within a given context. An explanation of what these forms of agrobiodiversity are and how can they be used in management is provided in the following paragraphs.

Diversity, the most important mountain specificity, creates physical, biological, and socioeconomic circumstances for generating agrobiodiversity in the mountains. For example, diverse agroecological regimes, ethnic cultures, and farming systems are found in the mountains and all of these add value to agrobiodiversity. From a management point of view, slash and burn agriculture, mixed farming systems, fully irrigated highland cold and dry zone agricultural systems, and pastoral systems represent different types of agroecosystem. Each one of these needs a different management approach in order to balance the use of bioresources with conservation. Diversity and niche, combined together, indicate that there may be several micro niches in mountain areas, resulting in a diverse array of agricultural systems and their components to manage.

Table 1.1: Framework for Identifying Forms of Mountain Agrobiodiversity for Management

	Factors instrumental in generating agrobiodiversity	Mountain specific forms of agrobiodiversity
Diversity	Range of agro ecological regimes and microclimates & ethnic farming communities that have evolved diverse adaptive farming and resource use practices to manage their livelihoods under different biophysical conditions.	Diverse forms of mountain agroecosystems (farming systems) crops, livestock and economic plants, land races of crops and animal breeds, farming communities in mountain agroecosystems, and their Indigenous knowledge/ practices
Marginality	Diverse marginal farming conditions-physical, climatic, biological, and socioeconomic adding to the creation of unique forms of agrobiodiversity (agroecosystems, species, sub-species of crops/ livestock) as part of the survival strategies of mountain people.	- Variety of marginal agroecosystems with varied crops/ animals and their land races / breeds adapted to different marginal farming areas - Range of indigenous knowledge and experience accumulated by local people about use and management of agrobiodiversity in marginal areas
Fragility	- Diverse fragile farming conditions-physical, climatic, biological, and socioeconomic adding to the creation of unique forms of agrobiodiversity (agroecosystems, species, sub-species of crops/livestock). - Physical and environmental circumstances leading to evolution of farming cultures, species, sub-species of crops and livestock adapted to particular fragile biophysical environments and socioeconomic environment	- Unique forms of agroecosystems, crops & anuimal land races and breeds helping local people sustain livelihoods under peculiar circumstances. - Endemic forms of agrobiodiversity-vulnerable because of presence in limited area (microclimates) Native human societies, livestock, and crop land races specially adapted to unique fragile biophysical conditions in some mountain areas and vulnerable because of their narrow ecological range
Niche	- Ecologically and socioeconomically suitable, varied habitats leading to evolution of farming systems, crops and animal breeds. An agroecological niche for crop or livestock species would mean that it would give this best performance under this environment without ecological backlash. - Specific crops or other bioresources of an agroecosystem providing comparative advantages to its farming community	- Niche-based farming systems and their agrobioresources which can make ecologically stable and economically productive agricultural systems. - Crop & animal resources that are most promising for particular agricultural habitats and farming systems. - Indigenously evolved agro-ecosystems for sustaining the livelihoods of native farming communities
Inaccessibility	Isolation-induced , self provisioning innovations of farming communities in terms of use of their agrobioresources in agriculture to sustain their livelihoods	Crops & animal resources of diverse use value for sustaining farming communities
Adaptations	- Genetic resources acquiring genetic potentials in response to changed physical conditions of soil and climate - Farmer innovations to make a living in the diverse mountain conditions of marginality, fragility, diversity	Genetic variability in crops / animals influenced by these biophysical conditions

Source: Compiled by the authors

The framework indicates that diverse marginal agroecosystems and crops – animals-farmers living therein are also an inherent feature of mountain agriculture. While marginal agroecosystems may be identified for their poor regeneration capacity and productivity, the potential of crop genetic resources and livestock surviving in these environments can be interpreted differently. Crops and land races that are frost resistant, cold tolerant, and tolerant of poor soils are among the examples. Mountain crops and livestock adapted to perform well under such unfavourable ecological conditions are valuable components of agrobiodiversity. There may be native species or sub-species of crops and livestock, that can be tools for combatting hunger and poverty, to be found in the untapped agricultural biodiversity of these marginal agroecosystems. Understanding the agrobiodiversity forms of marginal mountain agroecosystems may help to harness them more efficiently (Partap 1992).

The following seven sections are devoted to the state of the art of agrobiodiversity in the HKH. For, unless there is clearer assessment of the processes of change and contributing factors, effective management strategies can not be designed. Further, certain the processes themselves are indicative of the remedial measures required to save components of agrobiodiversity in specific locations.

I. The Contribution of Mountain Cultures to Agrobiodiversity

The general perception of the role of ethnic mountain cultures does not go much beyond considering them as custodians of the crop and animal diversity that they maintain in their farming systems. The way in which agrobiodiversity evolves under the influence of mountain farming cultures is less known. Within farming communities, various forms of agrobiodiversity evolved while making a living from the unique mountain micro-environments. The niches, food cultures, religious rituals, and migration phenomena all contributed. There is a unique diversity of human cultural and ethnic groups in the Himalayan region, but these groups tend to be marginalised by mainstream society. Studies by Ramakrishnan et al. (Chapter 2) found that, in the Eastern part of the Indian Himalayas, these farming communities maintained layers of agroecosystems in the same area. This is a unique phenomenon, in which each farming community sustains a functional niche, and different niches in the same area are used by different tribal communities. Ramakrishnan et al. warn that there is imminent danger to the survival and existence of some of these ethnic farming communities because of their declining numbers. In some ethnic farming communities (tribals), the last few hundred families are struggling to survive. If these communities vanish, we will also lose the agrobiodiversity and indigenous knowledge of which they are the custodians. The processes of change identified in this area indicate that agrobiodiversity in the region is threatened by external factors rather than by reasons internal to the communities themselves. The external institutional response is such that, although these human communities are barely managing to survive, they are expected to bear the responsibilities of agrobiodiversity conservation. The need instead is to enforce strategies that allow native people to benefit from their custodianship of agrobiodiversity.

The role of the different food cultures of mountain people in maintaining agrobiodiversity provides another dimension to the conservation objective. Gurung and Vaidya (Chapter 6) highlight the culture-, caste-, and ethnicity-based variations in food habits and the importance attached to different crop and animal species. The farming communities are identified with different ethnic groups, and they maintain different mixes of crops and animals according to their specific food habits and sociocultural and religious values. Most institutions engaged in agrobiodiversity research only consider the economic and biological aspects. Crop and animal diversity are often linked with the diversity of agro-ecological and topographic variations. Ignoring the sociocultural context may lead to a significant gap in knowledge about mountain agrobiodiversity. Other examples from the highlands of Tibet, the Hengduan mountains of China, and other parts of the HKH region also demonstrate the strong influence of ethnic cultures on both enhancing and maintaining agrobiodiversity (Chapters 3 and 4).

Migration is a common adaptation mechanism in mountain cultures. But do migrating farming communities carry with them their own farming culture and crops and livestock, and what happens to these in the new environment? A case study of the *Li* minority in the Henan mountains in China by Jiang et al. (Chapter 5) has highlighted some interesting facts. Immigration by members of the *Han* ethnic community adversely affected local agrobiodiversity. The immigrants brought with them their own crops and livestock, which in the process replaced crop land races and breeds maintained by the *Li* minority community.

Discussions during the meetings brought to light the fact that the HKH region has a great diversity in human cultures which are instrumental in shaping unique farming cultures, and that there is a wide gap in information on human-induced agroecosystem diversity. Experiences shared in the discussion fora provided insights into the agrobiodiversity maintained by such ethnic cultures. One example was that of the home gardens kept by the minority nationalities in mountain areas of China. Every garden is a unique creation with a complex set of trees, crops, and animals. The composition of species and varieties in these gardens varies greatly among ethnic groups and also between farmers of the same ethnic group. Home gardens are often integrated with fish ponds for breeding fish and other high-value animals such as eels and soft turtles. These discussions indicated that local people have developed immense skills in managing intensive home gardens using diverse bioresources. If research and development interventions for agrobiodiversity conservation management are to succeed, then they may have to consider incorporating farmers' management approaches into the agenda.

II. Transformation Processes in Mountain Agriculture and Implications for Agrobiodiversity

The farm dependent economy of the marginal and small farmers in the mountains has become economically unsustainable. In this context, agricultural diversification is seen as an inevitable process for managing food security and alleviating the poverty of farmers in the HKH (Sharma 1996, Jodha and Shrestha 1994), even though it has also initiated a process of crop replacement and addition. Interesting new facts have been brought to light by the case studies in China, India, and Nepal given in Chapters 7, 8, 9, 10, and 13. These studies highlight the various ways in which Himalayan farmers are influencing agrobiodiversity by diversifying their farming. In Himachal Pradesh, promotion of agroecological zone-based approaches to horticultural development has been successful in bringing about socioeconomic improvement. In this area there was little surplus farm land for new crops, so the conventional cereal crops of buckwheat, foxtail millet, chenopods, amaranth, pearl millet, and finger millet were replaced by fruit crops. In the case of staple crops, such as rice and wheat, new varieties were adopted, thus the crops remained but many land races were no longer grown. Not only crops were affected, the local breeds of livestock were replaced with new ones to fulfill the need for the new cash crop-based farming system. Sharma's investigations (Chapter 8) reinforce the point that a niche is dynamic and has the potential to change in structure and form through new knowledge. Sharma identified two other factors that facilitated the success of cash crop farming. These were political commitment and institutional support. His study identified the conflict of global and local interests; loss of agrobiodiveristy is considered to be a global interest and improved income from the new crops a local interest. Farmers will not ignore opportunities to improve their level of living and may not be interested in the strategic reasons for conserving the rich agrobiodiversity they possess. Such circumstances indicate the need for immediate ex *situ* conservation measures for endangered crops and to perpetuate the diversity of livestock resources in these areas. In the long term, the challenge to researchers is to develop equally remunerative crop resources from the local species, keeping in mind that there can never be a reversal to the old pattern of subsistence farming with the former crops by these desperately poor societies. These people deserve a change for the better, and conservation needs will have to take this overriding factor into account.

The factors and processes used by mountain farmers when making decisions about agricultural diversification are reflected in the long experience of Mr. Dhani, a mountain farmer from Himachal Pradesh, described in Chapter 10. His decisions about crop replacement and new crop choices reaffirm that farmers' decisions about crops are influenced by market opportunities, and that addition and replacement of crops are part of a continuous and dynamic process. Farmers see the transformation process not necessarily as reducing crop diversity but rather a replacement of those crops that do not offer any comparative advantage for maintaining livelihoods on farmlands at a given point of time.

Crop replacement during commercialisation of hill agriculture is not universal. The study by Lohar and Rana (Chapter 9) revealed that local germplasm and diversity are not necessarily totally replaced when commercial varieties are introduced. Farmers do manage additional diversity by readjusting their growing area if they find new materials useful. Commercial and subsistence farmers coexisted in the same area and complemented each others' efforts in terms of crop diversity at village level and introduction of new cropping opportunities. Traditional crops were maintained, although in a smaller area than before. There is evidence to suggest that genetic erosion is not necessarily associated with agricultural development. Certain vegetable crops, such as carrots, cabbages, cauliflower, and several others, were not grown traditionally by farmers and are definite additions. This was not true for field crops. The study highlighted the fact that the cash crops and varieties grown in transforming areas are usually introductions, whereas the original subsistence crops and varieties are grown in relatively non-transformed areas. This is because once farmers change their farming to commercial agriculture, their mindset is towards seeking more productive and profitable crops and varieties. However, the evidence presented by Lohar and Rana shows that technological interventions and commercialisation can also add to the Genetic Diversity at least temporarily, since farmers do not abandon their old land races until the performance of new ones is known to be reliable.

Often the interests of mainstream society that are reflected by interventions add new risks to the agrobiodiversity of mountain production systems. Wu Ning (Chapter 12) gives the example of the deterioration of yak-based agropastoral systems and agrobiodiversity in the highlands of Tibet resulting from inappropriate policy regulations framed by the government that favour the outside consumers of the produce. The knowledge and skills of agropastoralists in managing traditional pastoral production systems favoured extensive but low intensity use so that the land remained stable for a long time. However, intervention strategies imposing borrowed western perceptions of ranching without understanding the regenerative and carrying capacity of these unique fragile marginal agroecosystems. Farmers were forced to adopt intensive use strategies, and these have led to biological impoverishment of the pastoral-ecosystem and a trend towards loss of sustainability of the nomad economy. After 1980, the Government of China recognised the need for corrective measures and reformed overall policies to encourage market-oriented private sector initiatives and investment. Communal livestock were redistributed among the nomads. Traditional private trading of animals and their products, prohibited since the 1960s, was liberalised during the 1980s. However, the prices of livestock products produced by highland Tibetan pastoralists were kept artificially low through a strong price control mechanism to benefit urban consumers in Lhasa and elsewhere. In order to maintain their standards of living, nomads resorted to overstocking and defying regulations at the expense of degradation of marginal pasture lands. This initiated the erosion of a useful and diverse species of animals and plants within the agropastoral ecosystem. The lessons learned from China's case suggest that, unless institutional safeguards ensure favourable terms of trade for the products of marginal and fragile agroeocsystems, these systems will remain prone to degradation through overexploitation of their carrying capacity and diverse bioresources. This example also reflects the intentional undermining of the needs of marginalised mountain farming communities by mainstream society, causing loss to agrobiodiversity within these agroecosystems.

Institutional interventions at the local, provincial, and national level sometimes overreact in favour of environmental and biodiversity conservation, undermining the genuine needs of local communities. This enthusiasm is exhibited, for example, by afforestation measures that do not consider the needs of local inhabitants. By involving the local community, the same objectives can often be achieved while fulfilling the needs of the local people. A project in the Tiahang mountains of China made good use of local economic plant diversity for rehabilitating a marginal area (Chapter 11). Among the 348 species or varieties tried at the location, only 50 were used successfully. An interesting aspect was that afforestration *per se* did not interest local farmers much, for they could not realise any economic gain from these plantations. But when farmers were encouraged to plant fruit trees, they became motivated. The productivity of traditional walnut forests was improved by encouraging farmers to graft improved walnut scions on the trees. High-value medicinal plants (woody and herbaceous) were promoted as intercrops with timber plantations. The approach helped balance the conflict between strategic national interests (the need for afforestation) and the practical needs of the local people. As a result, this degraded marginal ecosystem was rehabilitated successfully. In Chinese terms, establishing Economic Forests (the term used in China for fruit orchards and other perennial commercial plantations) is a sustainable option for replacement of declining Natural Forests, accommodating both ecological and economic needs. From the agrobiodiversity perspective, the message is that the approach should be to promote local plant species of economic value. Combining afforestation with an agroforestry approach not only raises crop yields, but also provides additional sources of income. Examples show that carefully planned crop additions do not always replace other crops in agroecosystems. The new crops can have their own niche and play a complementary role.

However, there are not many examples of such efforts that are both ecologically and economically desirable. The only other case identified in the Hindu Kush-Himalayas, in which conservation of crop genetic resources was achieved through an ecologically and economically sustainable traditional production system, is that of cardamom farming in the forests of the Sikkim Himalayas (Chapter 15). Full details of the sustainability of cardamom farming and the effect on farmers' livelihoods are given in an ICIMOD study by Sharma and Sharma (1997).

The issues related to the impact of mountain agricultural transformation processes on agrobiodiversity are complex indeed. The positive and negative impacts indicate that, with fine tuning of the development approaches for agricultural systems, it should be possible to fulfill the practical economic needs of the farmers while even enhancing the level of agrobiodiversity both within and between agroecosystems.

III. Mountain Farmers' Traditional Seed Supply Systems: Value and Sustainability of Agrobiodiversity

If seed is the first source of Genetic Diversity and the means of on-farm conservation, then traditional seed supply systems are vital to the sustainability of subsistence farming, and to the conservation of seeds of a variety of native crops and land races. Diverse seed supply systems have evolved through different ethnic farming cultures in the mountains. This evolution has come about through generations of trials of institutional arrangements to ensure a secure supply of seeds for crops. In Nepal almost 90 per cent of the seed requirements for major food crops and 100 per cent for minor crops are met by farmers' own seed production and supply systems (Shrestha, Chapter 14). However, formal research and development interventions related to seed supply systems are undermining traditional seed supply arrangements and, particularly, the role of women as custodians. Shrestha found that the informal seed supply systems were of direct benefit to farmers. Strengthening traditional seed supply systems requires re-examination of policy regulations undermining informal seed supply, including relaxing the regulations on crop variety testing and release systems. Shrestha advocates promoting the continuation of traditional farmer-to-farmer seed supply systems, in which women are the main actors, as these systems are more reliable, cost effective, and sustainable. The formal system better serves when designed to complement the informal systems but may contribute to the erosion of indigenous crop diversity if promoted as an alternative.

Farmer-led domestication of crops is an important contributing factor to agrobiodiversity. Sharma and Sundriyal (Chapter 15) give an example of a farmer domesticated crop - cardamom – in Sikkim. The *Lepcha* pastoralists of Sikkim identified large cardamoms in the forests, selected the best varieties, and domesticated the species around homesteads with similar habitats. Over the centuries, they passed on the knowledge and information about cardamom farming to other ethnic groups such as the *Bhutia*(s) and *Nepali*(s). Today, cultivation of large cardamom has expanded to the adjoining hills of Darjeeling, Bhutan, and eastern Nepal. Vegetative clones of cardamom have been maintained and shared through an informal farmer-to-farmer network. The system is well-established and widely used.

The informal seed supply system may be more efficient and dependable than the formal seed supply system, even for introduced crops. This is explained by Sharma and Sundriyal (Chapter 15) using the example of the ginger crop introduced in Sikkim. Ginger is a vegetatively propagated crop like cardamom. Farmers first used to receive seeds from the government extension agencies - for they did not have the knowhow to select and maintain quality rhizomes. Then a few farmers started producing quality rhizomes for seed, and this led to direct exchange and supply from farmer to farmer. In the process, informal institutional arrangements for ginger seed (rhizome) supply evolved. Today, the weekly market system is the key to the informal seed supply system for ginger in Sikkim. Here, farmers sell and buy ginger rhizomes to plant their next crop. In other words a new crop has been incorporated into the informal seed supply system. However, the genetic uniformity of this new crop will soon cause a decline in crop yields. There are comparative benefits in maintaining both types of seed supply systems to manage both the native and exotic components of crop diversity.

The seed regulatory framework also needs a new direction. There are procedural problems. Discussions during the expert meetings highlighted the fact that *Variety release committees* are subject to professional biases and jealousies, interpersonal rivalries, and ideological stances and that personal and prestige factors often play a role in crop varietal release decisions. One possible way of introducing reform may be to re-examine the standards and criteria used by the release committees. When choosing which cultivars to grow, farmers pay more attention to the total value, rather than to the absolute quantity of yield. It is worth exploring how the voices of resource-poor mountain farmers can have more influence on the selection of crop seeds and their varieties. One reason why it will be worthwhile is that this will add to agrobiodiversity, because farmers will be looking for varieties of crops adaptable to the diverse agroecological microclimates they inhabit. But farmers' priorities will have to be included from the beginning of the plant breeding process, rather than only at the release stage, when many appropriate materials mcy have already been eliminated. If a plant breeding programme has developed a variety that is appropriate for a significant group of farmers inhabiting a particular microclimate, but does not meet all the official release standards, there should be mechanisms for accepting the farmers' choice. In this way breeders can enhance agrobiodiversity by releasing many varieties of a crop, suitable for diverse ecological conditions, from a single crop varietal breeding and selection process.

Unlike in other developing countries, seed is the focal point in the Chinese plant breeding, varietal testing, and release system. There are well-established, public sector seed multiplication and supply systems at the grassroots' level (Jiang and Liu, Chapter 16). About 85-90 per cent of the hybrid rice and corn seed requirements in the country are met by the formal system. Government seed companies maintain a monopoly on seed production and distribution for staple crops. Seed supplies by private companies/traders are non-existent in China because the seed regulatory framework[2] does not permit it. Unlike in other countries, the government owns the land, but farmers produce and sell seeds to the government. This is not to say that the mountain farmers of China did not have a traditional seed supply system, only that the original system has been disrupted.

During the expert meetings held in China, India, Nepal, and Pakistan, many issues were raised related to aspects of seed supply. A principal concern was the inability of the formal sector to support resource-poor farmers, as there was no provision for multiplying seeds of neglected minor and marginal crops or traditional vegetables. The research and development institutions of the HKH countries convey the impression that local land races are always inferior and a symbol of subsistence farming. In China, the traditional seed supply system was disturbed by the Cultural Revolution. Some farmers from productive areas have lost their natural instinct for seed selection and their ability to make their own decisions on farming issues. This has important implications, for there are few examples that show clearly when farming communities lose their indigenous knowledge and instincts. From the discussions held, it emerged that some mountain farming communities in remote areas of China are still maintaining seeds of minor crops and vegetables and the traditional exchange systems.

The gender roles in seed supply systems in mountain areas are specific to ethnic cultures. In this context, women farmers in mountain households play a crucial role in maintaining the seeds, farmer to farmer seed supply, and transfer of associated knowledge and skills. In Xingang province, male farmers play an important role in seed maintenance, whereas, in Henan province, women farmers are the key players. Women farmers enhance germplasm use by learning from each other about different ways of preparing food from particular crops, that encourages them to continue to grow minor crops on their farmlands. A better understanding of who maintains, improves, and supplies the traditional crops and who plays an important role in on-farm conservation may help to provide clues for formulating appropriate conservation strategies.

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2 *These are the laws, rules, and operating procedures that determine how varieties are tested and selected; when varieties can be released to farmers; how seed is produced and certified; and how seed can be sold.*

IV. Diversity and Risks to Crop Genetic Resources in the HKH Region

The scale of diversity of crops and land races in the HKH and the risks many of these crops and land races are facing are highlighted in this section. As an example, the North East Indian Himalayas cover about 38 per cent of the area of the Indian mountains. This area is a gene pool for several unique crops, land races, and their wild relatives. Upadhyay and Sundriyal (Chapter 17) describe the wide range of bamboo species found in this region. Bamboo is the life-line of the eastem Himalayan tribal people. They eat bamboo shoots and use the mature plants to construct houses and to make various income-generating goods such as baskets, furniture, and reeds.

The eastern Himalayan area is inhabited by tribes of Tibeto-Burmese stock who grow the primitive land races of rice appropriate for local conditions. Upadhyay and Sundriyal report a number of rice land races having special value and important agronomic traits, e.g, the black rice of Manipur and the scented land races *Pyapon, Horipuri,* and *Moyatsuk*. Some land races, *Batlong, Lyngsl, Pawnbuh, Bangnapdai,* and *Asienke,* are high yielders grown in upland conditions. Land races such as *Amiong, Addy, Changpalman,* and *Pyare* are adapted to drought and stress. Similarly, *Nemo, Maidangahu, Amo, Pangnaka,* and *Leitalbuhban* have a specific ability to tolerate *Fe*-toxicity. These land races have added value for targetted breeding programmes.

A glimpse of the richness of agrobiodiversity in Nepal is given in Chapters 19 and 20. Case studies on rice, barley, finger millet, grain legumes, and green manuring species (Joshi et al. Chapter 19) show that a number of factors, independently or in combination, may be contributing to the genetic erosion of crops in Nepal. The degree of erosion varies with the crop, the focus of national research programmes, and the location-specific circumstances. The Genetic Diversity of finger millet, barley, *ghaiya,* and grain legumes is still high because only a limited number of improved varieties has been released for these crops. However, genetic erosion of millet and *ghaiya* crops in Pokhara Valley is high because of labour constraints. Varietal replacement by farmers and changes in habitat are the main reasons cited for the disappearance of rice land races. It is often considered that exotic cultivars are mostly responsible for the genetic erosion of land races. The case study of rice diversity in Pokhara Valley shows that traditionally farmers always replaced poor performers with better land races. This study also collected evidence of the decline in the traditional practice of growing *Kaude*[3]. Local land races, such as *Mansura* and *Gauri,* have adapted over the

3 *This is the local practice, in Kaski and Tanahun districts, of growing rice by mixing seedlings of two to three rice land races. Mostly Kaude is composed of Aapjhutte + Mansara, Tulasi + Mansara, Bhangere + Mansara or Jetho Budho + Ghaiya. The farmers consider that Kaude yields better in marginal environments and bad years.*

years to rainfed drought cóndîtions. These have been replaced by superior exotic or more productive local land races under irrigated conditions. Similarly, high quality, scented rice varieties, such as *Samunderphinj*, *Brimphul*, *Tulasi*, and *Ramani*, have either been replaced or marginalised by more productive local cultivars.

If the genetic values (of ecological and economic significance) of land races maintained by farmers are ignored, then the erosion process of these land races will continue. Nepalese farmers used to maintain a diversity of green manuring species; but with the wider use of inorganic fertilizers, farmers' knowledge about plant resources for and processes of manuring is now eroding. In the past when the forests were not degraded, farmers widely used green manures processed from plants such as *ankhitare* (*Walsura trijuga*) and *siplikan* (*Euphorbia royleana*). Today, this knowledge is no longer used because the plants are no longer available. *Adhatoda vasica* was another widely used green manure for rice crops, but its use has declined markedly during the past two decades and few among the younger generation even remember it.

The institutional capacity for conservation of crop genetic resources was considered. It became clear that, although the Nepal Agricultural Research Council (NARC) maintains programmes for collecting, characterising, and evaluating the plant genetic resources, the poor institutional and financial capabilities of this organization mean that the potential benefits of these resources cannot at present be realised within the country (Upadhayay, Chapter 20). Some germplasm has been preserved *ex situ* for future generations. Because of poor facilities, most germplasm is stored in gene banks outside the country and is not easily accessible for local researchers and farmers.

Considering the importance of wheat crops for global food security and the need for maintaining gene pools of wild relatives and land races of the crop, the HKH region has a special place. The Pakistan mountains are home to two of the three major global wheat types (Bhatti Chapter 22). The mountain areas of Balochistan are specially known for tetraploid and hexaploid wild wheats. The local genetic populations of wheat are not only different in morpho-phenological characteristics, they have also adapted to saline and drought conditions and are thus a valuable source of genes. The local wild wheat, *Aegilops squarrosa*, has genes resistant to stem rust and leaf rust. *Aegilops triuncialis* is restricted to a microclimatic niche in the north-east of Quetta and also contains genes resistant to leaf rust and stem rust. Bhatti also describes the special case of foxtail millet in which the Indus River acts as a barrier to distribution. The two sides of the river harbour two distinct types of millet, the Asian types on the east side and the Western types on the west side. The Hindu Kush mountains are also home to wild gram, *Cicer spp*. A small locality near Barmoghosht is an important gene pool site for the wild chickpea, *C. microphyllum*. Usually cultivated chickpea varieties have one pod per peduncle, but this newly discovered wild species produces three pods per peduncle. This is a rare heritable trait of much significance for improving yields of chickpea crops. Similarly, northern mountain areas of Pakistan and Balochistan are home to a variety of land races of apricots, walnuts, mulberry, pistachio, and several other fruit plants, and many of these genetic resources are growing unprotected in wild habitats (Ahmad, Chapter 23).

Crop Genetic Diversity has been a part of subsistence farming in the Himalayas for centuries, but within the span of three decades considerable erosion has been witnessed. Crops are waiting for institutional initiatives to save them from extinction (Partap et al. 1998). Field investigations by Maikhuri and colleagues in the Central Himalayas (Chapter 24) revealed that some crops, such as Perilla *(Perilla frutescense)*, horse gram *(Macrotyloma uniforum)*, and *Vigna* spp have been completely replaced by modern high-yielding varieties (HYVs) of soybean and pigeon peas. More than 80 per cent of the buckwheat has been replaced by income generating kidney beans *(rajama)*, and traditional barley growing areas are now cultivated with improved mustard crops. In other areas, agricultural diversification has helped convert the marginal farmlands where original crops were grown into remunerative fruit orchards (Partap 1995). The study also revealed that crop diversity is far more important in rainfed marginal farming systems than in irrigated areas. As a result, farmers in rainfed areas know more about on-farm management of crop diversity. Farmers in the central Himalayas with irrigated land grow only four to five staple crops, whereas those with rainfed land grow as many as 20 to 30 staple crop species. Similar evidence has been provided by Joshi for horticultural and vegetable crops (Chapter 21). Local biodiversity has been used to domesticate several vegetable and fruit crops to meet the food security needs of the local population.

Several mountain crops in the HKH region are neglected and under-used by research and development programmes and are in the process of being replaced. These minor crops play a key role in the food security of many resource-poor mountain farmers (Partap et al.1998). These crops and the custodian farmers are both strongly associated with marginal farming environments with a combination of poor soils, unreliable rainfall, difficult topography, and degraded lands and poor access to markets. Such crops require institutional support for research and development.

The crops that are grown in both the plains and mountains are called common crops. The mountain dimension of these crops is seen in the land races and wild relatives that have either become naturalised to the mountains or are natives to the area. Yanglong and colleagues (Chapter 25), using soybean as an example, discussed issues concerning common crops. The soybean crop in China has rich diversity, mainly because farmers have been cultivating soybeans in a wide range of environments. Chinese soyabean germplasm is known for its high protein content. There are more than 350 accessions of wild soyabeans that have a protein content of more than 50 per cent. Genetic erosion of these varieties is taking place and will continue if national breeders fail to improve the traits of land races to make them attractive to farmers. This example reiterates that breeders need to demonstrate to mountain farming communities that conservation of land races is beneficial to them.

Gao and Hong (Chapter 26) indicate that erosion of genetic resources of common crops has been caused largely by social factors; diffusion of new technology (HYVs); commercialisation of agriculture through diversification into cash crops (which largely replaced cereals); the changing land-use preferences of farmers; the government allowing urbanisation and development of industry on crop land as well as in natural gene pool habitats. In China, the wild rice species, *Oryza rufipogon,* is endangered and the populations of *O. officinalis* and *O. meyeriara* are on the verge of extinction (Gao and Hong, Chapter 26). Seventy per cent of the 10,000 crop germplasm accessions of rice collected by the Sichuan Academy of Agricultural Sciences, Chengdu, are land races from Sichuan. Since 1950 all these land races have been replaced gradually by only five major rice varieties.

The widespread use of core parents for hybrid varieties raises questions about the stability of crop production and the threat of disease or pest attack. Such problems occur more easily in the marginal farmlands of mountain areas. It seems likely that rice and wheat crops could face this problem. The principal threat to yield stability for the genetically narrowly-based modern varieties is the increasing uniformity with continuous cropping. The issue here is whether research policy aimed at developing one or a few super hybrids for use in all the different kinds of agroecological conditions found in mountain areas is a sensible strategy? Surely the main reason for the popularity of the hybrid crops' approach in China was the government policy of punishing research institutes that failed to produce widely-adapted varieties. Several other countries in the region adopted other means to achieve the same goal.

V. *Ignored Potentials of the Diversity of Farm Animals/ Insects*

The HKH farming communities maintain a wide array of livestock species that they use for sustaining livelihoods in different ways (Joshi and Rasali, Chapter 27). Animals, such as yaks in the trans-Himalayan cold dry zone, mithun in the eastern Himalayas, donkeys in the highlands of Ladakh, and bullocks in the wet temperate Himalayas, are the backbone of mountain farmers' livelihoods. The livestock diversity of mountain farming systems contributes to food security and is a vital source of energy for agricultural operations (Singh 1997). However, the potential of indigenous livestock diversity in mountain farming cultures remains unexplored. Eight breeds of cattle and 40 breeds of sheep and goats are maintained by farmers in the mountain areas of Pakistan (Pirzada , Chapter 28). Many indigenous breeds of dairy goats, camels, and donkeys are known, but many more have not yet been listed.

Conservation of the diversity of mountain livestock may require a change in the mindset of planners and development institutions requiring them to look at value addition to the products of these animals to enable farmers to continue husbanding them. Joshi and Rasali (Chapter 27) cite some examples of high-value products obtained from mountain farm animals. Typical examples for which the values are already known include *pashmina* (fine wool for shawls) from *Bhyanglung* sheep, *chhurpi* (dried cheese) from yaks, meat from *Chhyangra* and *Khhari* goats, draught power from bullocks, and transport work from mules and donkeys. The most important value of indigenous mountain livestock races is their ability to thrive under the poor nutritional conditions on marginal mountain rangelands. The *Dhanni* breed of cattle from Pakistan, for example, is very agile and thrifty, and the bullocks of this breed are preferred for ploughing. Similarly, there are native stocks of camels, donkeys, and mules with special attributes that enable them to survive in difficult mountain environments (Pirzada, Chapter 28). In Nepal, China, and northern India, *Chauri*(s) (yaks/naks), sheep, and goats are used as pack animals because these animals have acquired special characteristics and are adapted to the difficult mountain environment.

Introduction of high-yielding milk breeds of dairy cattle of exotic origin is a common strategy. in the Pakistan mountains. Friesian and Jersey breeds of cattle, the *Ramboullit* breed of sheep, and *Sahiwal* and *Red Sindhi* cows are becoming popular among farmers. There are indications, however, that past attempts to increase livestock production using exotic breeds had limited success. However, the genetic potential of the indigenous stock is deteriorating as a result of unplanned breeding and negative selection practices. Joshi and Rasali warn that there is an immediate need for on-farm conservation of the dwindling populations of endangered, local livestock races, namely *Lulu*, *Achhame,* and *Siri* cattle. The thrust of the national livestock development programmes for all species of livestock has always been to develop crossbreeds. Unfortunately, most exotic animals fail to thrive in the mountain ecosystem of the region as a result of scarcity of feed and the high incidence of disease.

The range of varieties of insects seen in the mountains may also be the result of the diverse ecological conditions that prevail. Our general understanding of the use value of insects is poor, and increasing populations are not considered friendly to agriculture. Nevertheless, recent advances in science and technology look at certain insects as a potential means for controlling harmful insects. The Integrated Pest Management (IPM) approach is still in its infancy, and there are only limited examples of experience with it showing the importance of insects to mountain farmers. However, there are many examples of pesticide failure in Nepal resulting from the development of pesticide resistance. In some cases, pesticides have become more problematic than the pests themselves. Thus the use of 'beneficial' insects to control pests is likely to become more important in the future. There is still much to understand about the role of insect biodiversity for developing comprehensive IPM systems that can be used to limit the use of pesticides (Pandey, Chapter 29). However, sustainable IPM will only be possible if local insects are used rather than introductions. In the HKH region, both farmers and institutions lack awareness of the need for conserving insect biodiversity in order to maintain crop productivity through both IPM and pollination (Partap and Verma, Chapter 31).

Conservation of agrobiodiversity in mountain areas has little chance of success unless the mountain farming communities, the actual stakeholders, are actively involved in the initiatives. Participatory variety selection (PVS)[4] and participatory plant breeding (PPB)[5] are promising options for on-farm conservation of the local Genetic Diversity of land races (Sthapit and Joshi, chapter 30) . In order to be maintained by farmers, genetic resources must be either competitive with other options a farmer might have and/or contribute to food security and farmers' income. Value addition to crop resources can be achieved in two ways: (a) the material itself may be improved, or (b) the value of the product or the demand for the material or some derived product may be increased. The former means developing improved quality, disease resistance, yield, taste, or other preferred characteristics through participatory plant breeding and variety selection. The latter includes adding value to crops by better processing, storage, and marketing methods to increase the benefits that farmers receive.

Mountain farmers' participation in plant breeding is a relatively new idea and, as yet, there are only a few examples of successful programmes. Sthapit and Joshi (Chapter 30) describe the successful experience of a pilot programme for on-farm conservation of genes and the process for participatory plant breeding. The on-farm experiment in two highland villages, Chhomrong and Ghandruk, in Nepal, demonstrated the way in which value flows from the farm household to village society to farm household, acting as an incentive for maintaining Genetic Diversity. The project entailed minimum use of resources, using farmers' knowledge, developing farmer-preferred varieties, and enhancing the Genetic Diversity of

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4 *PVS is the selection by farmers of untested genotypes in the target environment.*

5 *PPB is the selection by farmers of genotypes from segregating generations.*

rice. The findings of the study indicate that if genetic resources are going to be conserved *in situ*, this must happen as a spin-off of farmers' productive activities. This means that *in situ* conservation must be put into the context of the agricultural development interests of the farmers.

When land race x modern cultivar crosses are used, and there is maximal farmer selection in the target environment in an early stage of segregating lines, then the breeding strategy most closely resembles the *in situ* genetic conservation of land races. The study by Sthapit and colleagues established that the value of the new PPB product was improved compared to Chhomrong *Dhan* because the grain was white and the straw quality better. These traits were incorporated from the exotic parent. It is a documented case showing that PPB can contribute to the achievement of development goals and that, at the same time, it can act as a dynamic form of *in situ* genetic conservation securing the survival of genetic resources on-farm in mountain areas. PPB also has the potentials to enhance agrobiodiversity, as the process leads to the development of different varieties by different farmers.

Farmer-led *in situ* conservation initiatives may be an imperative rather than an option, especially since farmers are the stakeholders. Using an example of ongoing loss in the Genetic Diversity of Himalayan honeybees, Partap and Verma (Chapter 31) explain the need and scope for involvement of farmers in promoting the wider use of bees for pollination of their cash crops. As a by-product, this approach will have ensured the *in situ* conservation of the endangered Himalayan honeybee. The authors explain that the Himalayan honeybee, which once dominated beekeeping in the HKH countries, has lost much of its habitat to the introduced European honeybee, *A mellifera*. The logic of farmers and extension agencies is simple. The European honeybee produces more honey, so the Himalayan honeybee will be replaced. The fact that the European honeybee is not cold resistant, and thus cannot pollinate early flowering high mountain (cash) crops, has been overlooked. There is increasing diversification to cash crop farming, and farmers need to manage pollination of these crops to achieve better yields and quality. Severe productivity decline as a result of failure of natural pollination has already been reported from apple farming areas in Himachal Pradesh (Partap and Partap 1997). Farmers in the Hengduan mountains, Maoxian county, China, are already practising manual pollination of their apple orchards on a large scale. Every flower in a hundred kilometre-long valley of apple orchards is hand-pollinated (personal observation of Partap). Fortunately, the Himalayan honeybee performs better as a pollinator than the European bee under the temperate, mountain climatic conditions. This is the basis for promoting wider use by farmers of the endangered Himalayan bee.

The inference of these experiences is that public interventions are still needed, but they need to be designed differently using the perspective of conservation with development. In the honeybee case, for example, a new policy is needed which focusses on research and development on pollination using the Himalayan bee, thus evolving a synergy between development goals and conservation objectives.

There may be practical reasons why mountain farming communities no longer feel obliged to consider conservation of crop Genetic Diversity and agroecosystems for national institutions and the global community. However, there are a few examples within the HKH region of initiatives in which farmers have made efforts to link *in situ* conservation of crop land races with improved productivity. One rare initiative was started by the farmers in a few villages in the Indian Himalayas (Singh, Chapter 32; Jardhari, Chapter 33). These farmers, spurred on by a near total loss of crops resulting from problems associated with the introduction of a limited number of 'improved' crops and varieties with a narrow genetic base, are now developing a unique institutional process to save their traditional crop land races through on-farm conservation, management, and utilisation. The *'Beej Bachao Andolon (BBA)'* or *Save the Seed Movement* of the Garhwal Himalayas is working to save the traditional land races of rice, beans, and neglected crops such as amaranthus. *'Save the Seed'* is an informal movement, not a formally institutionalised campaign. The initiative is based on the premise that the best way to save traditional seeds is to encourage farmers to continue growing them in their fields. Farmers will do this if they see an ecological or economic advantage, and finding this is the challenge. The efforts of BBA also focus on saving practices such as *Bharanaja* [6]. The BBA has successfully portrayed the value of traditional practices like this and is promoting their continuation. Comparative crop yield experiments organized by the BBA using HYVs and land races grown under marginal farmland conditions have shown the superiority of several local land races when grown in these specific, marginal and fragile farmland environments. The BBA aims to revive the use of indigenous land races in local habitats. The experiences gained so far by the BBA indicate that it is possible to combine agrobiodiversity conservation with agricultural productivity and improvements in the livelihoods of farmers .

VII. *Recovering the Lost Ground: Reshaping Institutional Responses*

The issues raised by the sustainable development paradigm have provided an opportunity for questioning some of the basic premises of past conservation and development thinking. We are entering the process of acculturation of science.

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[6] *Baranaja literally means twelve grains, and is a traditional practice in the Garhwal Himalayas in which farmers grow a mixture of twelve different crops together on a piece of land. The mixture is dominated by finger millet and includes buckwheat, amaranth, black gram, black soybean, horse gram, rice bean, faba bean, sorghum, foxtail millet, kidney beans, and cleome. Foxtail millet matures when other food stocks are almost depleted, and the other grains ensure a variety of produce and production sustainability under the unpredictable rainfed conditions*

The skills and knowledge of communities following traditional practices that were looked down upon as unscientific are beginning to be understood in a better light. While looking at the problems that emerged with the rapid advancement of agricultural science, Rastogi (Chapter 34) suggested that there needs to be a change in mindset towards greater recognition of the contributions of normal subsistence mountain farmers and inclusion of these farmers in future agricultural research and development on many topics, including averting risks to mountain agrobiodiversity. The argument is that agricultural research and development have tried desperately to cope with the pace of the general development process during the past five decades - and that this has added to the uneven thrusts and impacts of the green revolution. Transfer of Technology (TOT) has had only limited success, and marginal mountain environments have not benefitted. Completing the circle will mean acknowledging the mismatch between the TOT model and the priorities of mountain farmers cultivating small pieces of marginal farmlands.

Scientists clearly recognise the fact that farmers harbour a tremendous range of agrobiodiversity. However, whereas farmers have considered and promoted crop Genetic Diversity over generations as a dynamic resource, scientists think of it in more extractive terms as a static reservoir of desirable characteristics. This is a true reflection of the international mindset in which Herculean efforts have been made to put more and more seeds in deep freeze. Warning against the complexities of conserving agrobiodiversity, Rastogi emphasised that the research agenda will have to overcome the *'efficiency revolution mindset'* which came about as an answer to the *'limits to growth'* approach. In his view, acculturation calls for this conceptual shift of limiting efficiency by sufficiency.

It is important to emphasise that *in situ* conservation does not necessarily imply denial of development opportunities to the farming communities. Understanding of the household dynamics influencing agrobiodiversity is a prerequisite to identifying and containing the erosion processes. Genetic Diversity at species' and variety levels is influenced by both agro-ecological and sociocultural factors. Vaidya (Chapter 35) reported that some communities maintain a larger amount of Genetic Diversity in some crops than do other ethnic groups. For example, members of the *Darai* and *Kumal* castes in Nepal, who inhabit marginal non-irrigated *Tar* lands, maintain a greater diversity of *ghaiya* rice than any other ethnic group in the area. These communities depend on *ghaiya* rice for their survival. Even so, introduction of improved cultivars; market incentives; overexploitation of natural resources; and social factors such as technology diffusion, commercialisation, changing preferences, and government policies, are encouraging the community to discontinue their traditional practices.

On-farm management of mountain agrobiodiversity requires a wide range of management tools from complete protection to intensive management. There is a need to change the perceptions of institutions to include promoting the process of conservation in the mountains through niche-based farming. The concept is based on the principle of harnessing local agrobiodiversity for agricultural diversification. Thakur et al. (Chapter 36) highlight the disincentives to farming *Costus* resulting from a series of external factors. *Costus* or *kuth*, originally domesticated by the highland farmers of Lahul in the Indian Himalayas, was once a thriving cash crop of the area. The disincentives now limit the scope for conservation of *Costus* through farming. The farmers have faced decades of problems of artificially blocked markets, neglect by agricultural science, and ill-conceived ruthless imposition of conservation regulations. Looking at the wider application of the approach of harnessing niches for conservation, community awareness and participation will be required to strengthen the idea of using and maintaining agrobiodiversity at the same time. The problems arise when people try to earn immediate benefits by overexploiting biological resources that are common property from common land. Researchers and policy-makers, on the other hand, are too used to making simple assumptions, associating declining genetic resources with agricultural development *per se*.

As an example of the imbalance of past efforts to mountain agrobiodiversity conservation, when a comparative review of the institutional capabilities for *ex situ* conservation of crop genetic resources in the plains and mountains of China was made, it found that the 20 modern gene banks in the country are all in the plains, and the main collection activities managed by the Institute of Crop Germplasm Resources of the Chinese Academy of Agricultural Sciences are also largely confined to the plains (Yanglong et al, Chapter 25 Box 1). Currently a total of 360,000 accessions are preserved, and 80 per cent of the land races are from the plains. Crops such as rice, wheat, soybean, vegetables, millet, food legumes, oil crops, barley, sorghum, maize, cotton, sugar beet, bast fibre crops, forage grass, tobacco, buckwheat, amaranth, water melon, musk melon, and green manure dominate the collections. The 25 or so field gene banks established to maintain about 20,000 accessions of perennial crop species such as tea, fruit trees, wild grapes, mulberry, rubber, and sugarcane are also located in the plains. The situation for mountain genetic resources is very different from that of resources in the plains. It is only in recent years that programmes to survey and collect crop germplasm have included mountain regions. So far the proportion of germplasm diversity conserved from the mountains is small. *In situ* conservation efforts in mountain areas of China are even weaker.

Management strategies for mountain agrobiodiversity also need to consider the processes and factors behind changing mountain land-use systems. Declining natural habitats may have increased the feeling of responsibility for saving natural biodiversity - with an approach of 'save whatever is left'. It would be pragmatic thinking to see loss of habitat for natural biodiversity as gain of habitat for agrobiodiversity. Sharma (Chapter 38) describes the historical change in land use in a mountain state resulting from a mixture of circumstances that include government policy induced land-use changes and impacts, population pressures, and now opportunities for agricultural diversification on marginal farm lands. It is observed that more natural biodiversity may have been lost in the past because of public interventions on support lands - the common property resources – through which people lost the right to manage but had access to use. Sharma argues that there is a need to change people's attitudes towards conserving the agrobiodiversity of the support lands, forests, and other common property. This is a habitat on which mountain people depend heavily for their livelihoods. Therefore access to use and responsibility for management should go together.

The preamble to the convention on biological diversity has brought about a major shift in the international perception of claims over biological resources. There has been a 180 degree shift in attitude, from one of biological diversity being the common heritage of mankind (for free use by anybody), to one of countries having complete national sovereignty over genetic resources. This change places a great responsibility on national governments who will have to build up the necessary institutional infrastructure, policy regulations, and mechanisms for implementation. Pant (Chapter 39)analysed the issue of responsibility and preparedness of the institutional infrastructure citing the case of Nepal. She highlighted that, in Nepal, the only conservation law that exists for agrobiodiversity relates to non-timber forest products, trade, and export. More relevant to agrobiodiversity will be the institutional framework governing intellectual property rights and farmers' rights, and these subjects have not been dealt with so far. There appears to be no hurry in Nepal to enact any legislation or formulate a policy protecting (farmer) breeders' rights. The official position is that there is no threat of competition in the near future to the farmer breeders of Nepal.

The key observations are: 1) that it is time for national governments in the HKH region to start developing policy formulations to protect farmers' rights, and 2) that there is a need for regional cooperation among the countries of the HKH region to have uniform laws governing agrobiodiversity in the region. Weaker laws or lax enforcements in one country can jeopardise the efforts of other countries in the region. Both IPGRI and ICIMOD can be key players in promoting regional cooperation on agrobiodiversity in the HKH region.

Free sharing of unique mountain crops and livestock genes of high market value is associated with the risk for marginalised mountain communities of losing their comparative advantage. Since genetic resources do not recognise political boundaries, countries in the HKH region may possess much common biowealth (Sahai, Chapter 40). Logically, therefore, the HKH countries of the region should work together to formulate a regional policy on issues pertaining to plant genetic resources. The region as a whole may accept the patenting of products derived from micro-organisms, but nations are advised to refuse to accept patents on micro organisms. There is also a need to accept a *sui generis* system for protecting new plant varieties, but this should not be modelled on UPOV (Sahai, Chapter 40).

Today, the capacity of traditional production systems to provide adequate food security is being challenged. The maintenance of a wide range of local crop land races is threatened by the advent of intellectual property protection for crop varieties, accelerated by the formation of the World Trade Organization (WTO). Intellectual Property Rights (IPR) is a perception of those countries where less than seven per cent of the people depend upon agriculture for their livelihoods; whereas 80 to 90 per cent of the people in the HKH depend upon agriculture. Mass awareness of biodiversity and agrobiodiversity issues is required at all levels. Lack of understanding of GATT/TRIP and CBD requirements among policy-makers is itself a problem. Both policy-makers for the mountain areas and the mountain farming communities themselves need to be made aware of what is happening globally and how it can effect their agrobiodiversity interests.

Sahai maintains that the conditions in UPOV countries and the HKH region are very different, as agricultural research in developing countries is publicly funded and its products remain in the public domain, whereas in developed countries new varieties are the products of private investment. The system of plant breeders' rights (PBR) is acceptable in UPOV nations as seed production and supply in these countries are controlled by seed companies, but in developing countries more than 80 per cent of seed requirements are met by informal seed supply systems.

A further aspect of this debate is the problem of ' *mountain farmers' rights*', the ability of mountain farmers legally to save the seed of a variety, to exchange it with neighbours, and to adapt it to their own growing conditions. At present, these practices could be challenged by seed companies when crop varieties are sold under strict legal protection. It is even possible to envisage a situation in which varieties that originated in remote mountains or highland farmers' fields are legally protected somewhere in the west and then denied or sold at a high price to the same farmers who developed them. Bio-conservationists of the south are advocating recognition of Farmers' Rights (FR) parallel to Intellectual Property Rights (IPR), so that those who have been custodians of material and knowledge for centuries benefit adequately. It may be a noble idea to counter 'gene imperialism', but assessment of the potential value of each resource being exploited is also necessary, so as to attract wider attention to priority action over FR-protection, patenting, conservation, and management.

To counter the negative impacts of global action on mountain agrobiodiversity, countries of the Hindu Kush-Himalayan region should develop a common regional understanding about searching for solutions to the conservation of agrobiodiversity. The HKH countries should not grant Intellectual Property Rights over products and processes derived from the indigenous knowledge of their unique and diverse farming cultures. The rationale behind this is that knowledge and materials that belong to a less privileged farming community should not be made available for privatisation.However, this knowledge should be harnessed for agricultural diversification in the mountain niche for the betterment and well-being of mountain farming communities.

Inferences

Agrobiodiversity and its management in the Hindu Kush-Himalayas are under pressure. Transformation of agricultural systems resulting in land-use changes is having an adverse effect on native agrobiodiversity. The hunger, poverty, resource scarcity, and land degradation faced by a large proportion of mountain households are forcing farmers to look for alternative livelihood patterns. Wherever possible, new crops and varieties are replacing old ones in local production systems. Even though many people know about this replacement process, few of those involved in political and planning mechanisms are conscious of the serious implications this could have on the sustainability of agriculture in general and on the sustainability of mountain farming. The farmers are transforming their farming to achieve better production and more benefits, and traditional agrobiodiversity is the loser in this process. Inadequate technical understanding of mountain agrobiodiversity is another serious limitation to conservation management. Even though the region is considered rich in agrobiodiversity, knowledge of the content and forms is not sufficient for motivating policy-makers or farmers about the value of conserving agrobiodiversity. The main aspect that is lacking currently is economic valuation of mountain agrobiodiversity - how much can it contribute to the economy of the community, nation, and global community, and on what terms? How can we describe the investment value of saving agrobiodiversity and how can farming communities be encouraged to reorient their development thinking along these lines? Until this kind of knowledge and information are available, it will be hard to attract wider attention to the issues. There is also a lack of wider understanding of the management perspective of mountain agrobiodiversity. The economic and ecological potential of agricultural diversity should be harnessed as part of the effort towards sustainable development of mountain agricultural systems. Development of more productive niche-based farming systems using local resources is just one way of maintaining the diversity potential of agroecosystems and crops and their genetic resources.

Within the sphere of agrobiodiversity, concern is mainly focussed on the loss of crops and land races, and there is little recognition of the fading away of diverse subsistence agroecosystems. Many underutilised crop genetic resources may be vital to the survival of some mountain communities. These crop genetic resources should be combined with scientific knowledge to increase their productivity and provide added value. This will lead to double gains - meeting both conservation objectives and development goals. We do not yet have good examples of such developments from this region. Sometimes farmers may have selected land races for practical reasons that are not compatible with the maintenance of Genetic Diversity. We have only partial knowledge about how crops and varieties are publicised and exchanged (seed supply systems) or how to benefit from these systems. Formal institutions have yet to prepare themselves to recognise the role of the farmer as an agent in the introduction of new crops and to work together with farmers to promote these folk crops.

Looking at crop development initiatives, the challenge in plant breeding today is how to address the problems of resource-poor mountain farmers inhabiting marginal environments. The conventional breeding system was developed from a different perspective, that of improving crop production in areas with good potential by focussing on a few key crops. This approach has served its purpose, but it may not offer answers to handling the new challenges. The evidence suggests that the plant breeding strategies and seed regulatory systems in the HKH countries are neither sufficiently responsive to the needs of resource-poor farmers nor adequately adapted to the changing scenario. Seed regulatory systems in particular are inadequate and detrimental to the welfare of small and marginal mountain farmers, and thus do not serve the cause of managing agrobiodiversity.

Weak institutional mechanisms and poor resource allocation are common in the HKH region. Expertise and trained manpower may not be available in adequate numbers for effective research on assessment, economic valuation, and management of agrobiodiversity. There is scope for encouraging regional action and cooperation in evolving and implementing uniform policies and strategies. It is important that strong inter-country cooperation is developed between the countries of the HKH region, whereby smaller nations, such as Nepal and Bhutan, can make use of the institutional and physical infrastructure of bigger countries, such as India and China, as a prerogative.It is extremely important that the issues and challenges of agrobiodiversity are well understood at the political decision-making level so that the course of mountain agricultural development can be redirected towards a synergy with agrobiodiversity conservation. Public awareness is the key to mobilising popular opinion and generating appropriate political action within countries and globally. This may require changes in agricultural development strategies at national and provincial levels to favour the concept of agrobiodiversity management.

Finally, the welfare of the main stakeholders in mountain agrobiodiversity, the diverse mountain farming communities, will have to be the focus of management and conservation actions, whether development of niche-based farming systems - using agrobiodiversity to develop comparative advantages, development of varieties through PPB to suit specific microclimatic conditions on parcels of land, or distribution of benefits from farmers' rights or royalties. These actions may generate interest in protecting their agrobiodiversity among mountain farming communities themselves, thus lessening the burden on outsiders for caring for and conserving agrobiodiversity.

To sum up the whole discussion on sustainable management of agrobiodiversity in the Hindu Kush-Himalayan region, the issues and options discussed earlier are reformulated into the following set of guidelines. These criteria, which use the general principles outlined by Fowler and Mooney (1990), define imperatives of the future course of institutional responses / actions, be they at regional, national or at local level.

i. Diverse Strategies can better safeguard mountain agrobiodiversity: No one strategy could hope to preserve and protect what it took so many mountain cultures, farming systems, and environments so long to produce. Different conservation systems can complement each other and provide insurance against the inadequacies or shortcomings of any one method.

ii. The level of involvement of stakeholders should determine what and how much mountain agrobiodiversity can be saved: Marginal, subsistence mountain farming communities, progressive farmers involved in diversification of mountain agriculture, highland nomadic pastoralists, swidden farming communities, enterprises, commercial companies, research and development institutions at local and national levels, conservationists, and other stakeholders - all have different interests in mountain agrobiodiversity. Therefore, seeking participation of as many of the stakeholders concerned as possible will ensure better scope for conservation.

iii. Mountain agrobiodiversity cannot be saved unless it is used: The value of mountain agrobiodiversity is and will be in its use. Only in use will it be appreciated and saved. Only in use can it continue to evolve, thus retaining its value. Mountain farming communities' interest in conserving agrobiodiversity at the farm level - crops and land races - is generated because of the need for self sufficiency, reduction of risk factors, and several other considerations specific to the communities.

iv. Agrobiodiversity and indigenous mountain farming communities maintain a symbiotic relationship, one cannot survive without the other: Agrobiodiversity within the mountain agroecosystem is a part of the community that has evolved and maintained it. Therefore, it cannot exist for long without the mountain farming community and the circumstances that gave rise to it. Thus, ensuring sustainable livelihoods for the indigenous mountain farming communities is a prerequisite to saving the agrobiodiversity within their agroecosystems. Conversely, these mountain farming communities need to be assisted to save their own agrobiodiversity so as to maintain the sustainable options for food security, self-reliance, and socioeconomic development.

v. *The need for agrobiodiversity maintained by the mountain farmers will never end, and so the efforts to preserve it must also continue for ever.* It is hard to think of a technology that could relieve us of our responsibility to preserve mountain agrobiodiversity, both for our ourselves and for future generations. Thus, efforts need to continue to devise diverse strategies for conservation of agrobiodiversity at the same time as using it. These strategies should ensure the survival of, and better livelihood opportunities for, the mountain farming communities for as long as we want agrobiodiversity to exist.

To have a better chance of success, institutional responses reflected in their new strategies need to take these guidelines into account. Initiatives that ignore or go against these guidelines may not have the chance to succeed for long in saving agrobiodiversity of the HKH region in particular and mountain areas in general.

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