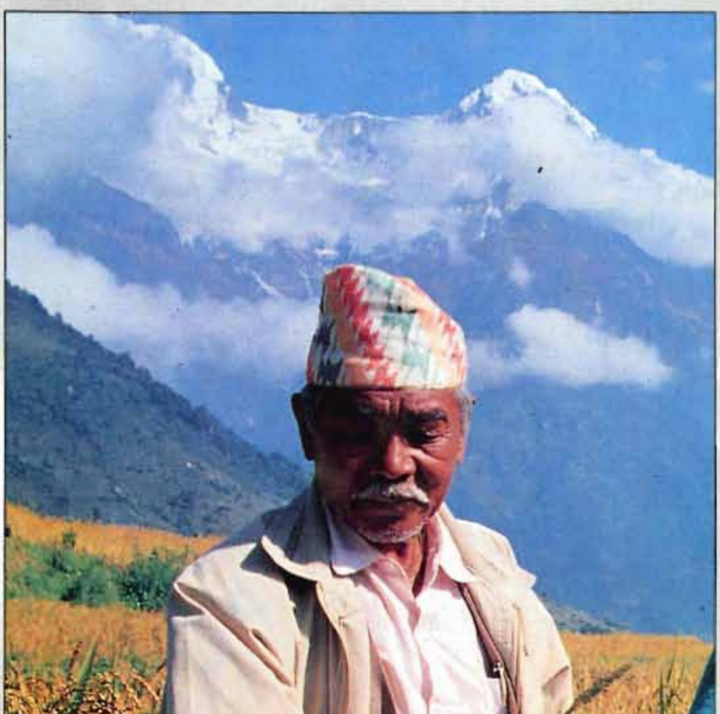
Managing Agrobiodiversity

Farmers' Changing Perspectives and Institutional Responses in the Hindu Kush-Himalayan Region



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Farmers' Changing Perspectives and Institutional Responses in the HKH Region

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International Plant Genetic Resources' institute

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A Pashmina mountain goat, a basket of plums, and grain *Chenopods*
by Tej Partap

Foreword

In the present paradigm of sustainable development, conservation of agricultural biodiversity is a prerequisite to sustaining agricultural production for both global and local food security. Nowhere is this more apparent than in the Hindu Kush-Himalayas which cover an altitudinal range of from 200-8,800m. The Hindu Kush-Himalayan region encompasses diverse environments throughout its span of 3,500km and is one of the important centres of origin and diversity of crop genetic resources. The agroecological diversity of the region has been important in the evolution of diverse farming systems that are built on distinct knowledge systems which the native farming communities tried and refined over generations. These farming communities also developed conservation and management strategies to ensure sustainable use of bioresources.

Subsistence farmers, by maintaining crop diversity and varietal diversity, are the main custodians of local, national, and global wealth in agricultural biodiversity. Indigenous knowledge about management of indigenous agrobiodiversity has been overlooked in the past, but it is now acknowledged as the cornerstone of conservation approaches. The mountains of the region, with their ecological, biological, and cultural diversity, are probably the largest storehouses of indigenous knowledge on agrobiodiversity in the world.

Today, various forces are at work that may result in genetic erosion. These are population pressure, increased aspirations for a better quality of life, urbanisation, and the available modern technologies. They have set in motion a chain reaction for transformation of mountain agriculture — that is now widespread — and only the degree and stages vary among areas. While acknowledging the positive impact these trends may have on absolute and short-term productivity, the unfortunate outcome of this process is likely to have a negative impact on the agrobiodiversity of native agriculture. Therefore, ways have to be found to mitigate this negative impact, and an obvious place to start is with the farmers themselves.

This is not easy, with market mechanisms pushing farmers towards specialisation and monoculture. Incentives have to be created or reinforced to encourage the maintenance of farm biodiversity, even if this means leasing parts of farm holdings for traditional crops. There is an equal concern among many organizations and individuals that indigenous knowledge and local genetic diversity are inadequately valued and reimbursed when used for the development of products elsewhere. In this connection, the term, *biopiracy,* has been used.

In situ conservation of wildlife and natural plant resources in the Hindu Kush-Himalayan region has made considerable progress over the last 10-20 years, and is reflected in the establishment of many national parks and other protected areas. However, there is a risk that these will become islands of conservation in deserts of genetic degradation.

While conventional institutional efforts for *ex situ* conservation of agricultural biodiversity must continue for mountain crops also, what is important is to find innovative ways of *in situ* conservation. Local initiatives, people's participation, and combining conservation with use are some of the important concepts in developing appropriate approaches that can combine maintenance of agricultural biodiversity with sustainable mountain agricultural development. In particular, the knowledge of rural women about plant species should be cherished and their involvement in managing agro-ecosystems sought.

This publication is comprised of commissioned studies and deliberations from a series of mountain agrobiodiversity meetings held jointly by the International Centre for Integrated Mountain Development (ICIMOD) and the International Plant Genetic Resources' Institute (IPGRI) in China, India, Nepal, and Pakistan. We are pleased that this publication will make available the state of the art knowledge and information about agrobiodiversity in the Hindu Kush-Himalayan region, about which so much is heard but little written. The two editors, Dr Tej Partap of ICIMOD and Dr B.Sthapit of IPGRI, had a difficult task in presenting voluminous information in a concise form and we put on record appreciation of their efforts.

We hope this joint publication of ICIMOD and IPGRI will be a valuable step towards creating greater awareness about the global importance of conserving agrobiodiversity and that it will encourage national governments, NGOs, scientific, and donor communities to develop and support mechanisms to maintain agrobiodiversity for the benefit of the world at large and the mountain people of the HKH in particular.

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Editors' Note

The Hindu Kush-Himalayan region is home to unique agricultural systems, crop species, and livestock which help the mountain farming communities living therein to sustain themselves. There can be little doubt that the agrobiodiversity of this region has great potential to provide a fundamental and resilient base for the regeneration necessary for sustainability of not only mountain agriculture and the standards of living of mountain people, but also for the global community in general. Whether these potentials have been properly harnessed so far is debatable. Agrobiodiversity is dynamic, and environmental setting, population and social organization, modern technologies, capital investments, and other kinds of interventions are known to trigger processes that can replace, deplete, or replenish any of its major components, i.e., genetic resources, species, or agroecosystems.

The reports available indicate that agriculture in the Hindu Kush-Himalayan region is in transition. On the one hand, people and institutions are faced with a predominant situation of deteriorating conditions in subsistence farming in which the farm economy, ecological environment and agrobiodiversity–all the three components–are adversely affected. Agrobiodiversity, particularly, faces threats from habitat destruction and replacement through changing land use. Another trend is the adoption of new cash crops by farmers, replacing old ones–leading to commercialisation of farming. In between a range of changing scenarios can be counted. Based on these past reports, it has been our supposition that the HKH region may be experiencing all of the processes described above on different scales and in different areas. Due to the lack of adequate knowledge and information, it is difficult to indicate the extent of loss, replacement, or replenishment of agrobiodiversity in this region. The implication also is that, unless we acquire this information, it is all the more difficult to proceed to discuss approaches to conserve and manage agrobiodiversity in the region.

It was in this context that the Mountain Farming Systems' Programme of the International Centre for Integrated Mountain Development (ICIMOD) and the International Plant Genetic Resources' Institute (IPGRI) launched an initiative to document knowledge and information about the status of management issues concerning agricultural biodiversity in the Hindu Kush-Himalayan region. There were three themes: one–the perspective of agricultural biodiversity and assessment of diversity at sub-species, species, and agroecosystem levels; two–assessing the risks to the agrobiodiversity of the region from agricultural transformation processes;

and three–alternative strategies for sustainable conservation and management of agrobiodiversity.

Having identified the themes, sub-regional reviews and micro-level field studies were commissioned on key topics. The findings were presented and deliberated upon at the National Expert Meetings held in China, India, Nepal, and Pakistan. It was an interesting exercise in which different dimensions of the same issue were presented in different countries. Several institutions, viz. research, development, policy, local NGOs, and farmers themselves cooperated in gathering information on several issues. It is time to thank all of them collectively– without naming each one individually. The following national institutions played leading roles in monitoring the studies and organizing the national meetings: i) Local Initiatives for Biodiversity, Research and Development (LIBIRD), Pokhara, Nepal; ii) National Bureau for Plant Genetic Resources (NBPGR) of the Indian Council of Agricultural Research (ICAR) Delhi, India; iii) Chengdu Institute of Biology of the Chinese Academy of Sciences (CIB-CAS), Chengdu, China; and iv) Pakistan Agricultural Research Council (PARC) and Balochistan Agricultural Department, Quetta, Pakistan.

The outcome of country studies and expert meetings was a collection of 67 papers with more than 2,500 pages of text, each one of them unfolding new information about agrobiodiversity in the HKH region. Each author had done a good job in putting together as much information as possible. The challenge was to compile it into a readable volume in which relevant issues are explained in a crisp and concise manner. It was a challenge to shape the document into the present form of less than 500 pages. In the process we may have disappointed some authors. Some papers were eliminated and key information contained in other papers was presented in boxes inserted into other chapters. Authors will also find that, in almost all papers, background and recommendations have been omitted. Some authors have made liberal use of vernacular and Latin names of crops and animals in place of English names. We decided to compromise by retaining these as such. In some chapters, there are little or no references. Readers may still find references that are not properly cited and we wish to apprise you of this beforehand. In this region, finding reliable references is difficult; and because of this we were unwilling to forego any we had.Our intention in doing so is to present critical information to the reader. The perspectives and recommendations have been discussed in the introductory chapter in which we have tried to synthesise the issues raised by various authors. The 40 chapters in the book are grouped into seven themes presented as seven parts of the book. In addition, the introductory chapter provides an overview of the issues presented by various authors. The idea is not to give advice on how to conserve and manage agrobiodiversity in the HKH region but to improve our understanding of it and what is happening to it.

The book has come into this shape because of the cooperation, encouragement, advice and support the project received from several people and institutions. We thank the authors and participants in the expert meetings for contributing to our knowledge and information about mountain agrobiodiversity. It is an area into which few, so far, have travelled. This made the task of the authors more difficult than we could have imagined at the outset. Country initiatives largely succeeded because of the patronage and interest of some key personalities, namely, in Pakistan, Dr. Zafar Altaf, Secretary, Food, Agriculture, Livestock & Cooperatives and ICIMOD Board Member, Dr. Qazi Azmat Isa, Director, Balochistan Rural Support Programme, Mr. Zulfikar Ali, Director of Agriculture, Govt of Balochistan; in India, Dr. R.S. Paroda, Director General ICAR, Dr. K.P.S. Chandel, Director National Bureau of Plant Genetic Resources and Dr. T.N. Khushoo; and in Nepal Dr. J. C. Gautam, the then Executive Director of NARC and Mr. R.B. Rana, Chairman Executive Board of LIBIRD. Dr. R. K. Arora, Coordinator of IPGRI's South Asia Office in Delhi was very helpful all along and we are especially grateful for his help in identifying people for the studies commissioned. Dr. Tang Ya, Dr. Shaheena Hafeez and Mr. Ajay Rastogi, three ICIMOD colleagues, were very helpful in organizing the national workshops in China, Pakistan and India. We would like to place on record the work of the copy editor and the Publications' Unit, DITS, ICIMOD for the hard work they undertook in bringing the document into shape for publishing. Both of us feel obliged to express our thanks to Mr. Egbert Pelinck, Director General, ICIMOD, and Dr. K. W. Riley, Regional Director, Asia Pacific Office of IPGRI for their constant support and encouragement to us in accomplishing this task.

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Chapter 1

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

T. Partap
B. Sthapit

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

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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 may 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 eastern 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 cónditions. 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

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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Part I
The Contribution of Mountain Cultures to Agrobiodiversity

Chapter 2

Contributions of Ethnic Diversity to the Evolution of Diverse Coexisting Mountain Agroecosystems: A Study of the North East Indian Himalayan Region

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Introduction

As in China, in North East India (NE India) there are large numbers of tribal communities with different linguistic, social, economic, and cultural backgrounds living together in the same geographical region. These communities may be mixed with other communities or living very close to them. Thus, in addition to ecological heterogeneity, human diversity plays an important role in agrobiodiversity. The concept of biological conservation is closely interlinked with the sustainable development and food security of these diverse ethnic groups of mountain farmers. This study reviews the state of ethnic and agricultural diversity in North East India and highlights the inter-relationships among different ethnic communities of farmers. The 255,000 sq. km. area of the North East region of India, which comprises just 7.7 per cent of India's total area, is home to a majority of the indigenous people in the country (more than 100 cultures). The seven states in this region are ethnically and culturally very diverse and distinct from the rest of the country. All the tribal populations have mongoloid features and are of Tibeto-Mongoloid origin. The non-tribal populations have caucasoid features and are of Aryan origin. Some communities exhibit features of both groups.

The Traditional System of Land Use and Tenure in NE India

The tribal communities depend on forests for agriculture. Denial of access to this land simply means withdrawing the means of livelihood from the population. Slash and burn agriculture is practised annually on an area of 3,865 sq. km., and a total area of about 443,336 sq. km. is affected by the practice. The region is rich with variants of slash and burn agriculture on slopes as well as variants in the settled terrace agriculture in the valleys. In traditional tribal society, all the land is owned by the village community or the chief of the tribe (Table 2.1). Normally the village council or the chief of the tribe distributes the available land

Table 2.1: **Differences in Land Use and Tenure Systems in North East India**

State	Main features
Arunachal Pradesh	1. The tribal community has customary rights over its *Jhum* land. 2. Both villages and communities have a right to cultivate land for 5 years. 3. The government only accepts individual ownership of homestead land or land under permanent or semi-permanent cultivation.
Assam Hills	1. There is no private ownership of land except in the Mikir Hills. 2. The tribal community owns the entire land of the village collectively. 3. The resident families possess land according to their capacity for cultivation. 4. The farming families pay a flat tax for using land regardless of the size of the land holding.
Manipur	1. The communal land tenure system operates where hill tribes dominate. 2. A chieftain system of land tenure, in which all land and natural resources are owned by the chief, operates in areas settled by the Kuki Naga tribes. 3. Farming tribes use land and pay a tax (*Changseu)* which varies from 75 to125 kg of grain per *Jhum.* 4. In *Thangkhul* tribal areas, local village councils own and manage land and resources.
Meghalaya	1. The land tenure system is very complicated and varied. 2. By customary law the wife of the *Nokma*[a] is the sole heiress to the *Akhing*[b] land. 3. The managerial rights are exercised by the *Chra*[c] ,and the *Nokma* cannot sell *Akhing* land without the consent of the *Chra.* 4. In areas settled by the Garo tribe, who follow a matrilineal system, the youngest daughter in the family inherits all the property. 5. In the Khashi Hills, land tenure is classified into four groups and follows a matrilineal system. 6. In the Jaintia Hills, land is classified broadly into three groups which are further divided into two to four types depending upon the altitude and value of the land.
Mizoram	1. The traditional Chieftain-based land tenure system was abolished by the State in 1955. 2. At present land property rights are vested with the district councils. The village councils allocate land for shifting cultivation. Settled agriculture and plantation encourage private ownership.
Tripura	1. Individual rights to land are recognised as a result of pressure from migrant populations. 2. The traditional practice of resource management is threatened.

a The *Nokma* is the constituent head of the *Akhing* land.
b A significant area of unclassified forests in the Garo Hills is called *Akhing* land and is owned by different lineage groups.
c The *Chra* is the oldest male in the *Nokma's* wife's lineage.

amongst the families for shifting cultivation on the basis of their capacity to farm. During the course of social development and government intervention, a number of different land tenure systems has emerged in the area (Table 2.1). This variation in the systems of tenure also affects the management of agrobiodiversity, and will influence future strategies for managing biodiversity at the community level in this region.

Agro-Ecosystem Diversity

The diverse ethnic groups have different agro-ecosystems and farming systems which maintain a range of agrobiodiversity. The structure and organization of the agroecosystems vary depending upon climatic conditions, vegetation attributes, topographic conditions and landscape processes, the land tenure systems, and the intensity of external impacts. Thus, *Jhum*[6] agriculture, the most dominant land-use system, has a range of variations. Between eight and 35 crops are grown together and harvested sequentially from July to December. The composition of crop species varies considerably depending upon the environmental niche and the ethnic group managing the land. The crops managed by the *Garos* (a tribe in Meghalaya) are shown in Table 2.2 as an example. Usually both long-term (30 years) and short-

Table 2.2: **Crop Diversity in the *Jhum* System Managed by the *Garo tribe* at Low Elevations in Meghalaya, and the Comparative Productivity of Different Crop species in Different *Jhum* Cycles**

Crop Species	Tuber & rhizome crops		
	30-year *Jhum* cycle	10-year *Jhum* cycle	5-year *Jhum* cycle
Staple food crops			
Oryza sativa	1161	378	66
Sesamum indicum	446	541	25
Zea mays	700	397	30
Setaria italica	193	23	9
Phaseolus mungo	10	-	-
Ricinus communis	5	-	-
Vegetable/fruit crops			
Hibiscus sabdariffa	44	139	96
Hibiscus esculentus	-	50	-
Capsicum frutesence	-	1	-
Lagenaria leucantha	140	81	-
Cucurbita maxima	62	-	-
Cucumis sativa	16	-	-
Momordica charantia	-	5	-
Musa sapientum	-	105	488
Tuber & rhizome crops			
Manihot esculenta	339	1352	690
Colocasia antiquorum	260	294	180
Zingiber officinalis	10	-	-

Source: Toky & Ramakrishnan 1981

6 *Local term for shifting (slash and burn) agriculture in the Indian Himalayas*

term (5-10 years) *Jhum* cycles are practised. Although both the grain yield and overall economic returns are higher from a long-term *Jhum* cycle, *Jhum* farmers in the Khasi Hills prefer the short-term cycle which gives higher yields of leafy vegetables, and tuber and rhizomatous crops, and, in particular, potatoes, sweet potatoes, *Colocasia antiquorum*, *Capsicum frutesence*, ginger, and cucurbits.

Unlike the *Jhum* system, which is confined to specific sloping land areas, valley agriculture is practised throughout the hills and mountains. It is a sedentary form of wet rice cultivation on flat or terraced lands where the nutrient washout from the hill slopes and forest humus keeps the soil fertile. In some areas three crops of paddy are grown and a range of varieties is maintained by the farming community to enable such adaptation.

Home gardens meet a variety of farmers' requirements and provide cash income to the farming households. Members of the *Mikir* tribe are migrants. They cultivate areca nut (*Areca catechu*), betel leaf (*Piper betel*), black pepper (*Piper nigrum*), and banana (*Musa* spp.) in plots of 0.5-1.5 ha per farming household. A legume tree (*Erythrina stricta*) is grown as support for climbing perennials such as betel leaf, pepper, yam, etc. Betel leaf and banana are harvested throughout the year to provide a continuous source of income. The economic returns from home gardens are very high in comparison to those from the *Jhum* system.

The home gardens of members of the *Khasi tribe* at Tynriang are between 1.5 and 2 ha and are more complex and diverse than those of the *Mikir*. New species are introduced into the system to diversify both the use of resources and sources of income. Bay leaf (*Cinnamomum obtusifolium*), betel nut, orange (*Citrus sinesis*), and Jack fruit (*Artocarpus heterophyllus*) tree seedlings are raised in nurseries. Four-year old seedlings are transplanted into the home garden plots in May before the onset of the monsoon. Betel leaf and black pepper vines are introduced two years later. Betel nut, citrus, and bay leaf start to produce fruit after six years (2 years after transplanting) and need replanting after a further seven to 15 years when yields start to decline. Banana, pineapple (*Ananas comosus*), and sweet potato (*Ipomoea batatus*) are cultivated before the tree plantations mature and start bearing fruit.

Traditionally, less labour intensive crops, such as broom grass (*Thysanolaena maxima*), bamboo (*Dendroclamus hamiltonii*), and thatch grass (*Imperata cylindrica*), were grown as cash crops. Harvesting of broom grass takes place once a year for seven years after which the area is replanted with fresh rhizomes to maintain yields. Coffee (*Coffea arabica*), tea (*Camellia sinensis*), and rubber have been introduced recently as cash crops through government intervention. Ginger (*Zingiber officinale*) and pineapple are two other traditional cash crops found in the system.

Agrobiodiversity in Ethnically Diverse Villages

Ethnic diversity contributes greatly to the agrobiodiversity in NE India. When considering the conservation of agrobiodiversity, it is important to understand the ethnic diversity and the environmental context of the sociocultural values of the traditional indigenous communities, as well as their economic development. Inaccessibility in the mountains over long periods has forced the evolution of diverse agro-ecosystems as a risk-avoidance practice, this has resulted in locally-specific agricultural opportunities and locally specific constraints. Most of these approaches are aimed at achieving food security on a local scale. Land and natural resources are considered as community property. Interestingly, the tendency has been one of encouraging optimum utilisation of agrobiodiversity within the local system of knowledge.

There are more than a hundred ethnic groups living in the North East Indian Himalayan region, including Tibetan refugees and Nepali immigrants. But the way in which these ethnic cultures manage agricultural biodiversity is poorly understood.

Between 79 and 94 per cent of the ethnic tribal farming communities in the east Indian Himalayas live in Arunachal, the Assam Hills, Meghalaya, Tripura, Manipur, Mizoram and Nagaland. Arunachal is the most remote and sparsely populated state but has as many as sixteen different ethnic communities and seven of the most endangered ones are given in Table 2.3. The other states each have between three and nine different ethnic communities. These ethnic farming groups have been identified as among the most deprived and least understood groups of people in India. It is estimated that the total population of the different tribal communities in NE India ranges from 108 to 543,615 *(Table 2.4)*.

There are seven ethnic farming communities with populations of less than 2,500. Three of these (the *Aimol* in Manipur, *Ralte* in Mizoram, and Khoira in Manipur), have less than 500 individuals left and are recognised as endangered

Table 2.3: **Tribal Communities of the North East Indian Himalayas with Populations of Less than 5,000 (endangered)**

Ethnicity	Ethnicity
Arunachal Pradesh	**Mizoram**
Aka	Ralte
Bongro	
Khamti	**Manipur**
Mishing	Aimol
Sherdukpen	Chiru
Singpho	Clothe
Sulung	Khoira

Table 2.4: **Diversity of Cultures and Their Proportion in the States of the North East Indian Himalayas**

Culture	State	Population (1991 Census)	
Adi	Arunachal Pradesh	99,372	
Aka	"	2,347	Threatened
Apatani	"	12,888	
Bongro	"	1,085	
Hill Miri	"	8,174	
Khamti	"	4,078	
Miji	"	3,549	
Mishing	"	3,359	
Monpa	"	28,209	
Nishi	"	80,325	
Nocte	"	23,165	
Sherdukpen	"	1,639	Threatened
Singpho	"	1,567	Threatened
Sulung	"	4,250	
Tagin	"	20,377	
Wancho	"	28,650	
Garo	Meghalaya	411,532	
Hajong	"	23,987	
Jaintia	"	82,493	
Khasi	"	384,006	
Boro-Kachari	Assam	543,615	
Chutiya	"	9,103	
Dimasa	"	37,900	
Karbi	"	17,360	
Lalung	"	10,650	
Mech	"	12,919	
Mishing	"	180,684	
Aimol	Manipur	108	Nearly extinct
Anal	"	6,592	
Chiru	"	3,590	
Chothe	"	1,117	Threatened
Hamar	"	38,207	
Kabui	"	17,360	
Khoira	"	406	Nearly extinct
Maram	"	19,968	
Tangkhul	"	58,167	
Mizo	Mizoram	270,312	
Pawi-Lakher	"	21,427	
Ralte	"	170	Nearly extinct
Chackma	Tripura	68,711	
Jamatia	"	22,446	
Magh	"	12,378	
Riang	"	74,931	
Tripuri	"	268,948	
Mariang	"	9,710	

Table 2.4: Diversity of Cultures and Their Proportion in the States of the North East Indian Himalayas (Cont'd)

Culture	State	Population (1991 Census)	
Angami	Nagaland	43,569	
Ao	"	62,275	
Chang	"	15,816	
Konyak	"	72,338	
Lohta	"	36,949	
Phom	"	18,017	
Rengma	"	8,578	
Sema	"	65,227	

ethnic groups (tribes) (Table 2.3). The diverse ethnic groups have various farming systems with a mix of agricultural crops. They each have unique features in their systems for agriculture, agrobiodiversity, sustainable land use, and land tenure ownership. If these groups vanish their indigenous knowledge and the agrobiodiversity they maintain will be lost with them.

The types of agrobiodiversity practised by the migrants from the mainstream communities of India are very different from those of the indigenous tribes. For example, the local communities in Meghalaya, such as the *Garo* and *Khasi*, practise *Jhum* (slash and burn) agriculture in communities and maintain a mixture of at least 10 to 13 different crops, whereas migrants, such as the *Mikir* and *Nepali*, concentrate on valley agriculture and do not carry out shifting cultivation. The migrants use animals for ploughing and manure and generate income through the sale of dairy products. Agricultural labour is a family, not a community, concern and only four to seven different crop species are cultivated.

In the *Jhum* system, farmers burn *Tapio* plant to produce a salt which is consumed by local tribal farming communities as a substitute for common salt. This practice is still important in those mountain areas where accessibility is a big problem. It is one example of the unique knowledge evolved by these ethnic farmers as a result of their isolation.

The main issue is how to maintain the benefits of management of agricultural biodiversity by ethnic farming groups. Ethnic diversity has to be understood in greater depth to discover why some of the ethnic groups maintain one specific type of biodiversity, whereas others in the same location value different resources. It would be useful to record the indigenous knowledge of marginalised ethnic groups on the management of agrobiodiversity, especially that of tribes which are endangered. At present these groups are affected by the direct and indirect impacts of modernisation such as transportation, communication, education, government policy, and, last but not least, an increasing population which has put increased pressure on natural resources. The exploitation of natural resources - especially forest and farmland - has increased in an unbalanced way. Establishment of protected areas and biosphere reserves in forests under government control has reduced the available area for shifting agriculture and led to a shortening of the cultivation cycle. Promotion of cash crop cultivation, such as rubber, coffee, and tea, among these tribal farmers has encouraged the development of individual rights to land and inequity. Promotion of settled terraced farming with full financial support from the government has led to severe soil erosion in a high rainfall area on the one hand and to social disruption on the other. The supply of raw material from the forests to industries at subsidised prices, but denial of access to local ethnic communities to the same government forests, has led to a feeling of alienation in local communities, and this is expressed in the socio-political problems prevalent in this region.

Thus, biodiversity in the region is threatened largely because of external rather than internal factors, a view the mainstream conservation and development agencies find hard to share. There is certainly a need to improve the economic condition of these diverse ethnic (tribal) farming communities and to integrate them with the outside world and development. But this goal could be better achieved by capitalising on the rich agrobiodiversity and traditional knowledge which the communities have, rather than forcing replacements and substitution of cropping systems and radical reforms in land use.

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Chapter 3

The Role of Ethnic Diversity in the Evolution of Highland Agricultural Systems in Xinjiang, China

Liu Wenjiang and Guo Yuhong

Introduction

Xinjiang is the largest of the 27 provinces in China with an area of 1.6 million square *kilometres*. Xinjiang, known in ancient times as the Western Region, was the communication hub of the ancient Silk Road, facilitating the flow of culture between Asia and Europe. Xinjiang is surrounded by three mountain ranges: the Himalayas, the Altay, and the Karakorom. The climate of Xinjiang is characterised by changing continental weather with limited rain, low humidity, long winters, short springs and autumns, plenty of sunshine, and a wide range of temperate regimes. Mean annual rainfall ranges from 50 to 200 mm.

Xinjiang is a multicultural region, home to 47 Chinese nationalities. People of thirteen nationalities, the *Uygur, Han, Kazak, Hui, Mongol, Kirgiz, Tajik, Xibe, Uzbek, Manchu, Daur, Tatar* and *Russian*, have lived here for many generations. Members of a few nationalities, such as the *Dongxiang, Zhuang, Salar,* Tibetans, *Miao, Yi, Bouyei*, and Koreans have migrated to the region since liberation. Agriculture in Xinjiang is basically an irrigated agro-ecosystem known in China as Oasis Agriculture. Although the land area under oases is small, it supports about 90 per cent of the population of Xinjiang.

In the arid regions, climatic conditions, such as temperature, hours of sunshine, and relative humidity, are ideal for crop production. Water is the only scarce resource in the system, but farmers have developed methods to harness the available water for irrigation. Farmers in this region use water efficiently to produce a range of cereals, cotton, oilseed crops, sugar beet, melons, fruit, and hops.

Table 3.1: Diversity of Nationalities in Ethnic Farming Communities in Xinjiang, China

Nationality	% of population	Language	Religion	Economic activity
Uygur	47.47	Uygur	Islam	Farming, livestock
Han	37.58	Chinese		Various
Kazak	7.30	Kazak	Islam	Animal husbandry
Hui	4.49	Chinese	Islam	Farming, livestock
Kirgiz	0.92	Kirgiz	Islam	Animal husbandry
Mongol	0.90	Tuoqin, Mongol	Lamaism	Livestock, farming
Xibe	0.21	Xibe, Chinese	Lamaism	Livestock, farming
Russian	0.05	Russian	Orthodox	Various
Tajik	0.22	Tajik	Islam	Animal husbandry
Uzbek	0.09	Uzbek	Islam	Commerce, farming
Tatar	0.03	Tatar	Islam	Various
Manchu	0.12	Chinese		Various
Daur	0.03	Chinese	Lamaism	Farming, livestock
Others	0.53	Various		Various

Different ethnic cultures have brought with them from their native places local knowledge and skills for growing and using various crops and have retained them after migration.

The impact of human intervention in arid agriculture has been significant. In the past, violent sandstorms not only ruined large areas of farmland but made numerous farmers homeless and penniless. Today, green belts protect arable fields from sandstorms. There are still 10 million hectares of waste land which could be cultivated with afforestation and efficient use of water resources. In arid zones, saline-alkaline soil is another limiting factor for crop production. About one million hectares, or one third of the available arable land in the region, suffer under such stress. Thirty years ago the farmers in Xinjiang developed ways and means to ameliorate the situation and benefitted through increased production of cotton, grain, and oilseed crops.

Xinjiang has abundant natural grassland and pastoral areas with rich animal genetic resources. About 48 per cent of the total area in Xinjiang is grassland. Grasslands are found in three geographic regions: the Altay, Tianshan and Kunlun mountains and Pamir Plateau; the oasis of the Tarim and Juggar basins; and the deserts of the Junggar and Tarim basin. The quality of grass is excellent. Studies have shown that beef cattle reared under natural pasture gain body weight at the rate of one gram per kg per day without supplementary feed or fodder. This kind of body weight gain is seldom reported from natural pasture. Livestock and animal breeds in this region are famous for their productivity and quality. The sheep breed in this region is known for the outstanding quality of its fine wool and quick growth of fleece. Xinjiang has been known for breeding horses and donkeys since ancient times. Donkeys are a major means of transportation amongst the *Uygur*, whereas camels are considered as the boats of cold deserts and contribute to both economic and cultural exchange. Besides horses, donkeys, and sheep, Xinjiang is known for cattle and domestic flying geese.

The Management of Agrobiodiversity in Xinjiang

The prevailing opinion at national level is that conservation has no meaning to people if it does not provide food and economic benefits to the farming community.

At least 3,500 species of plants and 608 species of fauna have been recorded in Xinjiang. Among them are 59 species of plants and 63 species of animals listed in the National Key Protected Plants' list. Xinjiang provincial government has established 20 Natural Protected Areas with a total area of about 102,522 square kilometres (Table 3.2) to protect agrobiodiversity. Although one of the objectives of these reserves is to conserve *in situ* the wild relatives of crops and potential new crops (gene storage in natural habitats), it is questionable whether this objective can ever be fulfilled by these means.

Table 3.2: **Number and Magnitude of Natural Protected Areas (*in situ* conservation) in Xinjiang**

Year	No of reserves established	Area (km²)	Type of conservation
1980	7	5,605	Forest & animals
1982	1	17,000	Animals
1983	6	49,526	Animals & forest
1984	1	15,000	Animals
1986	4	15,508	Animals & grassland
1990	1	380	Forest

Some of the issues related to agrobiodiversity which arise from the agricultural and ethnic diversity in Xinjiang are:

- ethnic diversity maintains a diversity of agricultural systems even in the same area/environment,
- conservation of agrobiodiversity should address the development needs of the people,
- the evolution of agro-ecosystems in cold and dry areas mainly results from the diversity of ethnic cultures inhabiting these areas and this diversity should be maintained, and

- conservation is most effective when linked to the livelihood and food security of the local people.

Chapter 4

Human Factors Influencing Agro-Ecosystem Diversity in the Hengduan Mountains of China

Liu Zhao-Guang

Introduction

The agrobiodiversity of different mountain agricultural systems includes not only the diversity of crop species or varieties, but also the diversity in the farming systems evolved and maintained by different mountain communities (ethnic groups). In different ethnic communities the production systems are changed to reflect differences in natural environments and traditional cultures. Ethnic diversity provides a fundamental base for diversification of agricultural practices and the development of a variety of coexisting economic systems.

Sichuan is a multi-ethnic province. There are over 20 nationalities (ethnic groups) in the province but minority nationalities account for only four per cent of the total population and the majority of these belong to only six groups, the *Yi*, *Tibetan*, *Qiang*, *Tujia*, *Miao*, and *Hui*. The minority communities inhabit the western and southern parts of Sichuan such as the Garze Tibetan Autonomous Prefecture, the Aba Tibetan and Qiang Prefecture, the Liangshan Yi Autonomous Prefecture, and the Qianjiang Tujia and Miao Prefectures. The mountain villages inhabited by minority nationalities in Sichuan are rich in natural resources. The natural forest resources in western Sichuan, for example, are the third largest in China: the forested area is 66 per cent of the total in Sichuan and the timber capacity 74 per cent. Minority nationalities also live in pastoral areas, the rangelands which cover 58 per cent of the province.

More than 60 species of plants and 100 species of animals in the national minority areas are listed in the National Protected Animals and Plants' Books respectively. Maybe it is for this reason that more than 20 natural reserves have been established in Sichuan during the last two decades, most of which are located in these ethnic areas.

Before the 1950s the rural areas had a closed economy. Barter was the only means of trading and marketing. The agrobiodiversity available in the traditional agro-ecosystem was sufficient to sustain the subsistence household economies. There was a well-developed system of barter exchange for the produce of these traditional farming systems which was used to procure household necessities such as salt, tea, and clothes.

In this paper, the farming systems and agrobiodiversity managed by three minority nationalities in the Hengduan mountains of China are studied in order to discuss issues of agrobiodiversity conservation from the perspective of local ethnic farming communities. The agricultural systems of the *Yi*, *Tibetan*, and *Qiang* nationalities are compared in terms of management and use of agrobiodiversity. Figure 4.1 shows the relative economic dependence of the three minority nationalities on different farming and other activities. Animal husbandry is an integral part of the Tibetan, *Qiang*, and *Yi* nationalities' farming systems besides arable farming.

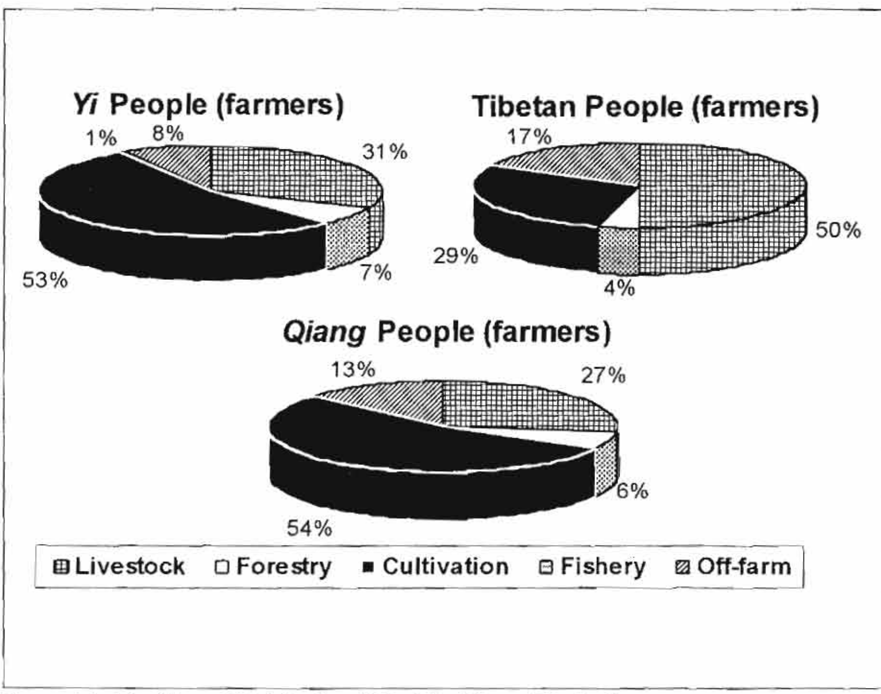

Figure 4.1: ***Livelihood Distribution (%) of the Three Ethnic Groups***

The *Yi* Farming Community

The *Yi* people are the dominant minority nationality in Western Sichuan. They are concentrated in Liangshan Yi Autonomous Prefecture. Before the 1950s the *Yi* community was divided into *Tushi* (rulers), *Heiyi* (black Yi), *Baiyi* (white Yi), *Ajia*, and *Jiaxi*. *Tushi* and *Heiyi* were the lords of slaves, *Baiyi* were subjects of the rulers, and *Ajia* and *Jiaxi* were slaves. The *Yi* people are predominately engaged in agriculture followed by animal husbandry.

After the 1950s, social systems changed resulting in the extinction of slavery and government implemented land reforms. Every farming household was given fields, livestock, and farm tools. The government invested in rural infrastructure, and modern technologies were extended. In the 1960s the government placed more emphasis on afforestation and fruit farming. The *Yi* nationality in Liangshan Prefecture added a diverse range of cash crops as part of a agro-enterprise development scheme. A variety of cash crops, harnessing of non-timber forest resources, animal husbandry, and off-farm employment replaced traditional agriculture-based livelihoods. Within the last decade the rural economy of the *Yi* nationality changed from a subsistence to a market-oriented economy. Plants such as sugar cane, tobacco, and mulberry trees have become the pillar of well-being of this rural minority. Since the 1980s the *Yi* area has become a production base for the sugar industry. This area also produces the best quality tobacco and cigarettes in China. Sericulture has become another important cash-generating enterprise. The silk is so fine that its length can be as much as 10,000 metres. Introduction of new crops into the agro-ecosystem of the *Yi* has increased the income of *Yi* farmers. However, there are still highland areas maintained under a fallow system where *Yi* farmers produce grain once every three years in rotation. This is the locally evolved, sustainable way of adapting to the fragile, high mountain environment.

The *Tibetan* Farming Community

Tibetans are the main ethnic group in southwestern China. They practice a mixed agro-pastoral system. The *Tushi* sub-ethnic group represents landlords, and it owns most of the land, forests, and livestock. The overall production capacities of agricultural systems in Tibetan areas are dependent on crop diversity. Animal husbandry is the main activity; timber, wild mushrooms, and medicinal herbs are the main sources of off-farm income. The knowledge and skills of this ethnic farming community have turned western Sichuan into the most important source of valuable medicinal plants such as *Fritillaria criihosa, Rheum officinale, Nardostachys chinensis, Cordyceps sinensis*, and *Gentiana scabra*.

As a result of the harsh mountain conditions, such as inaccessibility, marginality, and fragility, in Tibetan areas, promotion of introduced commercial crops is restricted. *Tushi* and other Tibetan farmers are custodians of the gene pools of Tibetan barley and bitter buckwheat, a treasure house of barley and buckwheat crops. Animal husbandry is an integral part of Tibetan life. Animals provide the butter, milk, cheese, and milk tea for daily life, whereas barley and buckwheat form the basis of food security.

The *Qiang* Farming Community

Historically the *Qiang* was an influential nationality occupying a vast area in the west of China. Their numbers are now declining. At present they inhabit the upper reaches of the Minjiang River. Since they are distributed close to the Sichuan Basin, their culture, economy, and farming system are greatly influenced by the majority *Han* Chinese, and very little of their original farming culture, knowledge, and skills are still practised. It is a good example of change in a farming culture over a period of time under the influence of a dominant majority.

Conclusions

These case studies of the three nationalities *Yi*, *Tibetan*, and *Qiang*, illustrate the diversity of farming systems, crops, and animal species that exists among different ethnic farming communities (see Box 4.1). These mountain communities have also evolved conservation strategies to ensure sustainable use of natural mountain resources, and they are the custodians of genetic resources. Some farming communities still maintain the crop and animal diversity on which their livelihoods depend within the agro-ecosystems. For example, *Yi* people live in the high mountains and sheep farming is an integral part of their life. Their lifestyle changes seasonally with the migratory sheep flock, and this is reflected in their clothing and food habits. *Yi* people like to wear a mantle made from sheep wool, which is locally known as *Chaerwa*.

There are cases in which *Yi* farmers have abandoned the traditional slash and burn system of agriculture and moved to market-oriented agriculture. This change in farming practice has increased the crop diversity because of the introduction of new crops, although there has also been some substitution of indigenous crops. The *Yi* ethnic groups traditionally maintained over 10,000 wild mulberry bushes in their villages. These were not used to breed silkworms, but rather the leaves were gathered to feed the pigs. The Liangshan *Yi* nationality in Sichuan is known for being the custodian of a bitter type of buckwheat (*Fagopyrum tataricum*) germplasm. These examples have highlighted the issue that on-farm management of agricultural biodiversity cannot be detached from its cultural context.

Box 4.1

Ecological Niches Occupied by the Different Nationalities and Their Present Crops

Minority nationality	Eco-zone	Major crops
Yi	Valley and low mountains	Cereals, sugarcane, mulberry, tropical fruits, vegetables
	Mid mountains	Cereals, tobacco, mulberry, temperate fruits
	High mountains	Potatos, cereals, livestock, forestry
Tibetan	Mid mountains	Cereals, fruits, forestry, medicinal herbs, wild mushroom
	High mountains	Barley, medicinal herbs, semi-migratory animal husbandr
Qiang	Valley and low mountains	Cereals, livestock, fruit, vegetables
	High mountains	Cereals, forestry, pepper, livestock, medicinal herbs

Chapter 5

The Impact of Migrating Mountain Farming Communities on Agrobiodiversity: A Case Study of the *Li* Minority Nationality in the Mountains of Hainan Island

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Y. K. Wang

Introduction

This case study attempts to identify the impact of migration and immigration on the retention of agriculture and agrobiodiversity among the *Li* people. The paper describes how the agrobiodiversity managed traditionally by the *Li* community has changed under the influence of migration and immigration of members of the *Han* community. The impacts of continual migration and immigration on the environment and on agricultural biodiversity are studied to identify lessons to be learned.

Hainan province is an island located on the northern edge of the tropical zone and is one of the richest regions in terms of biodiversity in China. There are more than 4,200 vascular plant species and more than 410 animal species, suggesting good conditions for agrobiodiversity management. Hainan province is inhabited by about 6,557,482 people, including 1,115,096 members of 37 different minority ethnic groups. The *Li* people were the original inhabitants of the island. Until 1990, *Li* communities were spread throughout the province, but now they are more concentrated in the southwest of the province. This change has been caused by continual waves of immigration of the Han communities from the mainland. This migration was in fact started during the *Tang* dynasty (221 B.C. - 960 A.D.). Most *Han* settled in coastal and accessible areas with a potential for market opportunities. As a result of the social instability brought about by the feudal dynasties of the past, the *Li* community had to migrate to the thickly forested mountains. The *Han* and *Li* communities by their nature occupy different ecological niches in the same area; they have different cultures and means of transport and communication. Their management of crop biodiversity and farm economies also varies considerably. The regions inhabited by the *Li* community have rich plant genetic resources but they are underused, the market is poorly developed, and farming is conventional. The *Li* community has not so far exploited the existing biodiversity for economic benefit. This experience suggests that a rich natural biodiversity/agrobiodiversity alone does not lead to the prosperity of a local community.

The Traditional Farming System of the *Li* Community

Before the *Tang* dynasty, agriculture in Hainan Island was basically primitive. 'Slash and burn' farming was the traditional practice of *Li* farmers, who called it '*shanlan*'. Farmers used to collect seeds of wild upland rice from the mountains and sow them in their fields. Yields were very poor, ranging from 450 to 1,500 kg/ha. Although they cultivated upland rice, the *Li* community were not used to growing vegetables and fruits. Traditionally they depended on wild fruits and vegetables. Hunting, fishing, and gathering of wild fruits and local vegetables were an integral part of the food culture. The system was simple but backward from an economic point of view.

The royal court ruled the island from 221 B.C.- 960 A.D. during the *Tang* dynasty and groups of *Han* immigrants migrated to the island. This resulted in

Box 5.1

Biodiversity in Chinese Home Gardens

Home gardens are typical examples of mainland Chinese culture. The composition of species and varieties vary greatly both among ethnic groups and between farmers within the same ethnic group. Every garden is a unique creation with a complex set of tree and crop species and animals. Mushrooms are often grown as well. Fish ponds are used to raise fish or high-value species such as eels and soft turtles. The operation and management of intensive home gardens require large-scale biodiversity and a high level of skills. These experiences could help other farming communities to develop strategies for on-farm conservation both in the Hindu Kush-Himalayan region and outside. Systematic documentation of such examples could add to knowledge of alternative methods for agricultural biodiversity conservation and management.

The common hypothesis is that crop diversity is associated with closed and subsistence farming systems because of the diverse needs of the people. Crop diversity declines with the increase in development opportunities, and interventions need to be examined in a wider economic, socio-cultural, and environmental context. There is considerable concern that commercialisation of agriculture has endangered crop biodiversity However, the case may not be universal as demonstrated by the tradition of home gardens. This system maintains Genetic Diversity both to fulfill the farmers' own needs and to meet local needs. But the difference in production systems and the area coverage in each system, are important, mainly from the point of view of food security. The issue that emerges is that Genetic Diversity in commercialised areas depends on outside sources because commercial farmers always seek productive and profitable crops and varieties.

development of a feudal economy in migrant areas. During the *Ming* Dynasty (961-1911 A.D.) farmers on the mainland were encouraged to move into places where the population density was low and large areas of wasteland were reclaimed for agriculture.

The Impact of *Han* Migration on *Li* Farming

The Li community learned vegetable farming from the migrated Han community and started to save vegetable seeds. Traditionally, the *Li* mixed seeds of early maturing varieties of rice with those of late maturing varieties. The seedlings were raised in the same nursery bed and transplanted together. The early rice was harvested separately, but the cost and labour of transplanting late paddy were saved. The *Li* gave up this traditional practice when they saw *Han* farmers producing higher yields by transplanting the two crops separately. In contrast to the *Han* community, *Li* farmers only harvest the panicles of paddy crops and leave the straw in the field to improve nutrient recycling. They still use this harvesting method today.

Both communities benefitted from the process of social mixing. The *Li* community improved the efficiency of their agricultural tools and implements, cultivation practices, and lifestyle. They added new crop species into their farming system acquired from the immigrating *Han* farming families. New crops, trees, and some animals were also domesticated. In relative terms, however, *Li* farmers were marginalised because of their relatively poor technologies compared to those of the migrant *Han* communities. This caused displacement of large numbers of *Li* people to forest areas in search of uncompetitive agriculture. The *Han*, on the other hand, acquired some local crops of the *Li* people for farming.

Population growth in Hainan Island continued, as did the rate of reclamation of wasteland and deforestation for arable purposes. Even so, the unit area available per individual farming household decreased. A large number of local species and varieties was lost from the Island. There are two major reasons. First, under such land pressure farmers started looking for short-term economic benefits and ignored the impact on agrobiodiversity and the environment. Second, local government policy supported replacing local varieties with improved varieties. Table 5.1 shows some of the now extinct varieties of rice and groundnuts of Hainan Island.

Issues from the Case Study

This case study shows how the Genetic Diversity of indigenous crops and animals can decrease as populations migrate to new villages. Migrants bring with them a range of their own crops and animal species which replace the

Table 5.1: **The Proccess of Agricultural Development and Replacement of Crop Varieties in Hainan Island**

Crop	Years	Popular varieties	Extinct local varieties
Rice	1949-56	Gaochong, Hali, Mozu	
	1957-65	Anpu, GN-2, GC-13	
	1966-77	Guangan, Jinjuan, Muquan	Gaochong, Hali, Mozu
	1978-85	Ke-b, Baotatian, Bx-2	
	1986-94	Hybrid rice	
Cassava	1949-59	Malaya	
	1960-77	Redtail, Greentail	Malaya
	1978-94	South China 205	Most local land races
Peanut	1950-56	Traditional varieties	
	1957-94	White oil-1	

traditional species and varieties. This process can lead to both replacement of local genetic resources and an overall increase in agrobiodiversity. This case study provides a beautiful example of how Genetic Diversity can be enriched by outside intervention as well.

Chapter 6

The Benefits to Agrobiodiversity of the Wide Range of Food Cultures in Nepal

J. B. Gurung and
A. Vaidya

Introduction

Contemporary cultural milieus in Nepal (religion, caste, ethnicity, gender, and associated value orientations) are social realities and their relationships to agrobiodiversity do not pose any *metatheoretical* problems. But some gaps in knowledge need to be addressed in order to understand agrobiodiversity management in Nepal's culturally complex society in which diverse groups of people, each group with its own social world, views, values, norms, and mores, are found scattered throughout the different agro-ecological zones. Analysis of agricultural and biodiversity issues in the Nepali context can be useful if it also addresses caste-related sociocultural phenomena.

The caste system in Nepal is categorised into four *Varnas* [1] and thirty-six castes (*Char Varna, Chhattis Jat*). In Nepal the state has played an important role in systematic hierarchisation by rearranging the classical strata into *Tagadhari*[2], *Matwali* [3] and *Pani Nachalne* [4] groups. Not only is Nepali society divided into different castes, it is also composed of a wide variety of different ethnic groups.

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1 The classical four-fold system is comprised of *Brahman, Kshatriya, Vaisya,* and *Sudra* in that order.

2 This is the sacred thread (*Janai)* wearing group composed of three sub-groups, the *Bahun, Thakuri,* and *Chhetri*.

3 This group belongs to the Tibeto-Burman (*Tamang, Magar)* family that was gradually brought into the sphere of Indo-Aryan culture, including the caste system.

4 This group is considered untouchable, people from whom water cannot be accepted (e.g., sweepers – *Pode*(s)

The different caste and ethnic groups in Nepal have their own food habits. It was felt useful to see how caste-based culture and sociology of food are related to agrobiodiversity. A brief exploration was made to gain a preliminary picture of the extent to which caste and ethnic variations in food habits and in preferences for different species and varieties of crops and animals are associated with differences in the management of agrobiodiversity.

Relationship between Food Cultures and Management of Animal Diversity

Traditional *Tagadhari*, especially the *Bahun* (brahmin), are not avid meat lovers. They do rear large animals, but only for dairy products, power, and manure. The *Bahun* are selective sheep and goat-meat eaters (some are strict vegetarians), but they do not hunt wild game, which in a certain sense supports biodiversity. This attitude of non-violence towards wild animals is neither the result of a particular love of wild animals, nor a response to religious dictum (as in Buddhism), it is a part of Hindu culture. The *Tagadhari* traditionally excluded pigs and chickens from their agricultural system, as both of these species are considered impure and unhygienic.

Traditionally, the meat-eating habits of the *Bahun* and the *Chhetri* are similar, but the *Chhetri*, being warriors, are more eager wild game hunters. The *Chhetri* and *Bahun* keep goats, sheep, ducks, and pigeons, but they are particularly keen on milk and milk products and are thus more knowledgeable in the management of cattle and buffalo.

The *Matwali* consume different varieties of large and small ruminants. While many of the animal species may be the same, there are also some variations within the group. Some *Matwali* eat pork[5], some do not touch it. As with the *Tagadhari*, some *Matwali* consider the local black pigs untouchable and ritually purify themselves if they happen to touch one accidentally.

Matwali, such as the *Gurung*, prefer chicken and buffalo as their main source of meat, thus these are an integral part of the farming system. The value of these animals is high in these communities. These groups not only rear good quality animals, they also maintain good farm forestry and diverse fodder species. Since they value free-range chickens in their daily life and rituals, their kitchen gardens are always poor in leafy vegetables because they are mostly eaten by chickens. Some traditional broad-leaved mustard seed (*Rayo*) is mixed with manure and planted in vertical terrace risers to prevent chickens eating the leaves. These

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5 Some raise and eat the exotic white breed only while others, such as the Rai and Limbu, can eat both the exotic and the local black pigs (e.g., *Chwanche*) which are traditionally untouchable even to some of the *Matwali* groups.

communities prefer to plant garlic or leeks around their homesteads because they are not eaten by poultry. Even within the same caste and ethnic groups, there are sub-groups that differ in their meat-eating habits. Traditionally, the *Ghale*, a sub-group of the *Gurung*, do not eat chicken or buffalo meat. They prefer sheep. The *Ghale* of Gorkha, Lamjung, and Kaski districts are custodians of the local migratory sheep and goat breeds. They raise the migratory sheep in a nomadic (transhumant) system and possess the indigenous knowledge and skills for managing these valuable resources in the marginal and fragile mountain niches. Generally *Matwali* groups are avid wild game hunters. This, and the relative absence of restrictions on eating a great variety of meats, gives the impression that the *Matwali* should be good managers of animals.

The *Pani Nachalne* group, although Hindus with Indo-Aryan cultural traditions, eat pork as well as all the other types of meat eaten by the *Tagadhari* and *Matwali*. The *Sarkee* (cobblers) are allowed to eat beef, but only when the cattle die from natural causes or accidents, as cattle slaughtering is prohibited by law in Nepal. In contrast to China and some South-East Asian countries, dogs, horses, donkeys, monkeys, cats, snakes, and rodents are all inedible species for most mountain communities and indeed most people in Nepal. Field rodents are, however, a main source of protein for the *Moshar* community in the Mahottari and Siria districts in the Nepalese *Terai*. The *Moshar* migrate from one place to another in search of employment and do not have arable land to farm and rear animals. The *Pani Nachalne* households in the vicinity of higher caste settlements sometimes find it hard to raise pigs and chickens. As a result, most *Pani Nachalne* groups are settled relatively far away from the main villages.

Food and Culture-related Plant and Crop Diversity

Like the cow, some trees, shrubs, and herbs have a special ritual conservation status in Hindu religious practice. Because of their perceived sacredness they are not exploited commercially or misused. Some of these vegetation species are: *ber (Ficus bengalenses), pipal (Ficus religiosa), sami (Ficus rumphii), lakuri (Fraxinus floribunda), rudraaksha (Eleaocarpus sphaericus)* and *tulasi (Ocimum basilicum)*. The *Tagadhari*, and especially the *Bahun*, are more particular about the maintenance of the ritual status of non-human living things in the community. *Tusa* (young shoots of the small bamboo) is an important delicacy in the Buddhist highlands, but, at lower elevation areas, it is seldom harvested for food because of its more important utilitarian values.

The *Matwali* grow a variety of finger-millet because they consume large amounts of millet and often have a supply deficit. The *Matwali* (liquor drinkers) use a sizeable portion of their millet harvests and, to some extent, their rice for making the local brews, *jand* and *rakshi*, the two most important home-made alcoholic beverages in the Nepali hills and mountains. In everyday life, *Matwali* households, like those of the *Gurung*, *Magar*, *Thakali* and *Bhotia*, and even the *Newar*, prefer to offer their elderly people and visitors *rakshi*. A *Matwali* household feels very uncomfortable if they do not have good quality *rakshi* to offer to visitors. *Jand*, another alcoholic preparation, requires fermentation not distillation and is popular with the *Rai*, *Limbu*, *Tamang*, and *Jyapu*. Both of these alcholic beverages are very important culturally because they are used in many of the *Matwali* festivals, both as an item to be consumed with much gusto and as an item for ritual offering. A rich diversity of finger-millet and rice is maintained for the specific purpose of preparing alcoholic beverages. In eastern Nepal, local land races of millet are grown specifically for *jand* and seeds are carefully maintained. Similarly, the *Gurung* and *Magar* in western Nepal continue to grow local millets to maintain the quality of their *rakshi*. Millet is not only used in the production of *jand* and *rakshi*, it also an important food item in the Nepali mountains. Normally a regular meal consists of a combination of boiled rice *(bhat)* and *dhindo* (a kind of porridge generally made from millet or barley). Farmers still grow low-yielding *juwai kodo* for special visitors, such as sons-in-law, as the quality of *dhindo* is better from this local land race. These items, depending upon the season, are eaten in combination with vegetable curries, beans, and pickles and, in relatively well-off households, with pulse soups, milk, and *whey*. Even if *dhindo* is a nutritious staple food item, it does not enjoy the status of rice. Empirical observations strongly suggest that the frequency of inclusion of millet *dhindo* in meals is closely associated with economic class, well-off people tend to eat *dhindo* less frequently. Some *Tagadhari* and *Matwali* communities in the hills and mountains do not like being seen eating *dhindo*. The different status of *dhindo* vis-a-vis *bhat* (rice) has some connection with the notion of ritual purity among different food items in traditional Hindu food culture. *Bhat* and *dhindo* have thus become a sort of dichotomy in the culture of food in the hills and mountains (less so in the mountains), in which the former is normally taken as symbolising beauty, prosperity, and affluence, while the latter is associated with poverty and ugliness. The cultural definition of 'white' and 'fair' as being more appealing and beautiful than 'dark' and 'dark brown' also applies to the *bhat-dhindo* dichotomy. In spoken Nepali, the word *kode* (millet eater) is used not only as a derogatory remark towards individuals, it also carries a negative connotation for the cereal itself. As a result, cultivation of finger-millet in accessible areas of Nepal is gradually being replaced by income-generating through vegetable crops, and food grain needs are met by purchasing from the market. In the past it was not possible to buy staple food grains simply because of the lack of access as well as the capacity to purchase. Despite its nutritious nature, finger-millet is considered a poor people's crop. It is an 'underused crop' as a result of lack of food processing research and promotion of the products. Farm workers in the hills and mountains would rather accept finger-millet as wages than the equivalent amount of maize or even unhusked paddy. There is no milling loss in finger-millet as with unhusked maize and paddy.

Furthermore, both *dhindo* and bread millet are thought to provide more energy than maize or rice. In addition millet keeps much longer than other cereals.

Maize is another important staple crop. It is eaten in at least six different ways without any major processing transformations, more ways than any other cereal in the hills and mountains. Maize is primarily consumed as bread (*Makai ko roti*), porridge (*Dhindo*), or *Aatto*[6] (*Makai ko bhat*). It is also roasted, boiled, fried, flattened, and popped. Younger, fully unripe maize cobs are eaten without roasting or cooking. Maize is also widely used in the production of *jand* and *rakshi*. Farmers recognise the use of different species and maintain different kinds of maize for different purposes. Such strategies are important to farmers in the context of the absence of modern food processing facilities in remote mountain farming communities and add to the diversity of varieties.

There are many such examples. It is thus clear that the relative importance of different food grains has strong cultural roots. This affects both the consumption and production patterns among different ethnic groups, leading to the conservation of some species and varieties and negligence towards others.

There are numerous variations (even in a single settlement) in the ways different ethnic groups grow, maintain, and prepare their food. Variations exist in the ways these groups perceive the importance of food crops and animals and food items prepared for eating. Variations also exist in the ways in which different groups perform agriculture. Thus management of agrobiodiversity in the Nepalese mountains would benefit greatly from a better understanding of the food cultures of different ethnic and caste groups.

Issues

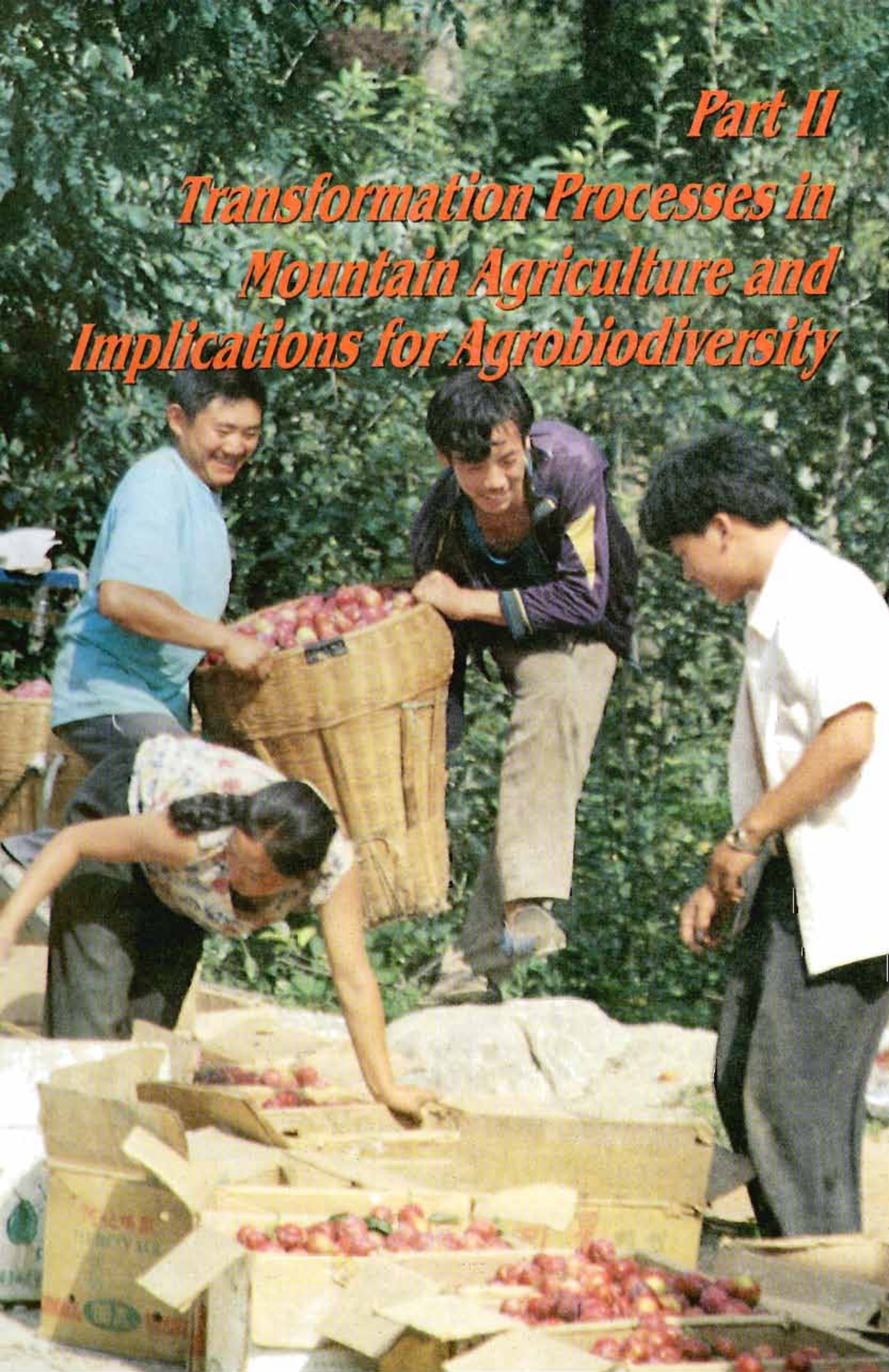
There are indications that various aspects of cultural traditions can promote agrobiodiversity. Variations exist in food habits, with different degrees of importance attached to different crop and animal species according to caste and ethnicity. These specific food habits mean that certain varieties of plants and animals are selected and maintained for specific purposes. Crop and animal diversity are often linked with diversity of agro-ecological and topographic conditions, but the diversity of human knowledge and skills for selecting and maintaining genetic resources for specific cultural purposes are ignored in most discussions about the management of agrobiodiversity.

Both academic and applied agrobiodiversity research focus largely on economics and/or biology. Sociocultural aspects are either left out or paid

6 Coarse maize grit cooked in the fashion of steamed rice. This food culture is usually common where rice fields are limited.

superficial lip service. Research is needed into ways of using existing cultural systems of caste and ethnic groups to help conserve and promote agrobiodiversity. There is an information gap about the extent to which agrobiodiversity is associated with sociocultural and market forces. Knowledge about the relationship between ritual status and maintenance of agrobiodiversity of cultivated crops and domesticated animals, the order of the domestication process for different crop and livestock species, and their association with centres of diversity and different ethnic groups would be of help in formulating effective approaches to management of agrobiodiversity.

Part II
Transformation Processes in Mountain Agriculture and Implications for Agrobiodiversity



Chapter 7

The Dilemma of Balancing Horticultural Development with Conservation of the Diversity of Genetic Resources in the HKH Region

T. Partap

Introduction

Diversifying agriculture in mountain areas has become a priority target, with the aim of economic security rather than food self-sufficiency. Governments and mountain farmers in the Hindu Kush-Himalayan (HKH) region have been making a concerted effort towards diversification of agriculture into cash crop farming. As a result there is a growing trend towards commercialisation of agriculture in the region (Partap 1995). This trend represents the efforts of mountain farmers to use their land resources for cash crop farming. This emphasis on high-value cash crop farming is succeeding in bringing people out of the poverty trap in some areas. The overall economy of these areas shows signs of food security and some measure of economic well-being (Partap 1995). Governments of the region have been encouraged by these successful examples and are emphasising the development of horticulture[1] wherever possible. Agricultural development planning at national, provincial, and local levels has been tuned to meet the new objectives. This paper analyses horticultural development strategies and experiences in many areas of the HKH from the viewpoint of their impact on the diversity of indigenous genetic resources. The paper highlights the fact that native agrobiodiversity has not been harnessed for horticultural development, although it is a potentially valuable source, and this indicates potential problems of lack of sustainability which may emerge if current approaches continue.

1 In this paper, horticulture is broadly defined to include cash crop farming, such as fruit farming, vegetable farming, floriculture, and mushroom cultivation, etc.

The Value of Horticultural Genetic Resources

A look at past efforts shows that genetic resources have been successfully used to our advantage in many ways — including the domestication of new crops and the development of plant strains with disease resistance, pest resistance, high yield, vigour, environmental adaptation, high food value (vitamins, proteins), cytoplasmic male sterility, petaloid male sterility, and adaptations for harvesting, transport, and post-harvest handling and quality.

The use of these resources can be expected to continue and will probably increase. This will be made necessary by the need to cope with new ecological conditions, more virulent diseases, more difficult pests, fluctuations in climate, and changing economic demands. Changes in technology and social expectations also encourage greater use of genetic resources.

Broadly, there is a great potential for using genetic resources in horticulture for the development of new domesticates and the improvement of existing domesticates. Hundreds of species could be used to improve existing horticultural domesticates alone. However, the main factor that determines the degree of their use is the availability of suitable germplasm. Breeders and genetic engineers can devise more and more ingenious ways of using available genes, but they cannot create new ones. The reasons for conserving variations within species are firstly that genetic variation is essential for species to adapt and survive and secondly that genetic variation is the new material for domestication and for the continued survival and improvement of the domesticate. Both reasons are equally valid and each requires different approaches to conservation. But so far conservationists have usually only considered the first reason, whereas the second has been mostly ignored.

The following pages explain how loss of habitat, overexploitation, and competition and predation by introduced species are threatening the horticultural genetic resources of the HKH region. The possibilities of finding new species of potential genetic value are diminishing, as the areas of greatest ecological diversity within the region are subjected to more and more deforestation, shrinking of habitats, and agricultural expansion. The wild gene pools of many fruit crops have been drastically reduced by habitat destruction already (Partap 1993).

Horticultural Development Strategies of the HKH Countries

Horticulture is being advocated as an important activity for mountain areas as part of the agricultural diversification process. The basic intention is to take advantage of different climatic conditions to provide better sources of income for mountain people, improve their living standards, and stabilise fragile mountain land.

Horticultural development strategies in the HKH Region have a three-fold approach: emphasis on self-sufficiency in horticultural items that are currently imported; promotion of those crops which could be exported to gain foreign exchange (especially crops with a proven market value that are well developed and cultivated in large amounts elsewhere); and a low priority effort to improve the nutritional status of undernourished mountain communities by encouraging the cultivation of fruits and vegetables for family use. Horticultural policy planning and research institutions are making earnest efforts to bring a range of activities, such as vegetable farming, floriculture, mushroom cultivation, and farming of medicinal plants, within the scope of horticulture.

Following the introduction of this approach, there have been impressive financial gains from horticulture in some areas of the HKH region. However, the objectives of rational use and conservation of available genetic resources and their biological diversity are still missing. The results of this neglect become clear when the strategies and impact of various programmes are analysed.

Competition between Old and New Crops

Several factors have dictated the choice of horticultural species in the HKH region. Some are stated in the objectives of programmes, others are not. Biological diversity, whether for use or for conservation has not been given attention so far. The chief objective of programmes in the HKH region is the introduction of well-developed crops with good marketing potential. Table 7.1 illustrates how little use has been made of the genetic resources in the region to develop new domesticates for diversifying horticulture in an ecological context.

An example of the crop gene pools that exist in the HKH mountains is the diversity of land races of pears and apricots maintained by the mountain farmers of northern Pakistan (Tables 7.2 and 7.3). The North East Indian Himalayan region

Table 7.1: **Diversity and Use of Horticultural Resources in the HKH Region**

Crop type	Number of species promoted for cultivation		Approximate number of species used locally
	Major	Minor	
Fruit trees	5	18	150-200
Fruit shrubs	2	5	80-120
Vegetables	8	20	230
Tuber vegetables	1	6	15
Spices	3	8	40
Mushrooms	1	6	280
Medicinal and aromatic plants	10	50	500
Other plant resources, e.g., fibres, insecticides	?	7	50

Source: Partap 1993

Table 7. 2: Diversity of Local Varieties of Pear Cultivated by Mountain Farmers in Pakistan

Vernacular name of variety	Preferred Traits for Selection of Variety
Parao	Large, pear shape
Sur Tango	Small, round
Shin Rulay	Medium, apple shape
Spin Tango	Small, round
Mamusay	Small to medium, round, early
Shakar Tango	Sweet, medium size
Nashpati	Medium to large, sweet
Tang	Large, pear shape
Khan Tango	Small, round
Batang	Large, pear shape, sweet
Nag Tango	Large, apple shape, hard
Nar	Oblong to pear shape
Shal Tango	-
Khar Nak	Large, hard
Gadarey	-
Bap Tango	Early
Khawaga maiwa	Small, round, sweet
Khapa	Sour

Source: Partap 1993

Table 7.3: Diversity of Local Varieties of Apricot Cultivated by Mountain Farmers in Pakistan

Vernacular name of variety	Preferred Trails for Selection of Variety
Marpho choli	Red apricot
Karfoo choli	White apricot
Warfo choli	*Pit* used for oil
Bro Choli	Late maturing
Khakas choli	Kernel partly split
Cho choli	Juicy
Apo choli	Large
Beru choli	Small
Blafo choli	Small red
Odumar choli	Partially red
Chun choli	Sweet pith
Yakar choli	Reddish
Gurdaalo choli	Like peach
Pharang choli	Dry apricot
Kartaksha	Early, juicy
Sara choli	-
Kacha choli	Hard, good to keep
Halsnan choli	Best quality
Kazangi choli	Sweet
Khashanda choli	Good taste
Kho choli	Bad taste, sour
Shakanda choli	Sticky
Tacho choli	-l
Marghlam choli	Early, good quality
Shanda choli	Small, early

Table 7.3: **Diversity of Local Varieties of Apricot Cultivated by Mountain Farmers in Pakistan (cont'd)**

Vernacular name of variety	Preferred Trails for Selection of Variety
Stun choli	Late
Mamoor choli	-
Ghom choli	-
Sara karfo choli	Early
Stun kuban choli	-
Khustar choli	-
Sapastan choli	Sour, kernel used for oil
Miting choli	Sour, kernel used for oil
Shakar choli	Sweet
Hongool choli	-
Brook choli	-
Halwar choli	-
Duspaong choli	Selected for specific agro-ecological characteristics
Yakab yak choli	-
Snair choli	-
Shikanda joo	-
Brum joo	White
Surasune joo	Good quality
Duda-sanag joo	-
Koropiam joo	-
Al. Shan l;akas joo	Late
Habi joo	Very late
Khanemish joo	-
Kartach joo	Very early, white
Dudar joo	-
Ghulam joo	-
Rashikin joo	Early
Alman joo	Good quality
Koropian joo	Early
Gakateen joo	-
Kaka shikanda joo	-
Source: Partap 1993	*Note: See also Table 24.3*

has a similar rich diversity of land races and wild relatives of citrus fruit, mangos, and bananas (Arora and Nayar 1984). The indigenous species of citrus protected in the citrus sanctuary include *Citrus lemon, C. medica, C. jambhiri, C. ichengensis, C. latipes, C. macroptera, C. assamensis, C. indica, C. aurantium, C. lamonica, C. karna*, and *C. aurantifolia*. The Indian wild orange, *C. indica*, is found in the Naga hills near Dimapur, and the Garo hills of Meghalaya contain many *Prunus* species such as *P. nepalensis, P. undulata, and P. cerasoides* (Kaul 1988). There is a good range of vegetable and tuber crops, such as *Alocacia, Abelmoschus, Amorphophyllus, Colocasia, Dioscorea, Luffa, Cucumis* and *Trichosanthes* in different parts of the region. *Alpinia speciosa, A. galanga, Amomum aromaticum, Curcuma zeodooria, C. amada, Piper longum*, and *P. peepuloides* are the main species of spices and condiments. The region is home to several species of medicinal plants such as *Berberis, Cassia, Coptis, Gynocardia, Litsea, Paedera, and Solenum* (Kaul 1988).

These examples show that there is much valuable indigenous plant material in the HKH region. In some areas of the Himalayas there is a vast genetic diversity within various fruit plants which remains underexploited or threatened by extinction, by habitat destruction, and by displacement with new exotic crops.

Tables 7.4, 7.5, 7.6 and 7.7 show that, by and large throughout the HKH region, the focus has been on a limited number of high-yielding varieties (HYV) of fruit and vegetable crops. This has created agro-ecosystems with monocultures of these crops. However, in some countries, such as Bhutan, the objective has been to develop agro-ecosystems with a limited number of lead crops, and this is justified from the point of view of economic viability (Table 7.8).

Table 7.4: **Agroclimatic Niche-based Selection of Fruit Crops in Nepal**

Fruit	Zone system (districts)
Citrus fruit	Dhankuta, Bhojpur, Terhathum, Sankhuwasabha, Panchthar, Ilam, Sindhuli, Ramechhap, Dhading, Kabhrepalanchok, Gorkha, Lamjung, Tanahu, Syangja, Kaski, Palpa, Gulmi, Salyan, Dailekh, Dadeldura
Apples	Solukhumbu, Sindhupalchok, Rasuwa, Mustang, Jumla, Kalikot, Dolpa, Rukum, Doti, Baitadi, Darchula
Bananas	Kabhre, Dhading, Nuwakot, Sarlahi, Dhanusha, Mahotari, Chitwan
Pineapples	Dhading, Nuwakot, Sarlahi, Chitwan
Mangos	Bara, Parsa, Rautahat, Sarlahi, Mahotari, Dhanusha, Sunsari, Sirha, Saptari, Chitwan, Kapilbastu, Nawalparasi, Rupandehi, Surket, Dang
Walnuts	Jumla, Kalikot, Bajhang, Darchula, Baitadi, Dolpa, Rukum
Pears	Dhankuta, Bhaktapur, Lalitpur, Kabhre, Dhading, Makwanpur, Sindhu Palanchok, Nuwakot, Rasuwa, Palpa
Grapes	Banke, Bardiya, Manang, Mustang

Source: Partap 1993

Table 7. 5: **Choice of Fruit Crops in the Mountains of Pakistan According to Altitudinal Zones *(metres above sea level)***

Altitude (m)	Fruit crops
1200	Almonds, pomegranates, apricots, plums, persimmons, peaches, grapes, figs, pistachios, mulberries, strawberries
1500	Almonds, pomegranates, apricots, plums, persimmons, peaches, grapes, figs, pistachios, mulberries, strawberries, cherries, pears, walnuts
1800	Apples, peaches, grapes, cherries, pears, walnuts, mulberries, strawberries
2100	Apricots, apples, peaches, plums, pears, walnuts, strawberries
2400	Apples, apricots, pears, peaches, berry fruits (gooseberries, currants, raspberries)
2700	Apricots, apples, berry fruits (currants, gooseberries, raspberries)
3000	Apricots (early-maturing cultivars), berry fruits (gooseberries, currants, raspberries)

Source : Partap 1993

Table 7.6: **Fruit Farming in Himachal Pradesh According to Agroclimatic Zones**			
Agrocli. Zone	App. elev. (masl)	Rainfall (cm)	Fruit crops
Low hills (subtropical)	365-914	60-100	Mangos, litchis, *valley*, loquats, citrus fruits, papayas, *ber figs low-chilling*, varieties of pears, early varieties of grapes
Mid-hills (sub-temperate)	914-1523	990-100	Peaches, plums, apricots, almonds, persimmons, pears, pomegranates, pecans
High hills (wet, temperate)	1523-2742	90-100	Apples, pears (soft and valley types), cherries, walnuts, almonds, chestnuts
Cold and dry Trans-Himalayas	1523-3656	25-40	Grapes, prunes, drying varieties of apricots, almonds, chilgozas, sarda melons, pistachios, hops, apples
Source: Partap 1993			

Table 7.7: **Fruit Farming in the Hengduan Mountains, China, according to Agroclimatic Zones**		
Agroclimatic Zone	Areas of Interest	Fruit Crops
Hot arid zone Av. annual temp. >20°C Winter, 7-12°C Summer, 24-28°C Humidity in sub-zones 0.67 – 0.50% 0.5-0.29%	• Yuanjiang river valley, Shangjiang River valley • Jinshanjing River valley, Ninnan, Qiaojia	• Coffee, mangos, bananas, papayas, *common* • Citrus fruits, bananas, guavas, longans, litchis *>1900 n* apples, pears, peaches, grapes
Warm arid zone Av. annual temp >14°C Winter, -5 to 7°C Summer, 22-24°C Humidity in sub-zones 0.67-0.50% 0.50-0.29%	• Dadu River valley, Lhasa River valley, Yalong River, reaches of the Lanchangjiang River valley • Jinchuan-Luomo in Dadu River valley, Binchuan Basin in Yunnan	• Apples, pears, peaches, plums, apricots, cherries, persimmons, grapes, walnuts, chestnuts, loquats, pomegranates • Hanyuan snow pears, Luding sweet-smelling peaches, navel oranges from Shimian and Dechang, Xig peaches of Xichang, green skin pomegranates of the hills, apples, pears, pomegranates, walnuts in Jinchuan Danba, tangerines in Binchuan basin
Temperate arid zone Av. Annual temp *>10°C* Winter, 0°C Summer, 18°C Humidity in sub-zones 0.67-0.50% 0.5-0.29% 0.29-0.2%	• Zagunor River valley, higher reaches of the Mingjiang River valley • Songpau in Minjiang valley, higher reaches of Dadu River and its tributaries • Batau Shangiatou area of the Jinshajiang River, higher inaccessible areas or lower reaches of the Nujiang River valley	• Concentrated areas for pears and apples • Snow pears, best quality apples • Pears, apples

Table 7.7: **Fruit Farming in the Hengduan Mountains, China, according to Agroclimatic Zones (Cont'd)**

Agroclimatic Zone	Areas of Interest	Fruit Crops
Cold arid zone: Av. annual temp. >4°C Winter, -7°C Summer, 12°C Humidity in sub-zones 0.67—0.50% 0.50—0.29%	• Bayu-Batan area of Jinshajian River valley, Changdu • Manhan in Lanchagjiang River valley, Bangda-Zougong in Nujiang River vallley • All high altitude areas	Wild domesticates of: flowering crab apple (*Malus toringoides*); Chinese crab apple (*Malus asiatica*); hawthorn (*Crataegus scabrifolia*); and Japanese apricot (*Armenzaca mume*).

Source: Partap 1993

Table 7.8: **Agroclimatic Zones in Bhutan and Horticultural Crops being Promoted**

Agroclimatic zones	Important areas	Horticultural crops
Northern 30 km wide. Alt. above 4000m. Cold climate, perpetual snow, glaciers, barren rocks	High mountain areas	• • No farming practices or horticultural activities
Central 70 km wide. Alt. 2000-4000 m. Temperate climate, major forest areas, horticulturally suitable	Thimpu, Paro, Ha, Bhunthang, Wangdiphodrang	• Apples, potatoes • Scope (trials): asparagus, apricots, peaches, plums, cherries, walnuts • Scope (planned): currants, blackberries, gooseberries, raspberries, loganberries
Southern 50 km wide. Foothills, alt. to 2000 m. Tropical to sub-tropical warm climate, horticulturally suitable	Samchi, Gaylephug, Chirang, Samdrup	• Cardamom (low-volume, high-value), lemon grass oil (wild resource, low-volume, high-value), oranges, ginger, chillies, potatoes. • Scope (planned): mangos, guavas, litchis, bananas, kiwi fruit, figs, black pepper

Source: Partap 1993

The data also show that there is a continual attempt to identify distinct mountain micro-climates, and to look at the agro-ecological requirements of known exotic species or cultivars in order to evaluate their suitability for introduction into these climates. Only the variations in climate are considered, not the whole agro-ecosystem that develops under the sum total of all conditions.

The strategies and programmes of Himachal Pradesh, recognised as the fruit or apple state of India, are presented as a further illustration of the position of genetic resources in horticultural development policies. These strategies and programmes include the following.

- A programme for production and supply of fruit plants. This material facilitates plantation of hybrid varieties, mostly apple.

- Under an apple cultivation support programme, financial support is given to farmers to purchase plant material, pesticides, and fertilizers. There are also projects supported by international aid agencies on apple crop development and promotion.

- A programme on top-working wild fruit trees was launched and wild relatives of fruit crops were top-worked *in situ*. The total target for the Sixth and Seventh Plan periods was 11 million plants to be detopped. This meant converting jungles into orchards.

- Diversification of horticulture, enlarging its scope to include mushroom culture, vegetable farming, cultivation of medicinal plants, and other activities is underway. Special crops such as hops, sarda melon, and pistachio are being introduced in high mountain areas where the climate is temperate.

One Indo-Italian project introduced olive cultivation in Himachal. Other introductions include rootstocks for various temperate fruits such as apples, peaches, plums, and cherries.

There have been several projects assisted by UNDP, FAO, and the Dutch government to promote the cultivation of mushrooms. Under these projects some strains of *Agaricus*, essentially introductions, were promoted for cultivation.

Introductions and Monoculture

The promotion of the production of temperate fruit crops in the Indian Himalayas has had a number of negative consequences. These are described below as an example of the problems associated with too great a dependence on introductions.

Temperate fruits (apples, pears, peaches, apricots, cherries, plums, almonds, walnuts, pomegranates, and persimmons) have been instrumental in transforming the farming economy of several hilly areas of the Indian Himalayas. But this success has been based largely on introductions of varieties and rootstocks of several of these crops. The focus of horticultural research in institutions in the region has been directed mainly at the introduction of convenient, developed genetic material (Table 7.9) and to the evaluation of the key features of such material (Chadha 1986). Higher yields through introductions are being pursued. Such large-scale

Table 7.9: Dimensions of the Introduction of Temperate Fruit Crops in the Indian Himalayas	
Apples	• All commercial cultivars introduced over time • Latest trend is the introduction of genetic material for dwarfing and disease resistance from Europe • The introduced cultivars are different spur types • At present promising rootstock introductions from the Malling Merton series such as M 26, M 7, M 25, MM 106
Pears	• Bartlett is the main introduced commercial cultivar being promoted for cultivation
Cherries	• Recent introductions include Megness, Devoc, Starkrimson
Peaches	• Many introduced cultivars such as Sletta, Merton, Bigarreau, Sunburst, Lapins, Sarn, Van • Some new hybrid selections from Canada under evaluation • Lack of availability of a suitable rootstock and heavy virus infection in existing plant material are critical constraints to the crop.
Plums	• Introduced cultivars are Kanto-5, Shnnizu from Japan, Red haven, Sun haven, three of the Prairie series and Veteran, all from the United States and under evaluation • Rootstock Brompton and St. Julian K are under evaluation • Recent introductions are Starking Delicious, Late Santa, Queen Ann, Nubiana, Burmosa, Laroda, Stanley, Cacenska Rana, Ruth Gersttater, all from the United States.
Apricots	• Santa Rosa, a known cultivar. • The introduced species Myrobalan is a promising clonal root stock • Newcastle cultivar introduced for the mid-hills • Some native varieties known for the high hills • Recent introductions under evaluation include Hargraud, Reliable, Forming, and many others from Bulgaria • No clonal rootstock available yet
Almonds	• Introduced cultivars are Non-pareil, Ne Plus Ultra, Drake • Other introductions under evaluation are Wonder, Bruce, Mercett.

Source: Partap 1993

introductions into a region may result in several unforeseen problems. One of the first problems observed has been the introduction of new diseases (Table 7.10). These diseases can be caused inadvertently by using genetic material that is infected but which has escaped detection. Investigation of such diseases in the region shows that they came with crops into which large-scale genetic material introductions were made (Partap 1993). Technologies are being perfected to avoid the transfer of such diseases, yet the dangers persist, especially in poor developing countries in which the application of these technologies depends on the availability and development of infrastructural facilities.

Apples have emerged as the number one crop in the HKH region in terms of both areas under cultivation and production (Teaotia 1993). There are already a number of indicators that apple monoculture plantations will not be sustainable

Table 7.10: Exotic Diseases and Pests of Fruits and Vegetable Crops Which Were Introduced with Genetic Resources into the Himalayan Region of India

Disease/Pest	Affected Crop	Source of Rootstock	Date of Introduction
Hairy root	Apples, pears	Sri Lanka	1940
Crown gall	Apples, pears	Sri Lanka	1940
Canker	Apples	Australia	1953
Woolly aphid	Apples, pears	England	-
Downy mildew	Grapes	Europe	1980
Fluted scale	Citrus fruit Guavas	Australia	-
Fluted scale	Mangos	Australia	-
Mosaic	Bananas	Not known	-
Rust	Chrysanthemums	Europe, Japan	1984
Late blight	Potatoes Tomatoes	Europe	1983
Wart	Potatoes	Netherlands	1953
Golden nematode	Potatoes	Europe (UK)	1961
Potato tuber moth	Potatoes	Italy	-
Downy mildew	Onions	Not known	-
Smut	Onions	Not known	-

Source: Partap 1993

in the long term. A two-way loss has been reported. *First, the large-scale incidence of disease is resulting in both increasing expenditure on plant protection measures and reduction in production.* This is altering the cost-benefit ratio to a considerable degree. In some areas the costs have increased to levels at which it is no longer economical to grow apples, and a serious search for alternatives has started. For example, reports from the Hengduan mountains of China (Rongsen 1993) speak of an increasing incidence of disease in the apple crop which has reduced production by 30-40 per cent. Pesticides are being used extensively and, with up to eight sprays a season, pests are becoming resistant and chemical control proving ineffective. The natural ecological community of apple orchards has already been damaged and the environment affected. At the same time, more land is being brought under apple crops. A similar situation has developed in the Indian Himalayas.

The second loss ascribed to apple monoculture is the degradation of the environment. Huge amounts of poisonous chemicals are being used as pesticides. In Himachal Pradesh alone, by 1992, more than 2,300 tons of pesticide were being sprayed annually over 425,000 hectares of apple crops. By the year 2000, many more thousands of tons of non-degradable lethal pesticides will have been sprayed over the state and will have entered most food chains to a considerable extent, poisoning animals and humans alike. The issue does not attract much attention at present because of lack of information and the human tendency to ignore problems for as long as possible.

The question that arises is whether we can find solutions to the present problems associated with the culture of temperate fruit crops by using available indigenous genetic resources. If yes, what constraints prevent such an exercise?

Use of Introduced vs. Indigenous Rootstocks

Using rootstocks is not just a way of developing new crops. Appropriate rootstocks can be used to manipulate plant size, for example the creation of dwarf varieties; to increase disease resistance; and to manipulate phenological calendars and fruiting cycles, so important for mountain areas. The selection of good rootstock is a key factor in the success of fruit crops. At present most rootstocks are obtained from introductions, but this can create problems and the possibilities of using wild genetic resources as rootstocks should be investigated more seriously.

The main problem that can be created by the wrong choice of rootstock is the declining productivity of fruit crops. Poor selection of rootstock and insufficient availability of selected rootstock resources are the principal problems for horticulture in the mountain areas of Pakistan (Partap 1993). Using poor rootstock results in lower yields. In areas where all trees have the same (poor) rootstock, farmers become discouraged and stop cultivating a particular fruit crop because they mistakenly believe environmental unsuitability to be the cause. Lack of availability of nursery plants raised on healthy rootstock is also a deterrent today to cultivating fruit crops in mountain areas successfully.

If there is a problem in obtaining sufficient amounts of good, healthy rootstock from introductions what are the alternatives? One possibility is to exploit the local agrobiodiversity and use indigenous alternatives, both as rootstock and to develop certain crops.

There are a number of examples showing that the HKH region contains promising rootstock genetic materials that could be used to improve many crops. Some of these are listed in Table 7.11. In some places, indigenous resources have already been exploited in order to develop needed characteristics or overcome problems. In China, flowering quince is used as a rootstock for apples to obtain dwarfing and early fruiting (in three to four years). In the Swat Valley of Pakistan, local people have gained experience in using incompatible species as rootstocks to cope with soil-borne diseases of apple. They use *Crataegus* (hawthorn) as a rootstock by first grafting *Sorbus* on to it and then grafting apple on to the *Sorbus*, which is compatible. These examples represent only a fraction of the potential of horticultural genetic resources in the HKH region. At present, lack of information and of information exchange seem to be the main reasons for the lack of use of indigenously available genetic resources.

Table 7.11: Examples Showing the Diversity of Potential Indigenous Genetic Resources for Rootstocks and Fruit Crops in the Himalayan Region

Species	Local Name	potential use
Pyrus pashia	Kainth	Rootstock for pear
Pyrus lanata	Kainth	Rootstock for pear
Prunus puddum	Wild cherry	Cherry and fruit crops
Prunus padus	Bird cherry	Cherry and fruit crops
Prunus cerasus	Arid cherry	Root stock for cherry
Fragaria vesca, indica	Strawberry	Fruit and root breeding materials
Cydonia vulgaris	Quince	Fruit rootstock
Pyrus baccata	Siberian crab	Fruit rootstock
Ribes grossularia	Gooseberry	Rootstock for gooseberry
Ribes glaciale	Red currant	Breeding of currants
Ribes nigrum	Black currant	Breeding of currants
Ribes rubrum	Red currant 5000-12,000 ft; new fruit better than R. glaciale	New fruit crop
Corylus colurna	Hazelnut 5000-10,000 ft	Dry Fruit

Source: Atkinson 1860, reprint 1980

Mushrooms: A Complex Case of Underutilised Resources

Like medicinal plants, mushrooms fall into both the farming and forestry sectors. Throughout the Himalayan region people collect and eat more than 283 species of mushrooms (Partap 1995), a vast resource of edible mushrooms by any standard. Except in China, however, few countries farm local species. In China, farming of different species of mushrooms is common, but, in other countries in the HKH region, the strategy is to cultivate the world-renowned species *Agaricus* extensively along with other species such as *Pleurotus, Volvariella*, and *Lentinus* on a minor regional basis. There is little concern for the diverse underexplored resources of indigenously available mushrooms.

Floriculture: The Comparative Advantages of Mountain Habitats

Floriculture, a relatively new ancillary activity of horticulture, offers much potential in the mountains. Around 1,700 species of beautiful mountain flowers are available for diversification of farming into floriculture in the HKH region (Partap 1993). The northeastern Himalayas of India and southeastern provinces of China are centres of diversity and of the evolution of several ornamental plant species such as *Rhododendron, Magnolia, Primal, Camellia, Iris, and Jasmine*. It is also home to hundreds of species of orchids — notably *Dendobium* spp, *Paphiopedilum* spp, *Cymbipidium* spp, *Phalenoosus* spp, and *Vanda* spp. Many of these orchids are of high value.

Several pockets of the Indian Himalayas are engaged in the flower trade. The practice is based on raising hybrids of known varieties. Cut flowers are sent to the cities in the plains during the off-season. The northwest Indian Himalayas supply such flowers as roses, gladioli, lilies, narcissi, daffodils, carnations, and chrysanthemums; and the Kumaon hills of Uttar Pradesh, Kalimpong, and Gangtok in Sikkim supply gladioli, orchids, gerbera, magnolia, camellias, irises, geraniums, and other temperate species. The comparative advantages of mountain habitats result in potentially tremendous economic benefits from cut flowers. The price of a sample spray of orchids, for example, is about US$ 1-2 in the markets. Roses (*Rosa* spp) offer great scope for farming because of their tremendous genetic diversity in the Himalayan region. The existence of races with a good potential for rose oil brightens the chances of increasing yields to economically acceptable levels.

The current emphasis in floriculture is on research and development to evaluate the climatic suitability and evolve improved varieties of the mostly exotic species known for their market value. Except for some attention given to orchids, few attempts have been made to harness mountain floral resources as a cut flower crop, for the production of essential oils of high value, or as garden and potted plants. Instead, most present programmes focus on the cultivation of hybrid, exotic flower varieties and are not concerned with harnessing the floral diversity potential of the mountains.

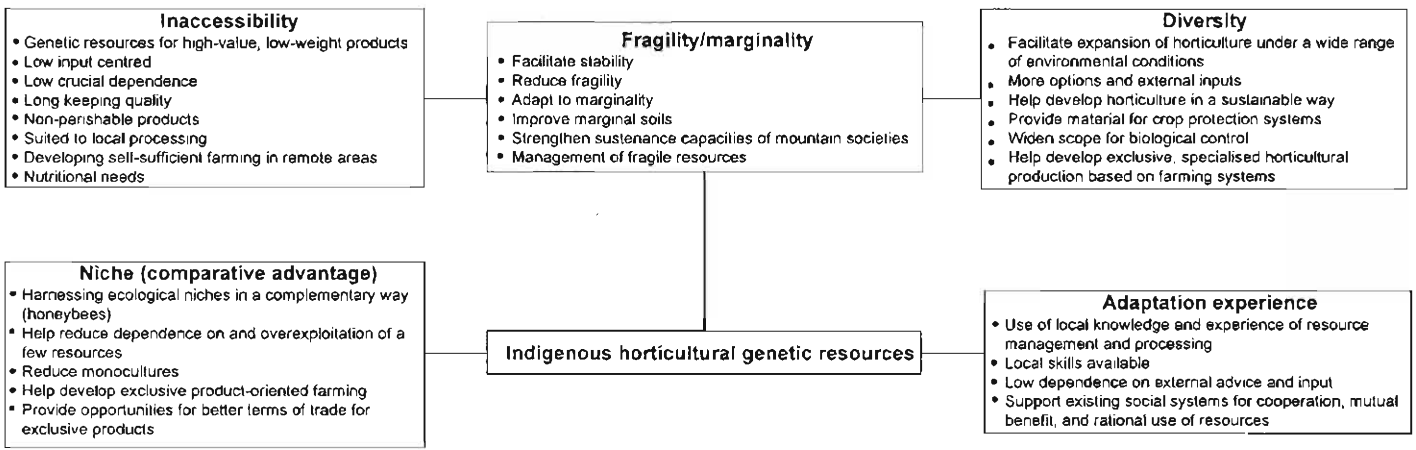
Selecting Horticultural Crops for Mountain Areas

The important factors for horticultural development under mountain conditions are certainly different from those in other areas. The potential contribution of indigenous horticultural genetic resources to mitigating specific problems associated with mountain areas or exploiting specific advantages of these areas are summarised in Chart 1.

Conclusion

There is little doubt that agriculture in the HKH region needs to be diversified in order to improve livelihoods in poor subsistence mountain communities. Promoting horticulture is one promising alternative, and it has proved successful in improving the economic well-being of poor mountain farmers in some pockets of the HKH. The challenge is to make horticultural development sustainable and compatible with the conservation needs of native agrobiodiversity. It is clear from the perspective plans and five-year development plans of the national and provincial governments of the region that these two issues have not yet been integrated into present approaches. For example, the agricultural perspective plan of Nepal emphasises promoting cash crop farming - the approach used in Himachal. The five-year plans of the hill provinces of India and Pakistan, and the development programmes of the mountain counties and provinces of China, also indicate

Chart 1: Range of Potential Contributions of Indigenous Genetic Resource Diversity to the Development of Horticulture in Mountain Areas



clear gaps in integrating conservation of agrobiodiversity with agricultural diversification. The region faces two problems in this regard: poor understanding of the subject itself outside the academic domain and dichotomy in the institutional framework. The institutions responsible for the development of horticulture are not the same as those responsible for the conservation of biodiversity and agrobiodiversity, although the genetic resources of crops are conserved by sections of these institutions.

International development aid has also contributed to the problem. The goal of both technical and financial international development assistance for the horticultural development of agriculture so far has been to help countries to improve their human, social, and economic conditions. Environmental and conservation ethics have not been included in the considerations. Interestingly, at present, such ethics seem to play a prominent role in traditional cultures as well as in highly developed nations. There are also examples of aid that indicate some confusion between development investment and conservation measures. Many programmes supported by international development agencies do not conform to agrobiodiversity conservation principles, wheseas the same agencies are willingly spending on genetic resource conservation elsewhere.

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Chapter 8

Micro-level Evidence of Impacts on Agrobiodiversity Caused by the Change from Subsistence to Cash Crop Farming in the Hills

H. R. Sharma

Introduction

Agricultural development in Himachal Pradesh (HP) provides us with a number of useful lessons for other mountain areas to follow. HP's success lay primarily in the ability of its planners to consider the specific attributes of mountains in development approaches. By reducing inaccessibility, the process of agricultural transformation from traditional cereal crops to commercial cash crops was expedited and resulted in remarkable improvements in the socioeconomic status of the farmers in the state.

The objective of the present study was to understand the process of agricultural transformation in one of the agriculturally developed areas and discover how it has affected crop diversity. The study was also intended to examine the implications of any changes in crop diversity for the sustainability of mountain agriculture in terms of the natural resource base, the quality of life, and equity. The case studies were carried out in two villages in Kullu district of Himachal Pradesh, Naggar (Katrain) and Banjar (Plach), which were selected to represent the transformed area (TA) and non-transformed area (NTA) scenarios, respectively (Table 8.1).

Material and Methods

The Kullu district of Himachal Pradesh was chosen for the study because the level of crop diversity in this district was higher than in other transformed districts. At the first stage of sampling, two development blocks (groups of villages), Naggar and Banjar, were selected to represent transformed and non-transformed areas

Table 8.1: Agro-climatic Conditions of the Study Area

	Transformed Area	Non-Transformed Area
Elevation	1000 to 1500 masl	2000 to 2500 masl
Mean annual rainfall	50-75 cm. Some rainfall throughout the year, but mostly during the monsoon	103 cm, mostly during the monsoon.
Temperature	0.6°C to 27.3°C	0.3°C in December to 20.8°C in August.
Soils	Sandy loam to clay loam	Clay loam
Irrigation	100 % (rice farming)	Rainfed
Dominant Cereal Crops	Paddy and wheat	Maize and wheat
Horticultural Crops	Apples, plums, and peaches	Apples, apricots, and plums
Average size of cultivated landholding	0.97 hectares	0.88 hectares

Source : Field Survey 1995

respectively. Two panchayats (clusters of a few villages) were then selected, again to represent the two levels of agricultural development. The selected panchayats were Katrain from the Naggar block and Plaich from the Banjar block. Finally, a total sample of 125 households, 62 from the transformed areas and 63 from the non-transformed areas, were selected randomly using the method of proportional allocation. In addition, 35 key informants, 20 from the transformed area and 15 from the non-transformed area, were also interviewed to assess changes in the natural resource base, quality of life, and equity at the community level based on their perceptions.

The salient agroclimatic features of the selected *panchayat*(s) are given in Table 8.1.

Changes in Crop Diversity and Yields

The process of agricultural transformation in the study area has led to significant changes in crop diversity during the past two decades, in both the transformed and non-transformed areas. Traditional crops, such as *Setaria italica*, millets, grain chenopod, and amaranth, are no longer cultivated in either area (Table 8.2). Hog millet (*Setaria italica*) is no longer cultivated in the transformed area and only to a very small extent in the non-transformed area. These crops have been completely replaced, mainly with fruit crops. Similarly, local varieties of wheat and maize crops have been substituted by exotic varieties, particularly in the transformed area. In both areas, there has been a complete substitution of local wheat with high-yielding cultivars. Similar trends are discernible in respect of other crops such as barley, potato, and oilseeds. The main additions to crop diversity have been kidney beans; different vegetables such as cabbages, cauliflowers, radishes, and tomatoes; and fruit crops. The area under fruit crops

Table 8.2: **Changes in Crops between 1975 and 1995 (% of area under crops)**				
Crop	Transformed Area		Non-Transformed Area	
	1975	1995	1975	1995
Setaria italica	1.75	-	4.17	0.22
Millet	1.50	-	4.71	-
Grain chenopod	1.00	-	2.60	-
Amaranth	1.50	-	5.50	-
Kidney beans	-	4.02	-	2.55
Barley	7.25	1.08	25.75	4.29
Oilseeds	1.50	0.31	1.04	0.18
Vegetables	2.75	2.79	-	-
Potatoes	2.00	-	6.75	0.40
Orchards	28.33	59.87	7.25	20.82
All crops + wheat & rice	100.00	100.00	100.00	100.00
Source: Field survey 1995				

has nearly doubled in the transformed area and has increased from seven to 21 per cent in the non-transformed area. These changes in the pattern of crops are usually leading to cash crop driven loss of agrobiodiversity.

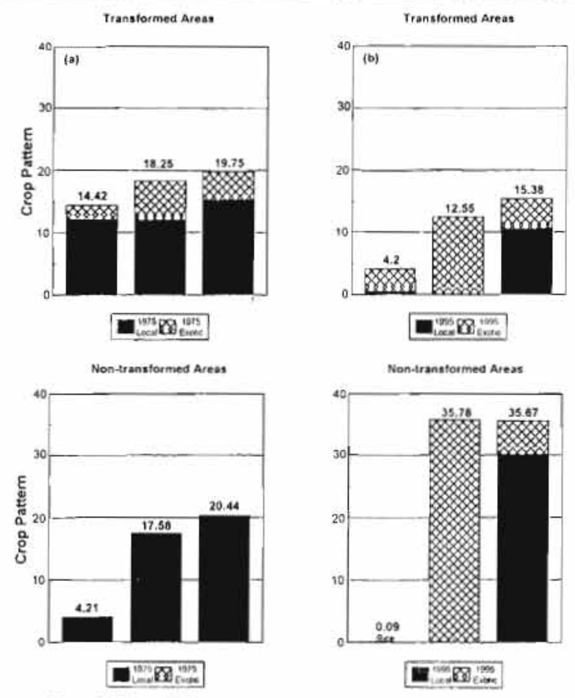

Figure 8.1: *Comparative changes (1975-1995) in percentage area under local and exotic cultivars of major crops in the transformed and non-transformed villages of Himachal Pradesh, India.*

The process of agricultural transformation has also led to the substitution of local breeds of livestock for hybrid breeds. In both areas, the number of livestock per household has gone down drastically; the most conspicuous changes being in the numbers of cows, sheep, and goats. The number of local cows per household has declined from 2.5 to 0.02 and from 3 to 1.05; and the number of sheep from 4.00 to 1.24 and from 10 to 1.44 in the transformed and non-transformed areas respectively. These changes can be explained primarily in terms of changes in crops. The spread of fruit crops, particularly apples, to marginal and fragile lands has led to a reduction in the area under pasture, forcing households to reduce the number of animals. Similarly, the replacement of local crop varieties that yielded more fodder with high-yielding cultivars has also resulted in a reduction in the amount of fodder available.

The changes in crop yields over time are shown in Table 8.3. The yields of all crops have increased to varying degrees, both in the transformed and non-transformed areas. This is attributed to such factors as the adoption of high-yielding varieties and the availability of inputs such as fertilizers. The evidence in Table 8.3 is in sharp contrast to that of declining crop yields in mountainous regions documented by the MFS Division of ICIMOD. It is clear, however, that crop yields in the non-transformed areas are still lower than those in the transformed areas, mainly because of low use of inputs such as fertilizers.

Table 8.3 : Changes in Crop Yields Over Time 1975 to 1995 (t/ha)

Particulars		Transformed Area		Non-Transformed Area	
		1975	1995	1975	1995
Corn – black gram	Local	1.6	2.1	0.9	1.3
	HYV*	1.7	2.6	-	2.0
Paddy	Local	1.7	2.0	0.6	0.9
	HYV*	2.0	2.7	-	-
Setaria italica		1.3	-	0.8	0.2
Millet		1.4	-	0.8	-
Grain chenopod		0.7	-	0.5	-
Amaranth		0.9	-	0.8	-
Kidney beans		1.6	0.5	-	0.5
Wheat	Local	1.3	-	0.7	-
	HYV*	1.5	2.2	-	1.1
Barley		1.6	1.5	0.9	1.0
Oilseeds		0.4	0.5	0.5	0.6
Peas		2.5	-	-	-
Potatoes		3.0	-	2.5	3.5
Cabbages		-	5.6	-	-
Cauliflower		-	6.3	-	-
Radishes		-	2.5	-	-
Tomatoes			8.3	-	-

HYV=high yielding varieties
Source : Field survey, 1995

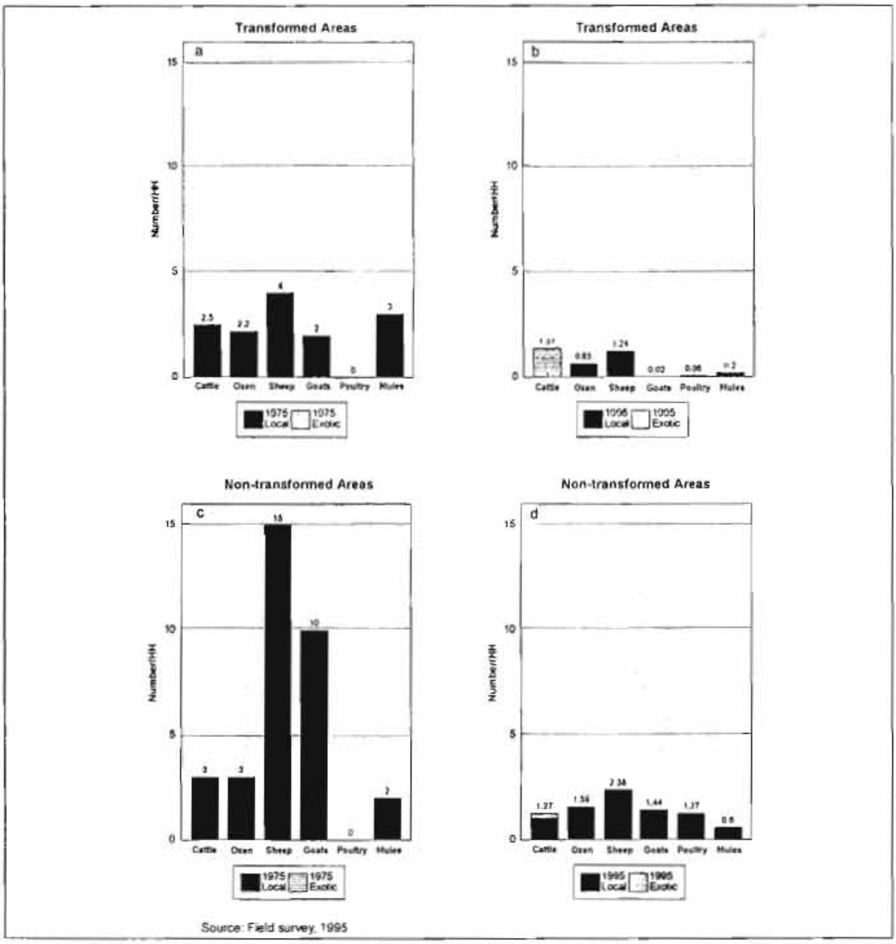

Figure 8.2: *Comparative (1975/95) Changes in Number of Local and Exotic Livestock in the Transformed and Non-transformed Villages of Himachal Pradesh, India*

Changes in Crop Diversity: Impact on Income and Employment

The process of transformation from traditional subsistence agriculture to commercial agriculture based on high-value cash crops has led to significant changes in household income (Table 8.4). There is a small difference in the number of household livelihood options between the transformed and the non-transformed areas; although around 80 per cent of the total households in both areas are engaged in three to four livelihood options. The clearest difference, however, is seen in the level of income; both the household and per capita incomes are nearly twice as much in the transformed areas as in the non-transformed areas. The contribution of different production/livelihood options towards total household

Table 8.4: Range of Livelihood Options and Levels of Household Income (Indian Rupees)

Range of Options	Transformed Areas			Non-Transformed Areas		
	% of HHs	HH income	Per capita income	% of HHs	HH income	Per capita income
Up to 2	9.68	82,498	13,026	3.17	8,309	1,846
3-4	85.48	67,423	9,684	79.37	33,574	5,134
5-6	4.84	88,135	15,553	17.46	48,089	5,750
All households	100.00	69,884	10,219	100.00	35,305	5,197

Note: Household and per capita incomes are net income figures. In June 1995, 35 Indian Rupees were equal to 1 US$.

Source : Sharma 1996

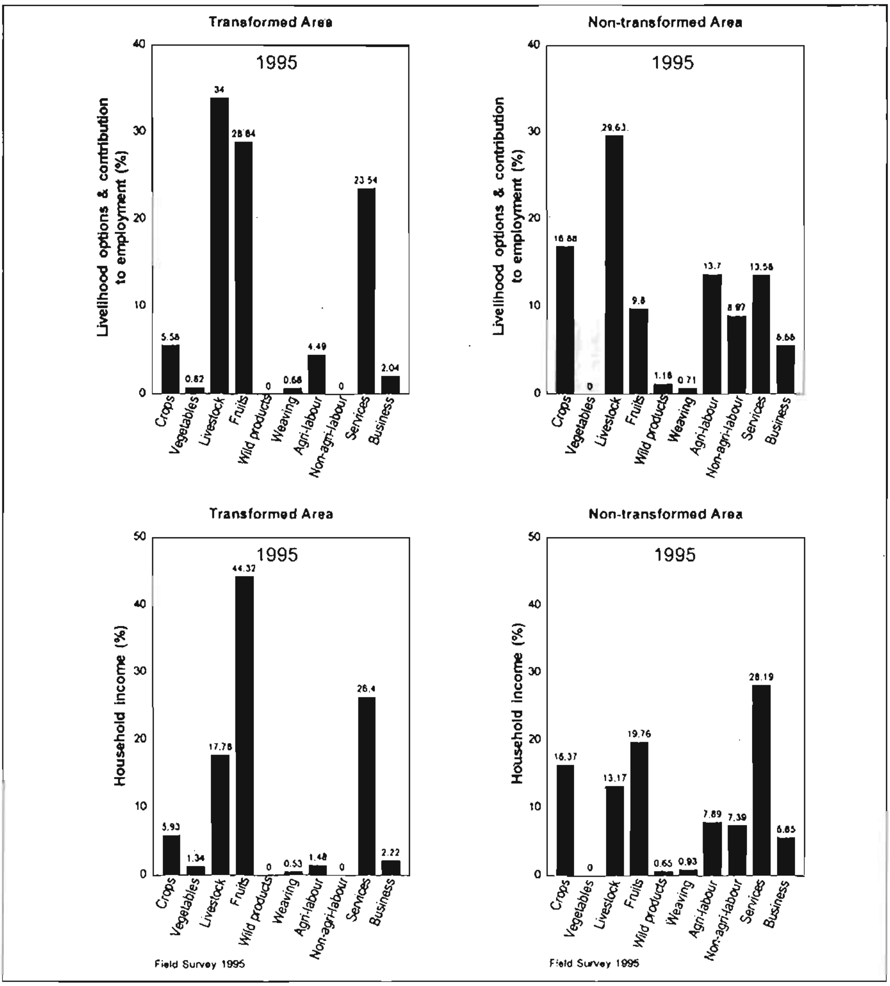

Figure 8.3: *Livelihood Options and Their Contribution to Employment*

employment and level of income are shown in Fig 8.3. A few significant features that emerge from Table 8.3 and Figure 8.3 need to be underlined. First, agriculture, defined broadly to include food grains, fruit, vegetables, and livestock continues to be the major source of livelihood in both areas. For example, in the transformed areas, fruit crops and livestock are the major production activities accounting for as much as 70 per cent of total employment days. In the non-transformed areas, crop production, livestock, and agricultural labour are the most important sources of household employment, accounting for nearly two-thirds of total employment days. Second, agriculture-related activities contribute two-thirds of the total household income in the transformed areas, with fruit production alone accounting for two-fifths of the total income. In contrast, in the non-transformed areas, the contribution of agriculture to the total household income is nearly one-half with fruit production contributing about the one-fifth, followed by crop production and livestock. Among the non-farm activities, service activities contribute more than one-fourth, followed by business and non-agricultural labour. Average per worker per day earnings, which take into account both amount of employment and level of income, are substantially higher in the agriculturally transformed areas than in the non-transformed areas. In brief, the process of substitution, replacement, and addition to the diversity of crops and animals in the agriculturally transformed areas has led to a significant increase in household income and, in the ultimate analysis, in the economic status of the local people.

Changes in Crop Diversity: Implications for Sustainability

The effect of changes in crop and animal diversity on sustainability has been examined in terms of changes in the quality of life, equity, and the natural resource base. Some quantitative aspects of sustainability are presented and discussed in this section. Some indicators of the quality of life are shown in Table 8.5. Expenditure on food, clothing, shelter, health, and education, amongst others, reflects the quality of life of the people. Expenditure on food items such as meat, eggs, milk products, and fruit could simply indicate the result of these households no longer having their own livestock or food crops. Similarly, the availability and use of facilities like telephones, liquid petroleum gas (LPG), and television, and the very high value of residential houses in the transformed areas, say a lot about the quality of life being enjoyed by the people. In comparison, people in the non-transformed areas are just surviving; not only is the expenditure on basic necessities such as food, clothing, and education very low, some households remain perpetually in debt.

Equity, both intra- and inter-generational, is one of the most important prerequisites to ensure sustainable development. A process of economic transformation accompanied by widening inequalities is inherently unstable. Agricultural development that dispossesses a large number of marginal and small farmers and makes income more inequitable cannot be sustained in the long run.

Table 8.5: Impact of Agricultural Transformation by Producing Cash Crops on the Quality of Life of Farm Families

	Indicator	Transformed Areas	Non-Transformed Areas
1	Expenditure on superior grains in IRs	5124 (10.49)	3461 (13.40)
2	Access to food (% of HHs)	100.00	100.00
3	Expenditure on clothing	4765 (9.75)	3040 (11.76)
4	Expenditure on milk & milk products.	11,771 (24.09)	2774 (8.80)
5	Expenditure on meat, fish and eggs	2344 (4.81)	893 (3.46)
6	Expenditure on fruit and vegetable	2378 (4.87)	697 (2.70)
7	Expenditure on education	5174 (10.59)	1826) 7.07)
8	Expenditure on health	1174 (2.40)	1594 (6.17)
9	Value of residential houses (Per household, Rs)	113,839	56,762
10	Percentage of households using LPG	43.33	-
11	% of households having telephone connection	21.67	-
12	% of households having television	100.00	20.00
13	Literacy level (percent)	52.19	35.00
14	% of households in debt	5.00	35.00
15	% of households without electricity	-	11.67
16	% of households below poverty line (official)	-	30.00

Source: *Sharma 1996*
Expenditure in Indian Rupees (Rs)

In fact, some scholars have argued that the ideal solution to the problem of making development sustainable lies in ensuring the equability of a system even at the cost of sacrificing some productivity and conservation (Conway 1985; Redclift 1987). Various indicators of equity in the transformed and non-transformed areas are shown in Table 8.6. It is clear from this table that the process of agricultural transformation has not exacerbated intra-household inequalities. On the contrary, the extent of inequality is somewhat less in the transformed areas than in the non-transformed areas. For example, in the transformed areas both income and land distribution, as measured by the Gini ratio, are less skewed, male-female differentials are less pronounced, female literacy is significantly higher, and sexual division of work is less rigid.

Some quantitative evidence related to the health of the natural resource base is shown in Table 8.7. The replacement of traditional crops such as millet and *Setria*

Table 8.6: Agricultural Transformation and Implications for Equity

Indicator		Transformed Areas	Non-Transformed Areas
1	Male wage rates (agricultural)	IRs. 30.00	IRs. 25.00
2	Female daily wage rates	IRs. 25.00	IRs. 20.00
3	Income distribution (Gini ratio)	0.37	0.40
4	Land distribution (Gini Ratio)	0.58	0.62
5	Female literacy	42.62	34.18
6	Male literacy	60.09	53.48
7	% of female participation in household decisions	90.00	40.00
8	Sexual division of work	Fewer activities exclusively performed by males; females are often seen managing shops, etc	Rigid, less flexible sexual division of work.
9	Female employment	The introduction of new cash crops has opened up opportunities for female employment. For example, many women earn a good amount of income by working in apple orchards.	Such changes are discernible in the non-transformed area as well, but the impact is much less pronounced.
10	% of females with secondary or higher level of education.	41.34	12.96
11	% of children going to school		
	Male	100.00	100.00
	Female	100.00	100.00

Source : Sharma 1996

italica with high-value cash crops such as apples, for which the area has a comparative advantage, has led to a decline in the cropping intensity, which in this mountainous region augurs well for the maintenance of soils. Likewise, the process of transformation has been accompanied by a significant decline in the number of livestock per household and a complete switch from grazing to stall feeding, which has positive implications for the maintenance and conservation of the natural resource base. There is also no evidence of land degradation in terms of such factors as an increase in the intensity and frequency of landslides, an increase in soil erosion, or a decline in the water level in natural water sources. All is not well, however. Shrinking agrobiodiversity (crop and animal diversity), a decline in the amount of support land, and disruption of social values are the emerging problems.

Changes in Crop Diversity: Factors and Process

The process of substitution, replacement, and addition in the diversity of crops and animals is caused by a number of factors — both exogenous and endogenous.

Table 8.7: **Agricultural Transformation and Implications for the Natural Resource Base**

Indicator	Transformed Areas	Non-Transformed Areas
Cropping intensity	128	167
% of area under fruit crops	75	24
Livestock (No./HH)	5	10
Use of fertilizer	Balanced	Unbalanced
Fuelwood	Use of LPG, kerosene, coal and less dependence on fuelwood	Total dependence on forests
Packing boxes	Substitution with cardboard boxes, recycling of boxes, and imports of timber from neighbouring states.	Similar trends
Livestock rearing	Stall feeding	5-6 hrs grazing
Land degradation	No evidence	No evidence
Awareness about natural resources	Very high	Very high
Natural water sources	No change	No change
Support land	0.11 ha per ha of crop land	0.45 ha per ha of crop land
Agrobiodiversity	• Reduction in the number of crops • Destruction of predators and useful insects	Problem is less acute, though the number of crops grown has declined
Investment in agriculture	30-40 per cent of total household income	10-15 per of total household income

Source : Sharma 1996

It is well known that farmers steeped in poverty with an extremely low standard of living are quick to seize any opportunity that might afford them a better livelihood. The experience of the transformed areas shows that the process of change has been caused primarily by exogenous factors. For example, wider promotion of apple farming and potatoes and the provision of infrastructural facilities such as roads set the whole process of change into motion. These new crops were not grown earlier because of lack of infrastructure and marketing facilities. Another factor that has played an important role in the wider adoption of fruit and other new cash crops is political patronage. A vast research and development network has been created to provide technical know-how to farmers. Support prices have been introduced to safeguard the farmers from extreme price fluctuations; institutional arrangements have been made to procure fruit in the event of prices falling to a very low level.

Summing up

In summary, the agricultural transformation experienced in our study areas has led to a substantial improvement in the quality of life of the people in terms of access to food and expenditure on clothing, health, superior grains, and so on. An improved level of welfare is also evident from the increase in the level of literacy in general and in female literacy in particular, the disappearance of poverty, and the decrease in the number of land and water disputes. The equity aspect is also positive; the Gini coefficient of income distribution is 0.37 in the transformed areas compared with 0.40 in the non-transformed areas. The evidence related to the impact on natural resources is also positive. In the process of transformation, factors and processes have been generated on both the demand and supply side that have lessened the burden on natural resources. These include the decline in cropping intensity, the decrease in the number of livestock per household, and the complete change over to stall feeding.

Another aspect of this change relates to the experiences of the transformed and non-transformed areas in the conflict between the maintenance of biodiversity and the level of development. Local agrobiodiversity is the first casualty of the onset of the process of transformation and integration of remote mountain areas with the mainstream: old crops are replaced with new crops; traditional varieties are substituted with high-yielding varieties; new crops are introduced; indigenous and local animals are replaced with crossbred and improved animals; traditional social and cultural values give way to new ways of life; and so on. The conflicts tend to increase with the increase in population pressure and spread of urbanisation. Farmers, who want to exploit any opportunity offered to improve their standard of living, cannot be expected to preserve the rich agrobiodiversity on their own. The solution for conserving species of crops and animals that are endangered and on the verge of extinction lies in combining their conservation with agricultural development.

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Chapter 9

The Dichotomy of Crop Diversity Management Issues in Subsistence and Commercial Hill Farming Systems in Nepal

D. P. Lohar and R. B. Rana

Introduction

In the last few years, commercialisation of agriculture has taken place in a few areas of the Nepalese hills. There is serious concern that commercialisation of agriculture has endangered crop biodiversity. We were interested in assessing the status of diversity in both species and varieties and in looking at the perspective of farmers by examining the real situation in villages where intervention had taken place and in those in which there had been no intervention.

Genetic diversity in crops is important for many reasons. First, the issue of present and future food security and sustainable development are based primarily on the ability of breeders to use the genetic diversity in crops to breed new, superior varieties. Second, the genetic diversity in crop species and varieties buffers the outbreak of diseases and insect pests, thus stabilising production over time and location. Third, genetic diversity helps to meet the different needs, tastes, and preferences of people from different parts of the world with different ethnic, social, and cultural backgrounds. Finally, the genetic diversity of crops forms a part of the chain of a larger ecosystem, the erosion of which, it is feared, will have detrimental consequences.

It has been widely documented that biological diversity (including plant genetic resources) is being lost at an alarming rate (Cunningham 1991; Haverkort and Millar 1994). The main reasons for this rapid loss are considered to be the degradation of natural habitats, the displacement/elimination of land races by modern crop cultivars, and the change in land-use systems (monocropping). The displacement/elimination of land races results from the need to increase the yield and quality (in some cases) of crops to sustain better livelihoods.

The mountains of Nepal are rich in crop genetic resources, the result of both ecological and sociocultural diversity. In the past, Nepalese hill agriculture was mainly subsistence farming. However, in recent years, increased urbanisation and transportation facilities, together with external technological inputs, have resulted in the rapid transformation of some areas in the hills into commercial centres of production of food and vegetable crops. This transformation has raised serious concerns about the potential depletion of plant and animal genetic resources. Nevertheless, the claims made so far have not been supported by quantitative information from the field. In this paper we describe the results of observations of crop genetic diversity made in commercial areas where there has been a lot of intervention and in areas with moderate to low intervention and commercialisation. This paper discusses the preliminary findings of the observations and experiences, together with some issues related to crop genetic diversity in the mountains of Nepal.

Methodology

The genetic diversity of field and vegetable crop species and varieties was compared in 'intervened' and 'non-intervened' areas in Tanahun and Syangja districts. The 'intervened' areas included Yampaphant (V_1) (475 masl) and Rishing Patan (V_2) (350 masl) where development and research activities have been going on for the last ten and five years respectively. The 'non-intervened' areas included Baradi (V_3) (410 masl) of Tanahu district and Bagtar (V_4) (370 masl) of Syangja district where direct intervention by development agencies is minimal. Yampaphant (V_1) and Baradi (V_3) are located along a major highway, they have good access to markets, and the majority of land is under irrigation; Rishing Patan (V_2) and Bagtar (V_4) are away from the main road, they have some access to markets, and there are equal amounts of *khet* (paddy field) and *bari* (rainfed upland) in the village. The findings presented are based on information collected at community level and describe the number of species and varieties of crops and vegetables.

Findings and Discussion

Diversity at Species' Level

Figure 9.1 shows the number of crop species grown at present, lost and added for staple crops and vegetables. Field crops show a higher crop diversity in the 'intervened' area than in the 'non-intervened' area, an average of 26 species per village compared with 16 species per village. Crop diversity in vegetables is

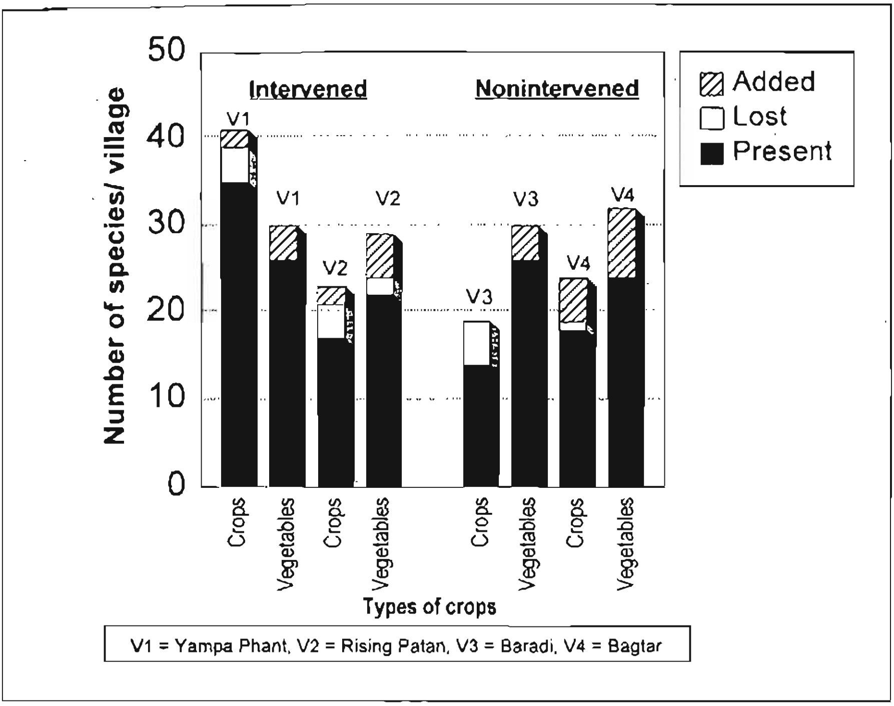

Figure 9.1: Diversity at Species' Level in Two Villages of 'Intervened' (V1 and V2) and 'Non-intervened' (V3 and V4) Areas, Nepal

comparable in both 'intervened' and 'non-intervened' areas, with 24 and 25 species per site respectively. Though there are a few commercial farmers in this area at present, they and others still maintain the old crops. Thus the species' diversity is higher on average in the areas with commercial agriculture than in those with non-commercial agriculture. The reason for the low diversity in field crops in the 'non-intervened' area is not known.

Four and three species of field crops had been lost from 'intervened' and 'non-intervened' areas respectively. Farmers did not report any loss of species in vegetables in the 'non-intervened' area, two species were reported as lost from one village, Yampaphant, in the 'intervened' area (Chinese cabbage and turnip). Thus, there was more species loss in field crops than in vegetables, irrespective of commercialisation. This could be mainly because of the higher original level of diversity in field crops. Second, more rationalisation of field crops has taken place with farmers concentrating only on a limited number of high potential crops and dropping others. The need and the market demand for a variety of vegetables require farmers to maintain different species. In addition, new vegetable species have been introduced, such as carrots, cabbages, and cauliflower, which were traditionally not grown by the farmers, whereas this is not the case for field crops. Both commercial and subsistence growers co-exist in the same area, thus complementing each other in terms of crop diversity at village level. Traditional crops are maintained in a small area. Therefore, evidence from this limited area suggests that agricultural development is not necessarily associated with genetic erosion.

Crops lost in both 'intervened' and 'non-intervened' areas include *kauno* (*Setaria italica*), *junelo* (*Sorghum* spp), *gahat* (*Dolichos biflorus*), *filongo* (*Guizotia abbysinica*), *siltung* (*Vigna umbilata*), cotton and tobacco. The first two crops are of minor importance and were only cultivated under the slash and burn (*Khoria*) system. Since *Khoria* cultivation has been abandoned, these crops have also been lost. This is the main reason reported by farmers. The loss of *gahat* and niger is the result of the change in the land-use system from *bari* to irrigated *khet*. Similarly, the loss of cotton and tobacco has resulted from their now limited utility in the villages since supplies of commercial products became easily available in the local market. This suggests that subsistence farming probably needs more species' diversity than commercial farming.

Diversity in Varieties

The number of varieties of field crops and vegetables grown at present, lost, and added is shown in Table 9.1. The general trend for six different field crops is that the number of varieties grown at present in the 'intervened' area is higher (41 varieties/site) than in the 'non-intervened' area (27varieties/site). The number of crop species lost in 'intervened' areas ranged from 9-16 species compared to 3-16 species in 'non-intervened' areas. The trend of vegetable species' loss ranged from 2-10 in 'intervened areas' compared to 1-3 in 'non-intervened' areas. The additional species' diversity in the 'intervened' system is comparatively higher (22-23) compared to 'non-intervened' areas (5-14). The situation is different for different types of crops, as shown for example by early rice and finger millet. The number of varieties of maize and finger millet grown in the 'intervened' area is less than in the 'non-intervened' area. This is because the 'intervened' area is highly commercialised and farmers are not interested in growing maize and finger millet. Instead, farmers usually grow cash generating vegetable crops. Early rice is an introduced crop whereas finger millet is an indigenous crop. There is a clear indication that displacement and replacement of varieties is a continuous process and is higher in 'intervened' areas than in 'non-intervened' areas. Intervention has resulted in an increased choice for farmers rather than depleting the genetic base of the area. However, the fate of indigenous land races as a result of the introduction of new varieties is not yet known.

There are 30 and 28 varieties per site of the nine types of vegetable grown at present in 'intervened' and 'non-intervened' areas, respectively. This indicates

Table 9.1: Diversity in Field Crops and Vegetables at Study Sites

Particulars	Type of crops	Number of crops		
		Present	Lost	Added
Intervention (Yampa)	Field crops	46	16	22
	Vegetable	35	2	18
Intervention (Rishing Patan)	Field crops	36	9	23
	Vegetable	25	10	17
Non-intervention (Baradi)	Field crops	22	6	5
	Vegetable	19	3	11
Non-intervention (Bagtar)	Field crops	32	3	14
	Vegetable	36	1	14

that there has been little loss in the total number of varieties of the vegetable crops included in the study. This may be because there is less diversity anyway at the level of varieties, a point which needs further study. Biodiversity is difficult to define as it varies with time and space (Witcombe *et al.* 1996). Intervention has actually added to the total diversity in varieties, but more species have been lost as well as more added. This clearly indicates a case of variety displacement, wherein local land races have been displaced. It also indicates that farmers have a greater choice of varieties in the 'intervened' area than in the 'non-intervened' area. Farmers are still trying to assess different crop varieties for the diverse situations, and this seems to be the main reason why the loss of variety is low and diversity still high in the 'intervened' area. The process of erosion in the number of varieties is still going on and superior varieties are displacing older varieties. There may be a need for *ex situ* conservation of rejected land races which could contain unknown traits that might become valuable in the future.

The varieties of different vegetable crops grown in three different areas are shown in Table 9.2. The three areas include 'intervened' and 'non-intervened' areas of site set 1 (Tanahun) and a 'non-intervened' area in Syangja. The diversity in varieties in the 'non-intervened' area of Syangja is higher than in either of the areas in Tanahun. The 'non-intervened' area of Syangja is highly subsistence in

Table 9.2: Diversity in Varieties of Selected Vegetable Crops at Five Different Sites

Crop	Number of crop varieties				
	Tanahun site, set 1		Tanahun site, set 2		Syangja
	Intervened (V_1)	Non-intervened (V_3)	Intervened (V_2)	Non-intervened	Non-intervened (V_4)
Cowpeas	7	2	4	5	6
Rayo	2	2	2	3	8
Radishes	4	3	2	4	5
Cucumbers	5	2	1	2	5
Taro	4	4	2	6	8
Chillis	4	2	3	6	7
Total	26	15	14	26	39

nature and is remote from the road head, so the level of intervention is very low. It was also found that the varieties grown in 'intervened' areas were usually introduced and the varieties grown in 'non-intervened' areas were usually local land races.

Some Issues

Crop genetic diversity is important at both species' and variety level. The case studies described here show that the loss of crop species' from an area can be low and rather slow. However, the loss of genetic resources at the level of varieties seems higher for field crops, whereas introduction has increased overall genetic diversity for vegetable crops. Technological intervention and commercialisation in an area can add to the genetic diversity since farmers do not abandon their old land races until the performance of new ones is known to be reliable. However, the process of displacement may well start later with local land races being displaced followed by older varieties, and the process will continue.

The issue that emerges is that genetic diversity in commercialised areas depends on outside sources. This is because commercial farmers always seek for more productive and profitable crops and varieties. Such varieties are bred at plant breeding stations. Private companies also breed and market seeds. This phenomenon is particularly applicable to vegetable crops. Farmers cannot produce seed locally (in the case of hybrids). There is no chance of local selection, segregation, and adaptation. The genetic diversity on commercial farms is controlled externally. This genetic diversity is not sustainable and does not belong to local farmers. Such uniformity has no meaning in non-mechanised farming systems. In contrast, in subsistence areas, the genetic diversity is locally produced, maintained, and used by the farmers. However, the situation is rather paradoxical; on the one hand commercialisation or intervention is required to improve the economic condition of the farming community and on the other hand genetic resources need to be conserved for sustainable development. Therefore, there is an urgent need to devise approaches to balance economic gains with long-term conservation goals. The diversity of species and varieties at household levels in different production systems needs to be studied, because maintenance of diversity actually occurs at the household level. The food security situation must also be taken into account when discussing large biodiversity conservation initiatives.

There are many approaches to genetic diversity conservation (Cooper *et al.* 1992). One of the most common methods is to collect local land races and conserve them in gene banks *ex situ*. In Nepal, this method has been used for some important crops such as rice, maize, and finger millet. However, it is hardly used for vegetable crops at present. Since there is wide genetic diversity in some local vegetable crops in Nepal, steps towards collection and conservation need to be strengthened. Nevertheless, this approach does not provide direct benefit to the community or to the individuals who contribute to the conservation process. Thus the need arises to complement *ex situ* with *in situ* conservation.

In situ conservation of crop land races is relatively difficult to implement because it involves farmers as well as their crops. Unless and until farmers are made aware of the potential benefits they can obtain by conserving genetic resources, it will not be easy to get their participation. Developing approaches that combine conservation with development of farming systems, and motivating the farmers, are the keys to the success of any *in situ* conservation strategy.

Commercialisation of crops in suitable areas could be initiated in order to help maintain the diversity in indigenous crop species such as traditional vegetables (taro, yam, chayote, *cyclanthera*, *Dolcichos* bean), upland rice, high quality rice, and different fruit crops. A similar kind of effort has been initiated in Kenya by the Indigenous Fruit and Vegetable Development Project (Kiambi and Opole 1992). This project aims to encourage the conservation of indigenous fruits and vegetables through increased use of local germplasms at the community level. The nutritional and other qualities of crop species/varieties traditional to Nepal could also be analysed in such projects. Participation of farmers in selecting the varieties of these indigenous crops/land races could also increase the diversification. Furthermore, organically grown land races could be promoted in the market and thus fetch premium prices.

Another approach to *in situ* conservation of indigenous land races is through farmers' groups. Farmers of a village or community can be organized into groups and made aware of their genetic resources, networking can be facilitated between these groups to enable them to share information and materials. Along with the introduction of high-yielding crop varieties, farmers would be asked to plant small areas with their local crops/land races. In this way, both commercialisation and *in situ* conservation of genetic resources can be achieved.

It has been observed that two kinds of farmer reside in the same village, one with a commercial scale of production and the other with a subsistence-scale of production. In such cases, subsistence farmers could grow the local land races found in the village to serve their own needs. This is advantageous to such subsistence farmers since they can enjoy the local taste and avoid the costs of extra inputs. However, creation of awareness of genetic resources is necessary even among such villagers.

Still another approach would be to encourage national programmes to recycle the useful genes available in land races in breeding programmes. Some successful approaches have already been demonstrated by Sthapit *et al.* (1996) for rice in

Nepal. This approach will combine the best of land races with the desirable traits in the exotic parent to give an output suited to the local environment.

Conclusion

Genetic erosion is taking place in both commercialised and traditional farming and in both cereal and vegetable crops. It is difficult to make the generalisation that commercialisation leads to genetic erosion. There are cases in which intervention increases agrobiodiversity, but it can also reduce agrobiodiversity. The detailed socioeconomic and anthropological situation should be taken into account. It was apparent from this study that farmers constantly update their genetic resources by dropping unwanted crops and varieties and adding useful ones. Further studies are required to understand the fate of land races, the area under different production systems, and the contribution of major varieties to the food security situation of the region. What is clear, however, is that when the increase in the number of varieties is based on seed produced externally, this is not genetic diversity for the area in the true sense because it cannot be sustained by the system.

Since commercialisation in agriculture is essential for raising the economic status of farmers, approaches should be devised to balance economic development with conservation of genetic resources. Approaches such as *ex situ* conservation of indigenous crops and land races, *in situ* conservation through the commercialisation of traditional crops, market promotion through breeding, farmer participation in variety selection, networking through farmers' organizations, cultivation of land races together with commercial crop varieties, and involvement of subsistence farmers can be useful to rescue endangered genetic resources. It is important to note that a high level of farmer awareness and motivation will be required to realise *in situ* conservation goals.

However, the preliminary findings from the current study do not support the contention that commercialisation of agriculture has endangered crop biodiversity, at least not in the villages studied. One aspect is clear though, the crop biodiversity in commercialised areas is mainly dependent on external sources and does not have a local base or long-lasting nature. It is mainly a replacement process, in which less beneficial types are dropped. Since some improved varieties have high yield and quality under ideal conditions, it is natural that farmers are attracted towards such varieties. Thus, the conservation of land races in a dynamic state is a real challenge.

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Chapter 10

Account of a Mountain Farmer's Crop Replacement Process on Farm Land in the Indian Himalayas

C. R. Dhani

Introduction

Improvements in the economy and quality of life of farming communities in Himachal Pradesh (HP), particularly apple and vegetable farmers, is widely acknowledged as a success story in the hills and mountains of the Hindu Kush-Himalayas. The significant point is that this success has been achieved without using the conventional strategies that focus mainly on industrialisation. The majority (75%) of farming families in the apple growing area of Himachal belong to small and marginal farming categories. The state has created a new concept in the development of hill economies through transformation brought about in agriculture, horticulture[1], and animal husbandry.

Case

Mr. Dhani, an experienced farmer from Himachal Pradesh, narrated his experience of crop choice and replacement over five decades. From 1940-50, 50 farmers in this area harvested wild mushrooms (*Morchella spp.)*, wild fruits, and medicinal herbs from the forest to earn cash to supplement the shortages in food supplies from their farmlands (Box 10.1). Mr. Dhani himself used to grow at least 17 crop species besides keeping animals and growing fodder species. Farming was based upon subsistence, and at least nine types of staple crops were grown to fit into the diverse niches of his 27 ha farm. Besides rice, wheat, and barley, a range of minor crops, such as finger-millet, persomillet, grain chenopods, foxtail millet,

1 *Here meaning fruit and vegetable farming*

and buckwheat, was grown. In those days food sufficiency was the priority. Mustard and sesame crops were grown for vegetable oil for home consumption and butter ghee used to be harvested from the seeds of the *chiuri (Diploknema butyracea)* tree. He himself grew potatoes and cocoyams but not modern vegetables and fruits such as apples. He, like other farmers, depended on the forests for fruits and wild vegetables. Farmers depended on the outside word only for commodities such as metal implements, salt, and clothes.

Agriculture was integrated: livestock, crops, grazing lands, and forests - thus there was plenty of manure to apply to the land. Table 10.1 indicates that this state continued until 1960-70. After Himachal became a fully-fledged state of India, it made efforts to improve farming incomes, especially in remote areas. Suddenly rural life became attractive. Roads broke the barriers of isolation and remoteness and provided market opportunities. After the road infrastructure improved, potatoes became the first source of income generation for Mr. Dhani, followed by peas and tomatoes (vegetable crops) (Figure 10.1). Farmers gradually abandoned the practice of collecting food and medicinal herbs from the wild as they had less time because of attractive interventions in farming.

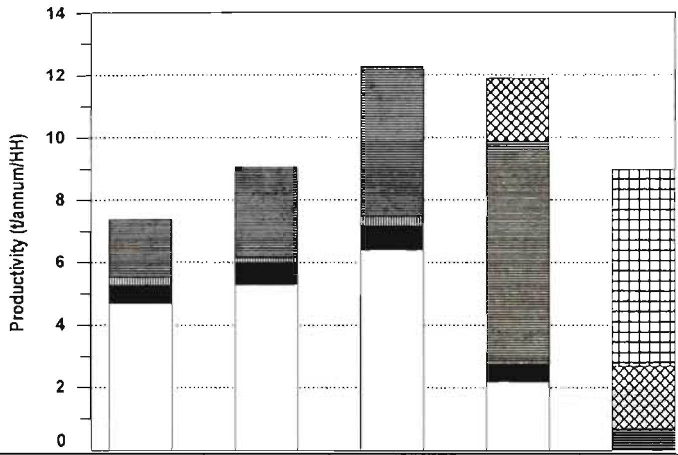
Table 10.1: History of Crop Replacement by Mr. Dhani over the Past 40-50 Years

Year	Staple crops[a]	Grain legumes[b]	Tuber crops[c]	Oilseed crops[d]	Vegetable crops[e]	Fruit[f]	Total
1940-50	9	4	2	2	0	0	17
1950-60	9	4	2	2	0	0	17
1960-70	9	4	2	2	0	0	17
1970-80	4	4	2	2	2	0	14
1980-90	0	1	2	1	3	7	14

a Wheat, barley, maize, rice, fingermillet, chenopod, persomillet, foxtail millet, buckwheat
b Lentils, native soyabean, black gram, kidney bean
c Potatoes and taro
d Mustard and sesame
e Peas, onions, and tomatoes
f Apples, peaches, plums, almonds, apricots, pears, kiwi fruit

By the 1990s Mr. Dhani was able to completely replace food grain crops with fruit orchards, mainly apples, and supplemented cash flow through commercial vegetable crops (Table 10.1). Agricultural development in Himachal focussed on the promotion of fruit cultivation because of the suitability of the climate for apples, pears, plums, and off-season vegetables, so, as with Mr. Dhani, almost all farmers adopted cash crop farming, their choice of crop depending on the type of farmland.

In addition to using some arable land, the approach has been to convert non-agricultural land that was not suitable for crop cultivation into fruit orchards. The



	1940-50	1950-60	1960-70	1970-80	1980-90
Cereals	4.70	5.30	6.40	2.20	0.00
Legumes	0.58	0.65	0.78	0.55	0.10
Oilseeds	0.27	0.18	0.30	0.10	0.00
Tuber	1.80	2.90	4.80	7.10	0.60
Vegetables	0.00	0.00	0.00	2.00	2.00
Fruits	0.00	0.00	0.00	0.00	6.24

Figure 10.1: *Trends in Crop Replacements by Himachal Farmers (Mr. Dhani)*

horticultural development programme has brought about a number of positive changes which have transformed the economy of this mountain farmer and the living standard of his family. Horticultural enterprise has flourished in the area because of the comparative advantages and the unlimited demands for fruit and vegetables in the adjoining lowlands of India. Mr. Dhani no longer grows food crops, but he is not worried about food security as he has enough money to buy food.

At a glance, the transition from subsistence to market-oriented cash crop farming seems successful. It is true that cash cropping has increased the household incomes of small mountain farmers. However, farmers are now facing marketing and other technical problems for potatoes and apples. Mr. Dhani expressed his concerns. Because of the initial success, large numbers of rural communities transformed their cultivated fields into apple orchards, and this process is now continuing in adjoining states. In order to retain the comparative advantages of the hills and to harness the potential of mountain niches, new opportunities for alternative cash crops have to be explored. So far efforts have focused mainly on introducing crops from similar agroclimatic zones. Not much effort has gone into exploring and harnessing local plant resources and indigenous crops for the development of cash crops.

The government is providing options for floriculture, vegetables, and kiwi fruit, but the success of these enterprises depends on the market. Mr. Dhani has doubts. For big farmers floriculture could be an attractive option, but for small farmers kiwi fruit (Chinese gooseberry) and vegetables could be beneficial alternatives. The cost of flower seeds can be as high as IRs 30,000/ha. Flowers are a highly perishable commodity, and marketing is difficult and expensive as market outlets are located in metropolitan cities. Mr. Dhani's experience suggests that kiwi fruit farming is considerably more profitable than apple farming. In 1996 he harvested 800 kg of kiwi fruit which he sold at the rate of Rs 96.00 per kg. The cost of cultivation was 17-34 times less than that of apple farming. The domestic market is still unexploited. Since Indian consumers have a taste for sweet foods, Mr. Dhani suggested that the market potential for kiwi fruit would improve if researchers could improve the sweetness of the fruit (TSS, a measure of sweetness).

Mr. Dhani's is a case that explains the ongoing trend of thinking among hill farmers by and large. Here in the hills, farmers are looking for improvements in their living standards and issues such as agrobiodiversity conservation are of less concern to them.

Domestication of medicinal plants is another attractive option. Many medicinal plants in Nepal, Bhutan, Pakistan and the Indian Himalayas are collected as wild plants. China is the only country with substantial experience in farming medicinal plants. In Nepal and India, scientists have tried to domesticate medicinal plants on arable land, whereas in China they were introduced on to marginal lands or leased forest or intercropped with agroforestry. Learning from farmers in other areas should be a priority in searching for appropriate technologies. Necessary training should be given *in situ* so that a large number of women farmers can participate, because women are the repositories of skills and knowledge.

Agrobiodiversity is not only a function of the total number of species and cultivars. The replacement of traditional crops by new species has increased the agrobiodiversity of new crop species and reduced the diversity of old local crop species. Biodiversity is difficult to define under these circumstances but should be considered over space and time.

Chapter 11

Using Agrobiodiversity for Developing Marginal Mountain Agroecosystems: The Experiences of a Pilot Project in the Tiahang Mountains, China

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The Taihang Mountains

The Taihang mountains in China cover an area of 100,000 sq. km. from 114° 15' E, and 37° 52' N onwards. The pilot area is in a part of the Taihang mountains 50 km southwest of Shijiazhuang, the capital city of Hebei Province, and 310 km southwest of Beijing. The experimental site was a seriously degraded one.

The climate in this region is characterised by an abundance of sunshine, low relative humidity, and an average evaporation of 1,589 mm per year. Average annual precipitation is 579.6 mm, 77 per cent of the rainfall occurring between June and September. The temperature is extremely variable. The annual average temperature is 13°C, varying between -11 and 39.3°C.

Seventy per cent of the mountainous areas are slopes where the soil is very shallow and stony. The soil in the valleys is relatively good with a better moisture holding capacity. The population density in the Taihang mountains is extremely high at 245/km. Farmers are very poor and the average per capita income is about US$ 43.

Studies were carried out at the Experimental Station of Ecology in the Taihang mountains to test conservation and whether rehabilitation of agrobiodiversity can play a key role in improving the environmental conditions and providing socioeconomic benefits to economically disadvantaged farmers.

Limitations to Environmental Rehabilitation

During the 1950s, a lot of investment was made to improve the environment in the Taihang mountains through an afforestation programme. Even so, the forest cover in this region is still less then 20 per cent. The reason for this is that the government paid too much attention to the improvement of the environment through afforestation with timber trees, and ignored the farming economy of the inhabitants. Trees planted during the 1950s and 1960s are still only six to eight metres tall with a diameter at waist height of less than 20 cm.

Conventional scientific thinking in China and elsewhere considers afforestation as a means of environmental rehabilitation. Forests can also be developed on marginal lands where the environmental conditions limit the development of crop production. Few lessons have been learned from the way peasants live in these areas. The local people were not allowed to use trees planted for environmental purposes in this area. For 30 years, the peasants obtained little economic benefit from these activities and they became nervous about afforestation. We tried to combine these two different aspects; environmental rehabilitation through afforestation and providing economic benefits to local farmers; by planting *economic* commercial fruit trees that have a relatively quick turnover.

Experiment and Results

Introduction of Economic Trees

Our surveys revealed that *economic trees* (in China fruit trees are understood to be economic trees) in the Taihang mountains were not very productive and the quality of their fruit was not good. Some varieties needed to be replaced for the market. The Experimental Station introduced a total of 347 species and varieties, including 45 varieties of pomegranate, six varieties of persimmon, 14 varieties of apple, 20 varieties of grape, eight varieties of cherry, 28 varieties of walnut, 28 kinds of forage herbs, and medicinal herbs. One hundred Chinese *mu* (6.7 ha) of land was used to test the adaptability of these species and varieties. During the ten-year experiment, more than 50 species and varieties were identified suitable to the harsh environment of the Taihang mountains.

Improvement of Native Walnuts

The walnut is a traditional tree species in the Taihang mountains. It is well adapted to drought and the low fertility of soil in the area. The productivity of local walnuts is very low (1.35 kg/tree per annum), however, and the quality of the fruit is considered poor as the shell is very difficult to break. There is little demand for local walnuts in the market. Fine walnut cultivars were grafted on to 354 old and low yielding trees in the early spring of 1988 to improve the productivity of walnuts. Since the old trees contained a lot of stored energy, new branches from the grafted buds grew very fast (Table 11.1). At the end of the second year, the tree crowns had reached 4.7 to 5.9m and 87 per cent of the trees gave some

Table 11.1: Yield of Old Walnut Trees in 1989, Two Years after Grafting				
Walnut variety	No of nuts per tree	Weight of nuts per tree (g)	Weight of dry kernels per tree (g)	Length of branches from each newly grafted bud
Liaohe 1	216	2383	1281	138.6
Liao 50609	202	2343	1337	-
Zhonglin 1	163	2039	1076	123.4
Zhonglin 5	187	1877	1133	-
Bofeng	190	2179	1146	156.0
Liao 50706	174	1829	926	151.0
Lubo	181	1852	1100	109.9

fruit. The average yield of seven well-adapted cultivars was 1.83 to 2.38 kg/tree. The average yield of these seven steadily increased to 3 kg/tree, that is 7.1 times the average yield of these trees in 1987.

Introduction of Pomegranate Cultivars

The pomegranate is a widely distributed species in the Taihang mountains and usually grows on the driest south-facing slopes. The fruit is usually very sour and the market for such quality is not good. The fruit fetches only half the price of sweet pomegranates. Most fruits are used for canning. However, the pomegranate is one of the few fruits that can be farmed on the very dry southern slopes of the mountains and it has good storage qualities. Therefore promoting pomegranates in a programme to rehabilitate degraded land could help to improve farmers' living conditions as well as to conserve native species.

Since 1987, more than 50 cultivars of pomegranate have been introduced at the Experimental Station. Several integrated methods were used to establish pomegranate plantations. These were:

- improvement of the micro-site environment,
- conservation of soil moisture, and
- introduction of new varieties.

Table 11.2 shows the degree (%) of adaptability under different mulching treatments compared to other local species.

Table 11.2: Establishment of Pomegranates and Other Fruit Trees and Degree of Adaptability under Different Mulching Treatments (comparison with other species)					
Tree species	plastic film	grass	stone	turf	control
Pomegranate	98.0	84.7	86.2	73.6	62.6
Local apricot (*Prunus sibirica*)	95.8	86.4	85.3	78.2	72.4
Local peach (*Prunus davidiana*)	96.9	85.6	85.8	76.0	67.5

Pomegranates are well placed on the south facing slopes of the mountains to avoid chilling. Ten cultivars of pomegranate withstood the drought and shallow soil conditions (Table 11.3). Seven cultivars produced a better yield than the others. The highest yielding cultivar was Erban which produced 11.7 kg fruit per tree compared to 2.0 kg/tree for the local land races.

Table 11.3 : Yield Performance of Pomegranates

Cultivars	Yield (kg/tree)	Mean fruit weight (kg)	Weight of biggest fruit (kg)	Weight of 100 grains (g)	Taste
Baden	4.75	140-170	300	52.0	Sweet
Erban	11.70	150-350	500	39.0	Sweet
Sanbt	2.75	120-280	380	27.7	Sweet
Yusz	6.50	100-330	390	48.0	Sweet
Daht	6.25	130-270	300	41.5	Sweet
Fenpi	2.70	100-250	250	39.2	Sweet
Chongbh		30-50	48	12.7	Sour
Qianch	0.60	190-350	420		Sour
Hongpt	0.35	70-100	140	23.0	Sweet
Tianhd	3.10	100-200	250	25.7	Sweet
Luyd	1 40	100-250	330	24.3	Sweet
Dazz	1.00	100-280	280	22.2	Sour
Mapz	0.50	100-150	200	22.1	Sweet
Maith	2.00	100-200	250	28.0	Sweet

Sweet Persimmon Tree

The persimmon is another indigenous fruit tree that grows wild in the Taihang mountains. The trees mostly grow wild in the valley areas where the soil is deep. *Persimmonis* is a drought-resistant plant. Its fruit is eaten fully ripe and therefore fruit storage is difficult. Because of this the prices fall as production increases. Six varieties of persimmon were introduced and evaluated. Of these, Dansiwan, Fuyou, Colong, and Songben contain no tannic acid so the fruit becomes sweeter before ripening. This helps solve the problem of storage and transportation of ripened fruit. Fruit from these cultivars can be sold 20 days earlier or stored for a longer time.

Medicinal Plants

The Taihang mountains are famous for their richness in medicinal plant species. The demand for Chinese medicine has been increasing as a result of improvement in the economic status of people. Therefore more medicinal products are needed in the market. As Chinese medicines are becoming expensive, there is a demand for more raw materials, and this is leading to overexploitation of nature. Thus many species of medicinal plants in hilly areas are endangered. The purpose of the study in this case was to collect endangered species and try to domesticate them on the farmlands of the Taihang mountains so as to increase incomes. Box 11.1 gives examples of high-value medicinal plants found in this area.

About 60 species of medicinal plants were planted in the experimental region. Of these, 18 species, including *Astragalus membranaceus, Perilla frutescens, Schizonepeta tenuifolia,* and *Cassia tara,* have been shown to be drought resistant species which can grow well on the dry slopes of the mountains. Fifteen species, including *Tagetes erecta, Achyranthes bidentata, Angelica dahurica,* and *Agastache yugosa* can be cultivated easily in shady environments. Two species, *Pinellia pedatisecta,* and *Corydablis bungeana,* can only be planted in shady conditions with a good soil moisture content.

Wild medicinal plants usually love a shady environment and thus cultivation can be integrated into agroforestry or mixed with other crops. There are several possible intercropping systems, for example, intercropping of fruit trees, such as pomegranate, walnut, apple, and apricot, with medicinal plants and shrubs such as *Forsythia suspensa, Eucommid vimodies, Macrocarpium papyrifera, Belamnenda chinensis, Anemarrhena aspehodeloidees, Arctium lappa, Angelica dahurica, Salvia miltiorrhiza, Ophiopogon japonicus,* and *Adenophora elata.*

Forage Herbs

A total of 29 species of forage herbs was introduced to improve soil fertility and supply good quality grass for livestock. Eleven species — including *Medicago sativa, Melilotus albus, Onobrychis viciaeofolia, Astragalus adsuragens, Panicum virgatum,* and *Andropogon geraidii* –were found to be drought tolerant and able to complete their full life cycle in the Taihang mountains. Most of the leguminous species studied needed 120 days to complete their cycle and produce seed. In contrast, most forage herbs in the grass family need 150 days to complete their growth cycle. The growth period of the introduced species was longer on average

Box 11.1

High-value Medicinal Plants for Farming in Forests and on Marginal Mountain Slopes in the Taihang Mountains

Ginseng	*Villous amomum*
Amur cork	*Cinchona ledgeriana*
Eucommia	*Perilla frutescens*
Magnolia	*Schizonepeta tenuifolia*
White aster	*A. membranaceus*
Nackberry lily	*Cassia tara*

than that of local grasses, which grow for three to four months during the rainy season to use residual moisture.

The types of land used for forage production were barren slopes, forest, orchards, and terraces. This practice helped improve the soil fertility of the forests, orchards, and barren lands, as shown in Table 11.4.

Table 11.4: The Influence of Herbage on Soil Fertility Three Years after Plantation

Herbage	*Medicago sativa*		*Melilotus albus*		*Onobrychis viciaeoflia*	
	herbage	control	herbage	control	herbage	control
Organic matter (%)	0.84	0.71	1.07	0.94	0.82	0.75
Total N (%)	0.084	0.011	0.113	0.082	0.076	0.054
Available N ($mg.kg^{-1}$)	51	37	63	43	48	36
Available P ($mg.kg^{-1}$)	1.0	1.0	1.5	1.0	1.0	0.5
Available K ($mg.kg^{-1}$)	128	126	113	123	170	152

The plantation of forage herbs greatly improved the biomass of terraced and old deserted sloping farmlands. It was observed that the annual biomass of three-year old *Medicago sativa* reached 9.9 t/ha, and the biomass of *Miliotus officinalis* reached 13.7 t/ha, ten times more than the biomass of other native grasses. In the fourth year, when crops were planted on this land, crop productivity on the deserted marginal lands was 4.8 t/ha for wheat, 0.6 t/ha for cotton, and 0.9 t/ha for soybean.

Agrobiodiversity and Economic Benefits of Intercropping on Mountain Farmlands

Fourteen different types of intercropping system in addition to grape and wheat intercropping were developed in the experimental region. These 14 systems can be divided into five types: fruit trees or economic trees intercropped with crops; fruit trees or economic trees intercropped with economic plants; fruits tree intercropped with vegetables; fruit trees or economic trees intercropped with Chinese medicinal plants; and fruit trees or economic trees intercropped with forage herbs. Tables 11.5 to 11.8 show the economic benefits of intercropped systems compared to those of the same crops grown as monocultures. It is clear that the economic benefits from all 14 kinds of intercropping systems were higher than from any trees or plants planted as monocultures. Both the economic benefits and crop diversity were maintained.

Socioeconomic Benefits of the Experiment.

The introduction of economic plants created opportunities for forest and agroforestry systems suited to the site conditions of local farmers. This approach

Table 11.5: Comparison of Economic Benefits of Fruit Trees and Crops Grown in an Intercropping System or as Monocultures

Inter cropping Model	Area (ha)	Age of tree (years)	Yield of fruit (kg)	Yield of crop (kg)	Economic output (*yuan*)	Economic results (*yuan*/ha)
Apricot + wheat	0.20	5	750	200	1210	6050
Walnut + wheat	0.135	20	170	200	1010	7575
Peach + sweet potato	0.135	44	900	1000	1100	8250
Wheat	0.5			1350	1080	2160
Apricot	0.4	5	1600	-	2240	5600
Walnut	0.04	20	25	-	250	6250
Peach	0.30	4	2250	-	2250	7500

* There are 8.28 *yuan* to the US Dollar.

Table 11.6: Comparison of Economic Benefits of Fruit Trees or Vines and Economic Crops Grown in an Intercropping System or as Monocultures

Intercropping model	Area (ha)	Tree spacing (m^2)	Age of tree/vine (years)	Yield of fruit crop (kg)	Yield of crop (kg)	Economic output (*yuan*)	Economic results *yuan*/ha
Grape and peanut	0.02	1x4	5	300	15	390	19,500
Grape and mung bean	0.02	1x3	5	420	12	540	27,000
Apple and soybean	0.04	6x6	18	440	18	588	14,700
Peanut	0.20				648	1296	6,480
Mung bean	0.10				120	480	4,800
Soybean	0.30				630	1890	6,300
Grape	0.03	1x3	5	400		480	16,000
Apple	0.20	6x6	18	2230		2676	13,380

Table 11 7. Comparison of Economic Benefits of Fruit Trees or Vines and Vegetable Crops Grown in an Intercropping System or as Monocultures

Intercropping model	Area (ha)	Tree spacing (m^2)	Age of tree/vine (years)	Yield of fruit crop kg)	Yield of vegetable (kg)	Economic output (*yuan*)	Economic results (*yuan*/ha)
Grape &potato	0.25	1x4	5	450	100	560	21,000
Grape and onion	0.25	1x4	5	400	60	516	19,350
Apple and garlic	0.02	3x4	5	400	40	488	24,400
Potato	0.02				290	58	2,900
Onion	0.01				70	42	4,200
Grape	0.40	1x4	5	5400		6480	16,200
Apple	0.40	3x4	5	6500		7800	19,500

has been successful in combining the objectives of environmental improvement and income generation opportunities for farmers. By the end of 1995, the technologies developed had been adopted in the surrounding 20 villages and the farmers' average annual income had reached 673 *yuan* per capita (a rise to US$ 116 from US$ 43). Local government institutions were made aware of this

Table 11.8: **Comparison of Economic Benefits of Fruit Trees and Chinese Medicinal Plants Grown in an Intercropping System or as Monocultures**

Intercropping model	Area (ha)	Age of tree (years)	Fruit yield (kg)	Medicinal plant yield (kg)	Economic output (yuan)	Economic result (yuan/ha)
Grape and *rhizome* of windweed	0.02	5	260	14	424	21,200
Grape and black-cherry lily	0.02	5	280	15	456	22,800
Apple and rhizome – large-headed atractylodes	0.03	5	380	10	536	17,867
Rhizome of windweed.	0.01			19	152	15,200
Black-cherry lily	0.02			42	336	16,800
Grape	0.03	5	360		432	14,400
Apple	0.20	5	1980		2376	11,880

successful approach to environmental rehabilitation (the development of economic forest) and several training programmes were organized to popularise it. More than 3,500 farming families have visited the experimental station so far. It is expected that the economic benefit resulting from technology transfer from this station will reach 0.1 billion *yuan* at the end of this century.

Some Common Issues

The study by Shijiazhuang Institute of Agricultural Modernisation demonstrated that promoting economically suitable options — including both local and exotic plant genetic resources — for rehabilitating degraded land can enhance agrobiodiversity. Of 348 species and varieties tested, a total of 50 species was found to be successful. The study raised the issue that afforestration for the sake of forestry *per se* is not an attractive option for farmers as they do not see any immediate economic benefits from such plantations. Providing the option of cash generating crops combined with economically useful tree species can be a good strategy to motivate community participation. High-value medicinal plants (woody or herbaceous) are often intercropped with an established timber plantation four to five years after first pruning. This agroforestry system can help balance the conflict between the long-term economic benefit of timber production and medium-term opportunities for livelihood. It can also help in meeting the increasing demand for high value medicinal plants. The system can be seen as an alternative method for maintaining agrobiodiversity through the participation of communitiies, because farming communities see the benefit of maintaining and cultivating high-value indigenous medicinal crops.

Chapter 12

Impact of Changing Agropastoral Systems on Agrobiodiversity: A Case Study of the Qinghai-Tibetan Plateau

Wu Ning

Introduction

The Qinghai-Tibetan Plateau consists of the vast area extending from the Pamir range in the west to the Hengduan mountains in the east and bordered by the Kunlum and Qilian mountains to the north and the Himalayas to the south. Because of the high altitude and harsh environment of the plateau, cropping is not practicable in most areas and the only way that the land can be used is for it to be grazed by animals tolerant of the cold. Thus pastoralism represents the main economy of the Plateau. There are 167 million hectares of natural rangeland resources on the Qinghai-Tibetan Plateau, 42 per cent of the total area of grassland in China. In 1986 there were 17.2477 million head of large livestock (mainly yaks, horses, cattle, and cows), 14.5 per cent of the national stock, and 37.6981 million goats and sheep, 20.9 per cent of the national stock. Animal products from this region, such as wool, cashmere, hair, mutton and beef, account for 12.32-13.47 per cent of national production. As a result of the geographical pattern, the Qinghai-Tibetan rangelands have attracted pastoral societies for thousands of years. Even now, more than half of the regional population makes a living from the various livestock production systems.

The study described here was conducted in the east of the Qinghai-Tibetan Plateau in western Sichuan, at an elevation of between 3,000-3,500m. The region plays an important role as a link, both economic and ecological, between the plateau and the hinterland of China. At present this region is impoverished. It has a long history of pastoralism. Today, following the changes that have taken place in China in recent decades, it is at the transitional stage between a self-sufficient subsistence economy and a market economy. This study describes the daily lifestyle of the pastoralists and discusses the economic progress and resultant pressure on the environment, particularly on the rangeland ecosystem and its biodiversity.

Livestock Farming Niches in Western Sichuan

Western Sichuan covers a vast area between the Longmen mountains and the Dadu and Jinsha rivers. It is located between 97°26' and 104°27' E, and 27°57' and 34°21' N. The total area of this region is about 236,000 sq.km., 41.6 per cent of the total area of the province. There are 13.9 million hectares of rangeland. Administratively, the region is divided into the Graze Tibetan Autonomous Prefecture and the Aba Tibetan and Qiang Autonomous Prefecture, which include 31 counties. The population in 1993 was 1.61 million, 1.46 per cent of the total in the province (SSB 1994).

According to the survey of rangeland resources in Sichuan Province (SAHB 1989), there are 22.5 million hectares of natural rangeland in Sichuan, about 40 per cent of the total land area. The 19.6 million hectares of available rangeland account for 35 per cent of the total land and are three times the present area of tillage land. These rangeland resources not only play an important role in the regional economic system and environment. They are also the basis of the livelihood of local communities (minority nationalities) and are home to a unique agrobiodiversity system, especially in terms of animals.

The traditional agropastoral system maintained a diversity of animal combinations so as to enable farmers to adapt to different agroclimatic conditions. Some of these animal combinations are as follow.

Pig-rearing in the Basin Area

As a result of the ideal climatic conditions and fertile soil in the valley basin, farming, and particularly pig-rearing, is well-developed. This system depends on the provision of fodder and grain and forms the pillar of animal husbandry in the basin. Pigs comprise up to 86.0 per cent of the total number of domesticated animals. There are also goats (5%) and cattle (2.3%). The basin is largely dominated by *Han* farmers who play a dominant role in rural societies. *Tujia* farmers are mainly scattered in the southeast of the region.

Cattle, Goats and Pigs on the Periphery of the Basin

Hills and low mountains surround the basin, agricultural land is marginal and fragile, and sloping pastures create the conditions for combining farming of domesticated cattle and goats with pigs. In this periphery area, cattle make up 33 and goats 17 per cent of the livestock. The number and proportion are more than in the basin and there is more potential for development. There are settlements of various ethnic groups scattered in the region, *Qiang* (*Kiang*) and *Han* along the northwest upper reaches of the Mimiang river in the Dahangshan and Xtaoliangshan mountains and in the north in the Daba mountains, and Tibetans on the western fringe.

Yak and Sheep Farming on the Plateau

With its extensive rangelands, the northwestern plateau is the most important area for Sichuan in terms of developing herbivore husbandry. About 76 per cent of the total number of herbivores in the province are found here. Among these, sheep and goats dominate, followed by yak, *zu*[1] and cattle. Yak and *zu* constitute 80 per cent of the total number in the province and 20 per cent of the total number in China. Beef and mutton production in this area is 26 per cent of the total production in the province. Most inhabitants of the Plateau belong to the Tibetan ethnic group.

The Four Pastoral Systems

Table 12.1 summarises some key descriptors of present pastoral systems. Common to all systems is the use of communal land as pasture, they differ in the degree of mobility of herds and households. With increasing altitude, in particular the transfer to the plateau, mobility increases reaching its extreme in the migratory pastoralism that uses the most marginal areas in the region.

Very different management considerations and practices apply to the livestock production spectrum from nomadism through semi-nomadism to mixed agro-pastoralism. The available resources influence both the occurrence or choice of production system, and the manner in which the system is managed. This is especially true for the nomadic system (including nomadism and semi-nomadism), which is a response to the environment. The central concern of nomadism is to maintain animal numbers and animal products, such as milk and butter, by seeking good grazing areas and adequate water and avoiding predators and known foci of disease.

There is no single management system which applies to all livestock over the large area of their distribution on the Qinghai-Tibetan Plateau. Since yaks play a vital role in the pastoralism of western Sichuan, the management system here is

1 *Zu* also called *Zumo* is a crossbreed between yaks and cattle (*Bos taurus*), which may date back to 3,000 years ago when the *Qiang* nation adopted this technique of reproducing animals. The word comes from the *Qiang* language. The result of continuous crossbreeding of *Zu* with yaks for five generations is considered to be a yak.

Table 12.1: Descriptors of Pastoralism	
Agro-pastoralism	Combination of crop production with grazing of livestock on both individually owned and communal land in the immediate vicinity of a permanent homestead
Sedentary pastoralism	Grazing livestock on communal land in the vicinity of permanent homesteads throughout the year
Semi-sedentary pastoralism (Semi-nomadism[a])	Grazing livestock on communal land in the vicinity of a permanent homestead for part of the year, and long-distance movement of herds during the warm season
Migratory pastoralism (Nomadism[b])	Grazing livestock on communal land and moving herds and homesteads as seasonal forage supply demands

a The term 'semi-nomadism' is used to describe those lifestyles and economic systems for which migration and livestock are still the most important economic factors, but in which extra-pastoral activities - in particular arable farming - are also of great significance. Further typical characteristics of semi-nomadism are shorter migration distances with greater frequency of husbandry small livestock, and the possession of permanently fixed huts/houses in long-term settlements around cultivated areas or other places of employment where at least some members of the group remain for a large part of the year, in addition to 'portable housing' (Scholz & Janzen 1982).

b The term 'nomadism' is taken to mean a lifestyle and economic system in which the groups concerned carry out episodic and/or periodic migration together with their main source of income, livestock, in order to ensure their livelihood, and on the basis of special physical-economic and/or sociopolitical conditions in specific areas. Nomads usually carry their housing accommodation with them on their travels, and may also carry out other extra-pastoral activities on a temporary basis (for example, arable farming trade, transport services, wood/herb collection, employment as agricultural labourers) (Scholz and Janzen 1982).

mostly based on yak breeding. Grazing methods differ according to the different regions, influenced by altitude, climate, and other natural conditions. In recent decades, proximity to centres of population or urban areas that provide a market for yak products has also affected the pattern of management. Proximity to markets determines whether certain products, such as milk, are used primarily by the families herding the yaks or whether they are supplied to the market.

Temporal Differentiation of Nomadic Systems

The temporal differentiation of nomadic systems means that grazing systems are arranged according to the seasons that delimit the grazing period and spatial migration. In the plateau area the natural rangelands are always divided into two parts, winter-spring pasture (cold season pasture) and summer-autumn pasture (warm season pasture), which are used in a rotational 'two season grazing system'. Such a division can also be found in areas where pasture land is too limited for livestock to migrate over a long range.

A 'three season grazing system' is sometimes found in mountainous areas, characterised by winter pastures, spring-autumn pastures, and summer pastures. In this system the migration is from low altitude to high altitude, and the transitional belt between the winter pasture and the summer pasture supports the grazing activities in spring and autumn.

'Two season grazing systems' and 'three season grazing systems' are present all over the Plateau, with different ways of life and economic organization. The 'two season grazing system' is closer to the nomadic system and is found in northwest Zoige, Hongyuan, northern Zatang, and Sertar and Serqu counties. The 'three season grazing system' is a part of the semi-nomadic or mountain nomadic system[2] present in mountainous areas of NW Sichuan. As a result of the vast area and complicated natural conditions the duration of grazing time and composition of livestock are different in different areas.

Evolution of Adaptive Practices and Knowledge of Traditional Pastoralism

From the perspective of evolutionary ecology and cultural ecology, traditional pastoralism is an intrinsic feature of rangeland ecosystems in extremely harsh environments, and thus represents a form of human adaptation to a plateau environment. In order to survive, man has to struggle with nature and use natural resources to obtain energy, food, and shelter.

Although mainstream societies often have the impression that pastoralists are irrational in such matters as stocking rates and management of grazing, recent observations indicate that within their economic and natural environment they are as rational and productive as their counterparts elsewhere. Adaptive processes on rangelands brought on by pastoralism may have included elimination of favoured forage species and their replacement by species capable of preventing herbivores escaping, or adaptation of plant species already prevalent to withstand a different, heavier grazing pressure. Pastoralists keep evolving new herding and husbanding strategies in order to occupy different habitats without causing deterioration. They maintain the fitness of their herds through optimisation of herd size or stock composition by culling. The resource exploitation strategies involved in traditional pastoralism include herd management practices as well as biodiversity and pasture management approaches.

2 'Mountain nomadism' is a form of vertical nomadism. It is considered a type of semi-nomadism, adapted to orographic conditions, in which nomads migrate seasonally with their livestock along the mountainous relief upwards from their base rangelands, situated in the mountain valley or forelands, over intermediate pasture stages to the highest mountain pastures, and vice versa.

Transformation Processes of Pastoral Systems

The aim of pastoral systems is to use animals to harvest limited amounts of vegetation scattered over long distances that cannot easily be gathered by any other method. In energy terms it is very inefficient as only a very small proportion of incoming solar radiation is converted into usable material, yet without the method no benefit at all would accrue. The various nomadic groups follow a regular pattern of movement from one grazing ground to another at different times of the year so that they can always be where biological productivity is at its maximum. Of course, nomadic groups were never fully self-sufficient. They depend on the sedentary agricultural groups for cereals and fodder, and on trade to supplement their diets, thus maintaining strong linkages between production systems.

Transformation Processes in Pastoral Areas

Traditional pastoral production systems have remained stable for a long time. Today, however, numerous demographic and economic changes of a long-term nature have occurred which are triggering adaptive changes that are likely to transform the production systems. The most salient feature is the emerging precedence of market-oriented production over traditional subsistence production.

For some decades, highland development strategies in China were not related to the motives and aims of the pastoralists. Interventions focussed on modernising or fundamentally transforming the pastoral way of life. Individual pastoralists have sought to cope with pressures of intervention by such adaptive mechanisms as labour migration, increase in herd size, diversification of pastoral production, and the pursuit of education. Large sectors of, or even entire, pastoral societies have been involved in planned programmes and projects of development coordinated by the national government, with the aid of administrators, planners, technicians, and extension officers at provincial and country levels. The present crisis derives from unsustainable 'modernisation' such as the pressure to absorb pastoralists into the non-pastoral economy (settlement programmes, wage policies favouring migrant labour, forced commercialisation, a relative drop in the value of pastoral products) and measures that directly deprive pastoralists of their former share in economic and political life (the expansion of farming, restocking programmes, and the destruction of traditional systems of land tenure). The result of these powerful forces is that pastoralism is increasingly being relegated to people too old to change, lacking the skills needed to leave, or too far away from centres of power for anyone yet to care.

Since 1958 an attempt has been made to stabilise the nomads in western Sichuan through permanent settlement and communal rather than individual ownership of livestock. After the 1970s, under the Gongse (people's commune) system, attempts were made to grow forage crops for winter fodder, veterinary facilities were made available, and winter livestock shelters were constructed. Livestock were also allowed to use state land as pasture, but seasonal movements to pastures were still made and allowed. In effect an attempt has been made to convert nomadism into a ranching system, the so-called 'modernisation' of animal husbandry, but the economy is still essentially nomadic.

After 1978, and mainly from the early 1980s, the government of China recognised a general need for corrective measures. There was a major shift in policy with a slow movement away from state control and ownership (planned economy) towards a more market-oriented economy with policies to encourage private sector initiatives and investment. Communal livestock were again divided between families, but the tenure of pastures still belonged to the state. This left the shadow of an ecological crisis looming large in the high-frigid meadows because of overstocking and overgrazing.

From the mid-1980s, various major economic policy changes were introduced. These included the disbandment of the livestock marketing organization, a considerable reduction in marketing organizations for animal products, and the release of control over prices. Since the late 1980s there has been a move towards conservation policies and attempts to adjust stock numbers to the carrying capacity of the land.

Modern management techniques were introduced to improve the productivity of pastoral systems. While this can be accomplished fairly easily under private ranch conditions, it is much more difficult when the areas to be managed are vast, the range resources are publicly owned, and the animals are owned by individuals. Most new project strategies in the pastoral zone consider reintroduction of the old system of community control over the range resources to be a precondition for improvement.

The trend towards a mixed, more private economy, combined with liberalisation of the marketing of locally-produced animal products and a reduced role for public sector institutions, has proved successful. Thus, the very fact that the change in state-stipulated basic conditions led to the production increases mentioned, proves again that it was not — as is a common complaint — for exchanging a lack of mechanisation or pastoral inputs which are responsible for the poor yields.

Market-oriented Production

The nomads' strategy aims to secure rapid harvesting of the growing vegetation through their animals. But isolation, remoteness, and a primitive marketing system are handicaps to commercial exploitation of animal products. Inefficient marketing discourages expanded commercial off-take but governments pay less attention to such factors

Schemes of pastoral development are often assessed by herd off-take and numbers of marketed animals. Yet, these rates are not simply a product of the various innovations of ownership such as credit, or fattening, they are fundamentally influenced by marketing opportunities, the requirements of the herd and its reproduction, and pricing structures. As long as prices are kept artificially low for the benefit of urban inhabitants, stockholders cannot be faulted for retaining stock. However, many people accuse pastoralists of not using the official markets and are indignant that they use unofficial marketing channels.

In western Sichuan, ineffective marketing outlets have led to an increase in the number of animals carried on the rangelands and a further decrease in prices. Although the private channels are never blocked, their capacity is still limited.

The traditional strategies modifying herd structure include trade, capital accumulation, and production of secondary animal products such as wool and skins. Herd owners try to track and exploit major regional, seasonal and year-to-year fluctuations in resources in order to optimise herd productivity through strategies of maximising potential reproduction and optimising potential mobility. Traditionally, the trade in products from live animals has always been the business of private entrepreneurs. Although prohibited in the 1960s and 1970s, when it was replaced by communal trade, private trade continued to function through a 'black' market. From the 1980s onwards, private business has been restored and become a second main trading channel, alongside communal trade.

At present trade is driven by market forces and not dictated by the government, although the state has stepped up its purchase of animal products and supplies of grain to pastoral areas. The market-pricing process has made people more aware of the new prospects.

In addition to the constraints of the socioeconomic system, limiting factors are also found in the ecological environment of livestock breeding and sustainable marketing. The milk trade in *Hongyuan* is a good example, here livestock rearing for marketing is generally characterised by short-term, profit-seeking production strategies which tend to promote inappropriate land-use practices. The process of settling nomads is encouraged because the market-oriented livestock breeder tends to settle near roads, settlements, and watering places where milk can easily be sold to traders. Another result is that pastoral migration distances are reduced, resulting in higher stocking rates and often longer periods of grazing in the vicinity of settlements. This concentration of man and animals in these fragile environments leads to degradation of land resources and unsustainability of the production system.

Modernisation of Pastoralism: Approaches and Implications

Enclosure of Rangelands

In western Sichuan, as well as in the rest of the Qinghai-Tibetan Plateau, enclosure was introduced as a management technique at the end of the 1960s. At that time it was only used for cutting pastures in order to supply winter foodstuff to domesticated animals. In the last two decades, it has been used to delimit pasture boundaries, to enclose degraded pastures or abandoned fields for forage cultivation, to divide pastures for rotational grazing, and to provide better defence against the invasion of wild, predatory animals.

From one point of view, the construction of fences around pasture land is undoubtedly beneficial to the growth of grasses. After the regeneration of grass, the fenced pastures have improved soil, a better quality of grass, and a better vegetation structure. However, enclosed range areas are not immune to the problems of degradation of range condition. One problem is overstocking beyond the carrying capacity, which is common because of the needs and demands of the stock owners. Further, erratic precipitation and snowstorms can reduce forage growth in enclosed areas leading to temporary, functional overstocking and degradation. Enclosure leads to the breakdown of traditional resource-sharing attitudes in the pastoral system since it prevents emigration of herds from fenced lands.

Under natural conditions, herbivores act as predators on the rangeland vegetation, and grazing must be considered as a part of the energy flow of the rangeland ecosystems. Moderate grazing maintains the balance between plant species on the rangelands and stimulates productivity of above-ground biomass to twice that in ungrazed areas (Holzner *et al.* 1983). Total protection, on the other hand, leads to stagnation in vegetation growth and more or less complete dominance of a few species. Thus, no grazing has a detrimental effect on plant communities with a long history of grazing. So-called 'sustainable development in pastoral society' means rational use of rangeland rather than absolute protection.

Settlement of Nomads

Settlement indicates a changing process from a more nomadic to a less nomadic and sedentary way of life. This process is occurring with varying frequency in virtually all contemporary nomadic groups. The indications suggest that settlement of nomads, singly or in groups, has resulted largely in their participation in non-pastoral activities.

Today, settlement has been forced on nomads by the market orientation of government policies. In western Sichuan the settlement of nomads started at the end of the 1950s and was mainly popularised in the 1970s. The process can be further divided into: 1) settlement, in which former nomads are settled in permanent settlements in order to build up a ranching system as in in Hongyuan; and 2) semi-settlement, in which nomads (excluding semi-nomads) live in fixed winter houses during the cold season (winter and spring) with their grazing animals close by, but migrate to pastures far from the winter settlements in the warm season (summer and autumn).

Semi-settlement helps livestock survival during the cold season and helps establish the infrastructure for raising the living standards of nomads. But the change from a highly mobile herding system to a semi-sedentary way of life can also have negative effects. The most obvious negative effects are outlined in the following sections.

Increasing Risk of Environmental Degradation

Settlement is always accompanied by the enclosure of pastures. The emerging trend toward short-range herding systems has a bad effect on range vegetation and soil. The most severe impacts are found around permanent water sources and in the immediate vicinity of permanent settlements, although at the beginning they were limited to a small section of the total range. Grazing pressure on the residual open range is overtaxing the capacity, and migrations have to be rerouted. When areas with a higher potential are enclosed first, the residual open range areas, possessing lower support capacities, are prone to faster degradation.

Reduction in the Diversity of Production Systems as a Result of the Disappearance of Traditional Adaptive Management Strategies

One of the main purposes of settling nomads is to maintain adequate stocking rates and practice some form of grazing rotation. If pastoral areas are sparsely populated and include access to reliable, cold-season pastures, this presents no problem. Neither of these two conditions is met at present. Under the centrally controlled economy, long-term protection of larger range areas is impossible to achieve without a large police force. However, compulsory restocking, which has been suggested frequently in the past, would further reduce the already narrow base for subsistence of the pastoral population and damage the enthusiasm of nomads, as it may threaten their survival and traditional social structure.

Nearly all pastoralists are engaged in multi-resource economies and pastoralists' economic strategies are geared not just for current production but for the long-term security of that production even through quite severe environmental fluctuations. Nomads will not easily abandon the lessons they have learned through bitter experience in hard lands. As a result, since pastoralists have their own systems of health control, breeding, insurance coverage, range and water conservation, and the like, there can be little doubt that improved methods will find acceptance among them as long as they are compatible with ongoing schedules and routines. In fact, simplification of local production systems to just western style ranching increases the risk of local people losing the basis of their subsistence.

Accelerating the Breakdown of Social Structures which Previously Served As a Form of Social Security within Herding Communities

Settlement of pastoralists is a clear change in lifestyle, defined by its substance, and exemplifying the process of sociocultural change. Left to their own devices and the vagaries of their environment, societies change all the time, self-initiating even quite profound transformations. Traditional mobile livestock keeping is founded upon a traditional social system that secures the realisation of the multiple goals that pastoralists pursue rather than economic goals alone.

Government thinking is perhaps that it can help secure food and water supplies for pastoralists through settlement in order to improve the output of pastoral products. However, this oversimplifies the diversity of the real situation and undoubtedly neglects some of the diversity in pastoral societies. A nomadic economy requires different strategies for short-term productivity and longer-term insurance. Moreover, pastoralists also use their animals to acquire prestige and influence in their societies and for other purposes. All of these are not strictly justifiable on economic grounds alone. A nomadic society works as an entirety in response to changes in the environment and the availability of resources. Every attempt in which only part of a system is changed will lead to an imbalance in the whole system.

Introduction and Cultivation of Forage Grasses

Shortage of fodder for winter and spring grazing is one of the main constraints to increasing the production of livestock. The germplasm of grasses is considered to be a very important factor in animal production because appropriate grasses are needed to develop locations for animal husbandry and to construct the basis of production. In western Sichuan, research institutions are busy breeding forage species for high altitudes, focussing on both indigenous and exotic species. Since the 1960s, more than 200 varieties of forage plants, belonging to 16 families, 49 genera, and 98 species, have been collected or introduced and tested in the pastoral areas of Sichuan.

Various valuable grass species have been introduced in western Sichuan since the 1960s. Many grasses have been selected and identified as suitable for this area, including smooth brome (*Bromus inermis*), wild rye (*Elymus mutans*), Siberian wild rye (*Elymus sibiricus*), common oat (*Avena sativa*), *Trifolium pratense*, and afalfa (*Medicago sativa*). Some indigenous grass species have also been improved, including *Elymus breviaristatus*, which is mainly suitable for artificial cutting pastures, and red fescue (*Festuca rubra*) and sheep fescue (*F. ovina*), which have been used for the rehabilitation of degraded pastures. Turnip (*Brassisca rapa*) is one kind of indigenous and popular succulent forage in pastoral and agro-pastoral areas. It is always planted near the winter houses and used for winter fodder.

Common oat (*Avena sativa*), introduced in Zamtang in 1978, can give a fresh biomass production of 58 tons per hectare per year. Having been tested for a long time, it has now been planted widely in the county and is accepted by most herdsmen. In 1987 and 1988, 10 tons of common oat seeds were distributed free or bought by families. Through its cultivation around the winter houses and on winter pastures, the pastoralists were able to cope with the heavy snowstorms of the following years. After 1990 more and more pastoral families have been buying forage seeds from the government seed multiplication unit. People's participation has further improved the introduction and distribution of suitable forage plants.

There are some problems associated with the introduction of new grasses. In western Sichuan, trial pastures planted with improved seeds are always treated with an ammonia-based fertilizer. But the cost of fertilizer makes the benefit of its use on pasture debatable. Furthermore, in conditions of drought the present hybrids either die or revert to their original natural form; and they tend not to breed true above 4,000m, again degenerating to their natural form. A more serious problem is that the introduction of alien species is creating niches for pests and diseases of vegetation, animals and humans. Statistics show that there are about 600,000 hectares of rat-damaged rangelands, and 500,000 hectares of pest-damaged rangelands in western Sichuan. Locals attribute this disaster to the introduced species on these lands. Apart from these other factors such as environmental degradation of and deversity in the ecosystem can also be attributed to this disaster.

Maintenance of Agrobiodiversity

The following sections describe some of the prerequisites for the maintenance of agrobiodiversity in pastoral livestock. A successful pastoral system enables people and their animals to live in harmony. Development of the livestock sector can only be successful in the long term if development projects are economically, socially, politically, and ecologically sustainable.

The Need to Use Indigenous Knowledge

Over the past decades, environmental changes and economic development on the Qinghai-Tibetan Plateau have accelerated and are having a serious impact on biodiversity, traditional production systems, and landscapes. The biodiversity of this plateau's ecosystem is believed to be deteriorating more rapidly than that of many other global ecosystems.

Traditional attitudes and behaviour in pastoral societies reveal a deep-rooted pastoral culture. Pastoralists perceive and manage both biodiversity and other environmental resources in their habitats for their needs. The biodiversity of the rangelands is the most important resource system and landmark of the Qinghai-Tibetan Plateau. High-frigid pastoralism, both nomadic and semi-nomadic, is directly supported by high-frigid range-lands.

In the traditional societies of this plateau, both the management of natural resources (including land-use protection, wandering, and grazing) and distribution practices are based on the perception of a man-environment relationship. Traditionally, rangelands and grazing systems are managed by pastoral societies as multiple-use systems to meet the needs of the people, namely, food, fodder, fuel, leather, wool, and medicinal products. The indigenous people of the plateau have a long tradition of practice in maintaining biodiversity as a sustainable resource.

In traditionally pastoral communities, one still finds a stronger sense of community and social responsibility than presently experienced in many developed societies where individual rights and freedom take priority. Villages and communities in western Sichuan have conserved biodiversity in the ecosystems surrounding their habitats over centuries with the help of their lifestyles, religion, and the interdependent relationship established with nature.

The current notion of pastoralism is that of a traditional, simplistic and somewhat static, low-input low-output system, which needs to be corrected to generate short-term successes. The opposite is true: if the terms 'traditional' and 'modern' are taken as a starting point and a temporary final point within the transformation process of a society, then there is no longer a 'traditional' sector in western Sichuan. All aspects of nomadic life are affected by 'modern' conditions and are thus modern. Pastoralists are today faced with a new set of problems resulting from these changes. During the previous 'Cultural Revolution Phase', enforced settlement of pastoralists was undertaken with the aim of transforming their production into that of a *"modern sector based on scientific production and management"*. This policy, however, was not really supportive to pastoralism in the long term, for subsistence pastoralism is not only a particular mode of production, but also embodies the complex features of a total social system.

Traditional pastoral production systems have reached a very high degree of adaptation to the marginal environments they are using. The driving motive behind the high mobility that is a characteristic of these systems is risk aversion and sustainable use of biodiversity. These strategies have worked exceedingly well for many centuries, otherwise the system would have disappeared when confronted with recent changes. However, faced with rapidly changing conditions, such as increasing traditional social assurance systems, reduced mobility due to political and administrative restrictions, and widespread political strife, this adaptation is no longer sufficient to preserve the biodiversity. The danger of losing the traditional knowledge about diverse biospecies, mobility, and land-use practices is increasing.

Management systems for natural resources are localised systems that form a basis for decision-making for pastoral people. The majority of grazing systems on the Qinghai-Tibetan Plateau operate under indigenous knowledge systems, as do all productive land systems in developing areas. Thus these indigenous knowledge systems are not only of value for the culture from which they evolve, they are also useful for the scientists and planners striving to improve conditions in rural societies. They should be carefully studied, assessed, and incorporated into rural development strategies on a case by case basis, both for the improvement of livelihoods and for environmental conservation.

Those societies in western Sichuan that are associated with a nomadic way of life permit a degree of exploitation of ecosystems because their biodiversity cannot otherwise be used. Consequently, the management systems for conservation, production, purchase, and marketing need to be integrated, and this may provide a basic guarantee for protecting biodiversity.

The nomadic Tibetan, using different bio-types at different altitudes, can contribute considerably to the affluence of the state; the future depends on willing cooperation and the readiness to accommodate individual interest groups and institutions.

The most commonly-used indicators of progress in pastoral development projects are increased production and changes in income. While these economic measures are important, they are not adequate as indicators of sustainability or of biodiversity conservation. Economists must find a way to place an economic value on the resource base and assist with the contrasting choices between individual short-term gains and long-term benefits to society as a whole from conservation approaches.

The development of pastoral production systems is intertwined with biodiversity protection goals. However, the maintenance and sustainable use of pastoral ecosystem biodiversity cannot succeed without planning and cooperation between the decision-makers on the one hand and livestock breeders on the other. Development approaches need to permit improvements in livelihood conditions and provide plans to cope with drought through effective food security programmes for herders, both mobile and permanent.

Participatory Approaches

The natural resource scene of pastoralism on the Qinghai-Tibetan Plateau is composed of a harsh climate, high altitude, scarce water, and hardy livestock grazing the rangelands. The central figure in the management of these resources is the pastoralist who is the primary user. The pastoralist on the range should be the decision-maker in using and conserving the rangeland. The pastoralist's attachment to the land and pastoral customs should govern the herder's decisions with respect to maintaining the long-term utility of the grazing land. Technological developments should be used to supplement this conventional wisdom.

Biodiversity loss in the Qinghai-Tibetan Plateau of the Himalayan region is basically a product of human intervention for the use of various natural resources such as land, forests, pastures, water, and minerals. The scale and dimensions of disturbances are such that changes are often irreversible. The biodiversity of the Plateau is threatened by overgrazing — caused largely by mistaken policies.

The impact of biodiversity loss extends very deeply into the economy and environment and directly affects food, fuelwood, and fodder supplies. Further, livelihoods are affected by changes in production of land-based activities. It is these trends that need to be reversed so that the pastoral people can sustain their livelihood in full harmony with the environment. The conservation of biodiversity should only be one of the goals tied to the well-being of the people.

The conservation of biodiversity and the rehabilitation of degraded rangelands are now urgent concerns. In practice, the highest priority should be given to more rational harnessing of those pastures not yet degraded. This could be linked to a reduction in the density of herds to a level below the carrying capacity of the rangeland, and in some cases to partial protection to allow the regeneration of grasses and other species.

High-frigid pastures are and will remain a marginal resource. The only conservation technique applicable is the carefully considered use of such lands. This implies that the pastoral economy cannot sustain growing numbers of animals because the resource base is finite. Reducing pressures on this area means reducing the number of people dependent on livestock. Although there may be other chances, the overall need to find employment opportunities outside the pastoral sector should be a priority. At the strategic level, diversification of the pastoral economy is seen as a viable solution for meeting the increased needs of pastoral societies, achieving economic growth, and alleviating poverty. Highlands in western Sichuan have rich biodiversity resources and varied ecological locations. These forest-pasture-based natural products could be further developed using an agribusiness approach.

Macro-policies for the use of sustainable resources in highland areas should be given priority. Many of the present policies on credit, prices, and access to resources have been designed and formulated with the needs of organized urban-industrial groups in mind. These policies have almost completely overlooked the needs of rural groups, including the need for protection and conservation. Very few policies, in fact, provide any benefit from or incentives for conservation. Therefore, policy reforms at all levels must take into account the basic needs of the local people and provide direct economic benefits to them. Incentives for rural development must be oriented to improving household livelihoods and to agro-biodiversity conservation.

Conclusion

The case history of a pastoral ecosystem discussed in this chapter shows that, despite the growing body of literature on monitoring the structure and function of biodiversity in range-land ecosystems and on species' inventories, a comprehensive framework for analysis is lacking at all levels. The complex nature of the interrelationship between biodiversity loss and sustainable development of pastoral areas has not yet been sufficiently clarified. However, pastoralists' control over their resources, decisions, and actions is a key factor in the success of strategies designed to include conservation of this unique agroecosystem.

In the decades ahead, the erosion of agrobiodiversity in pastoral areas may be attributed to many factors. Amongst others the modernised transformation of the pastoral ecosystem engineered by public intervention has contributed substantially to the high growth in the demands of human on natural resources and the decline of biodiversity. Meanwhile, limiting pastoral mobility, redefining rangeland tenure, overstocking of grazing animals, and rangeland degradation have played very decisive roles in the socioeconomic changes.

Undoubtedly the modernisation process has bought improved access and services to previously remote pastoral areas. But it does not recognise the efforts of pastoralists to use scarce land resources more efficiently for gainful employment and increased livestock. With the growing commercialisation of high-frigid pastoralism on the Qinghai-Tibetan Plateau, the loss of agrobiodiversity is unavoidable. It is imperative that we ensure the survival of traditional pastoralism for as long as we want agrobiodiversity to exist. The concern and emphasis here are on the need for containing the backlash effects of the process of transformation of pastoralism on native agrobiodiversity.

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Chapter 13

A Study of the Process of Replacement of Old Crops and Land Races by New Crops in Sichuan, China

Liu Zhong-qi and Zhang Yong

Introduction

Sichuan is located in southwest China. Most of the area of 0.57 million sq. km. is covered by hills and mountains, except for the Chengdu plain. The altitude of the populated area ranges from 300 to 4,000m. Affected by the mountains and plateaus, the natural environment and agricultural resources are complex and diverse. As the Sichuan valley is surrounded by high mountains, its climate is much warmer than that of other areas located at the same latitude.

This paper describes the rate of genetic erosion of wheat and rice that has taken place in Sichuan during the process of agricultural development from 1950-1995 and highlights the problems associated with the introduction of new varieties. The case studies of wheat and rice are presented as examples to show the magnitude of changes.

Traditional land races of rice and wheat were the main basis of food production in Sichuan before 1950. The genetic diversity was substantial. Of 10,000 crop germplasm accessions collected by the Sichuan Academy of Agricultural Sciences (SAAS), Chengdu, 70 per cent were land races from Sichuan. A number of these land races may have evolved through both natural selection and selection by farmers. These land races were maintained by local farmers to meet various qualitative preferences and environmental requirements. Since 1950, China has introduced a number of exotic crops and varieties after systematic yield trials, and this has initiated a process of genetic erosion of land races and crops. After

1950, local land races of rice and wheat were gradually replaced by three to five major varieties.

In the late 1970s, hybrid maize and rice varieties were introduced and rapidly replaced officially registered high-yielding varieties. It is a matter of concern that among the released hybrid varieties, 80 per cent of them used the same male fertility restoration line, Minghui 63. From 1988 to 1995, SAAS developed 122 hybrid lines, 25 of which used the same male sterile line. In some cases the same sterile line was repeated 30 times (Zeng 1995). The extensive use of core parents in hybrid production has also reduced the genetic diversity in this major crop. Similarly, there are many such examples of wheat varieties showing the same problem. Since 1980, a total of 30 wheat varieties was released in Sichuan, but resistant genes for yellow rust were all taken directly or indirectly from the 'Fan-6' variety. This variety was grown extensively in Sichuan in the 1970s. In recent years (1991-1995), 22 new wheat varieties were developed by SAAS, but eight of them still shared the same parent (77 Zhong/2882). This case is not unique to Sichuan. The same process is probably taking place in the Consultative Group on International Agricultural Research (CGIAR) centres and other NARC (National Agricultural Research Centres) breeding programmes as well. The principal threats to yield stability from the use of such hybrids or high yielding varieties (HYV) are the increasing uniformity and continuous cropping. Because of such uniformity, regional diseases, such as maize leaf blight (*Helminthosporium maydis*) and rice blast (*Pyricularia oryzae*), began to spread widely and have become epidemic diseases in China. The issue raised here is whether research policy to develop hybrids or HYVs with the same genetic background is a sensible strategy or not. What are the principal drawbacks to widening the genetic background in introgression processes faced by breeders? Issues related to institution and government policy need to be analysed in order to rectify such problems.

The Status of Wheat Cultivars in Sichuan

About 150 land races and 22 varieties of wheat were used in Sichuan during the 1940s. These land races were divided into three types, normal, round and *floriferous*, of *Triticum aestivum* and *T. turgidum*. Most of them adapt well to stress environments and farming conditions and have a tolerance to local diseases. They are generally adapted to niches and their coverage was usually small. Only a few of them, such as Chengdu Guangtou, were planted widely.

During the 1950s most land races were replaced by the four excellent varieties, *Mentana, Villa Glory, Ailiduo* and *Chengdu Guangtou*. In the late 1950s, the annual planting area of *Mentana*, which was introduced from Italy, was about 700,000 hectares, half the total area under wheat at that time. This was the first big replacement of wheat cultivars on a large scale. As a result, the average wheat yield in Sichuan increased to 1,185 kg/ha from 850kg/ha in 1949. On the genetic resources' side, more than 70 useful land races were completely replaced by new cultivars in the high potential valley areas (Table 13.1).

Table 13 1: **Changes in wheat cultivars (cv) and their planting area**

Years	Area covered by released cv	% area covered by modern cultivars	Land races replaced	Dominant cultivar 'HYV'
1940-50	233,000	4	125	Jinda 2905
1951-59	1,020,000	7	58	Mentana
1960-65	933,000	7	56	Shannong 205
1966-70	1,200,000	29	41	Abbondanza
1971-80	2,130,000	37	57	Fan 6
1981-90	2,000,000	34	50	Minanyang 11

After 1960 another four varieties replaced the previously well adapted cultivars in Sichuan. During this period, the number of introduced cultivars increased and the land races became fewer (Table 13.1). By this time land races were confined to remote mountain areas with special climates, niches, and disease problems; land where the modern cultivars could not be established.

By 1965, only four to five cultivars were used widely in production but their phenotypes and genetic background were significantly different. One came from Australia, *Chuanfumai*, and two from Italy, *Mentana* and *Villa Glory*. A few were developed from local land races, for example, Jinda 2905, original name *Nanxuzhou*. The cultivars released after 1965 were all progenies of the above-mentioned parents. The released cultivars and advance lines were hybridized again to breed new cultivars of new generations. In this manner, most advantageous traits of different old cultivars and land races were joined together year after year. As a result the genetic basis of new cultivars became narrower and narrower like an upside-down pyramid.

After release of the new cultivars, the wheat planting area increased to 2.2 million hectares in 1950. The number of land races replaced by new cultivars also increased accordingly. No efforts were made to improve the yield level of land races and, as a result land races could never compete with improved cultivars.

Institutions failing to produce new widely-adapted cultivars had to give up their breeding programmes. Because of this popular fear, breeding institutions always tried to use the most popular core parent. Because breeders in the same institute usually use similar breeding methods and parent populations, different cultivars developed in the same institute generally showed similar characteristics and shared the same core parents. The genetic diversity among cultivars decreased because of this process, despite the increased number of varieties released. In recent years, the genetic diversity of new cultivars produced by breeding programmes has definitely become much smaller.

Further to orders to release new cultivars as soon as possible, many breeders adopted a so-called 'amending breeding method', which aimed to improve one or two of the unsatisfactory characteristics of newly released and widely adopted cultivars. The frequent use of core parents has accelerated the erosion of genetic diversity in wheat cultivars. For example, the 12 cultivars used in the third replacement were developed at seven breeding institutes. Five of them shared the same parent, *Mentana*. Similarly, the 21 cultivars used in the fourth replacement came from 10 breeding institutes; six of them shared the same parent, *Flora;* another six shared *Abbondanza*; and another four shared the parent *Mara*. The 17 cultivars used in the fifth replacement were from only four institutes and 13 of them had the same parent, *Fan 6*.

Rice Genetic Diversity and the Erosion Process

Rice (*Oryza sativa L.*) is the most important food crop in Sichuan. It has been cultivated in this area for millennia. Therefore, a great diversity of land races is found here. In the 1940s, more than 85 land races were in use, but their yield levels were poor.

Between 1949 and 1995 about 324 rice cultivars were registered in Sichuan. Among them, 141 cultivars had a great impact on rice production, the largest area, covered by one of them, exceeded 3,500 hectares. In the 1950s, 11 excellent cultivars, including five local land races, three introduced cultivars, and three improved cultivars, were grown extensively (Table 13.2).

The first big replacement of rice land races took place in Sichuan between 1950 and 1956. Several elite local cultivars, pure line cultivars, and hybrids from

Table 13.2: **Process of Genetic Erosion in Rice: Replacement of Land Races by Cultivars in Sichuan from 1936 to 1995**

Years	No of cultivars developed	% of rice area planted with released cultivars	% of rice area planted with landraces	% of rice area planted with hybrids
1936-39	85	0	100	0
1947-49	46	0	100	0
1950-59	11	27.2	72.8	0
1960-69	41	14.6	21.8	63.6
1970-79	71	23.9	0	59.2
1980-83	18	16.7	0	83.3
1987-95	52	NA	0	100

the breeding programme were developed and they slowly replaced the traditional cultivars (Table 13.2). Rice output in Sichuan steadily increased year after year to reach a record of 13.17 billion kilogrammes in 1956, 41.9 per cent higher than in 1949. The average rice yield increased to 3.7 t/ha in 1956 from 3.2 t/ha in 1949.

After 1970, there was a second big replacement by new cultivars. During this period, the number of cultivars released in the rice production system increased, but at the cost of replacement of land races. The third replacement of cultivars started in 1977. From that time on, only hybrid rice sustained the production (Table 14.2). Only a few semi-dwarf traditional land races with good adaptability and preference survived in remote villages.

Compared with the 1950s, the rate of cultivars released for rice was remarkably high in the 1970s (Table 13.2). As hybridisation between similar parents was carried out in different breeding institutions, many cultivars shared the same core parents and the biodiversity among cultivars did not enlarge with the increasing number of cultivars. Pedigree analysis showed that of the 112 cultivars released between 1960 and 1979, 82.2 per cent were related to one of six core parents: *Guanchangai, Aijiao Nante, 29ai, Chengai 8, Lushuang 1011, Zhulianai.*

In the late 1970s, hybrid rices began to be used in production. It is interesting to note that all land races of rice were completely replaced by hybrid rice from 1970 onwards when hybrid seeds were made available. Even new varieties developed by conventional breeding could not compete with hybrid rice. The registered number of traditional cultivars declined. Uniformity of rice fields became very serious (Table 13.2). Most rice planting areas were covered by a few hybrids. In addition, with the exchange of excellent parents and advances in breeding, the genetic background of different hybrids became more or less similar (reported in the Sichuan Regional Hybrid Rice Yield Trail in 1988). Eighty per cent of combinations were produced using the identical male fertility restoration line *'Minghui 63'*; only 25 male sterile lines were used in total. In the 122 new combinations of hybrid rice accepted in the Sichuan Regional Yield Trial from 1988 to 1995, some sterile lines were used repeatedly — over 30 times (Zeng 1995). The extensive use of core parents will certainly have added to the decrease in genetic diversity, increasing the vulnerability of the crop.

Reduction in Diversity and Increasing Epidemics

The extensive use of new improved cultivars on a large scale increased the crop yield, but the genetic diversity among cultivars decreased. As a result some regional diseases, such as maize leaf blight (*Helminthosporium maydis Nisik et Miyake*) and rice blast (*Pjricularia oryzae*), spread, finally reaching epidemic proportions. In the past, rice blast was controlled effectively by using genes of many land races. Before 1960, rice blast mainly occurred in the mountainous districts surrounding the Chengdu plain. But later it gradually started spreading. In 1984, 366,000 hectares of rice fields were blasted and there was a yield loss of about 300 million kg of rice. The area affected by rice strip (*Xanthomonas oryaze*) was only 7,300 hectares in 1971. Now it has became a major disease covering an area of 67,000 hectares. This affected area is still growing, with even more severity in new areas. This is the outcome of narrowing down the genetic diversity of crops in diverse mountain environments.

Strip rust in wheat was originally a disease of the marginal areas of the mountainous districts surrounding Chengdu. After the spread of Mentana in the 1950s, the physiological races of yellow rust also evolved. The appearance of a new race of yellow rust 'Tiaozhong-13' made Mentana susceptible to yellow rust. As a result, yellow rust began to spread throughout the whole province. The second dominant cultivar 'Shannong-205' showed good resistance to 'Tiao Zhong-13' which helped control the epidemic of yellow rust. Unfortunately, Shannong-205 lost its resistance to yellow rust after five years. During this period, the physiological races of yellow rust kept on evolving. With the appearance of new yellow rust races, Tiaozhong 18 and 19, the new cultivar Abbondanza also lost its resistance to yellow rust in 1972. The release of Fan 6 and its offspring maintained resistance to yellow rust for 20 years until the appearance of Tiaozhong 30 and 31 in 1992. Analysis of this 'hide and seek' process between cultivars and diseases indicates that the cycles between disease epidemics and cultivar replacement must be the result of genetic diversity reduction in cultivars.

Effects of Genetic Diversity on Yield Steadiness and Cultivar Improvement

The replacement of the genetic diversity of land races not only supplied opportunities for epidemics of crop diseases, it also decreased the adaptability of new varieties to other environmental stresses. During the wheat growth period in 1966, the temperature in winter was higher than in a normal year, which accelerated the development of the wheat, but much lower in April when the pollen was developing. Most of the wheat cultivars showed sterility caused by the low temperature during the pollen formation period. The yield loss from cold stress was about 10 per cent. Therefore, the value of local genetic diversity may be gauged from the advantages it provides in the adaptability of crops to environmental conditions.

The genetic advance of new varieties has apparently decreased in recent years. One of the important limiting factors is the lack of sufficient genetic diversity among parent populations. The similar genetic background makes it very difficult to use the accumulative effects of different alleles and epistasis among genes.

There is hardly any chance of selecting genetic variants markedly better than the parents (Jing 1983). This analysis of wheat and rice crops in Sichuan highlights a common process of breeding and land race replacement and reflects its potential danger to the sustainability of mountain agriculture.

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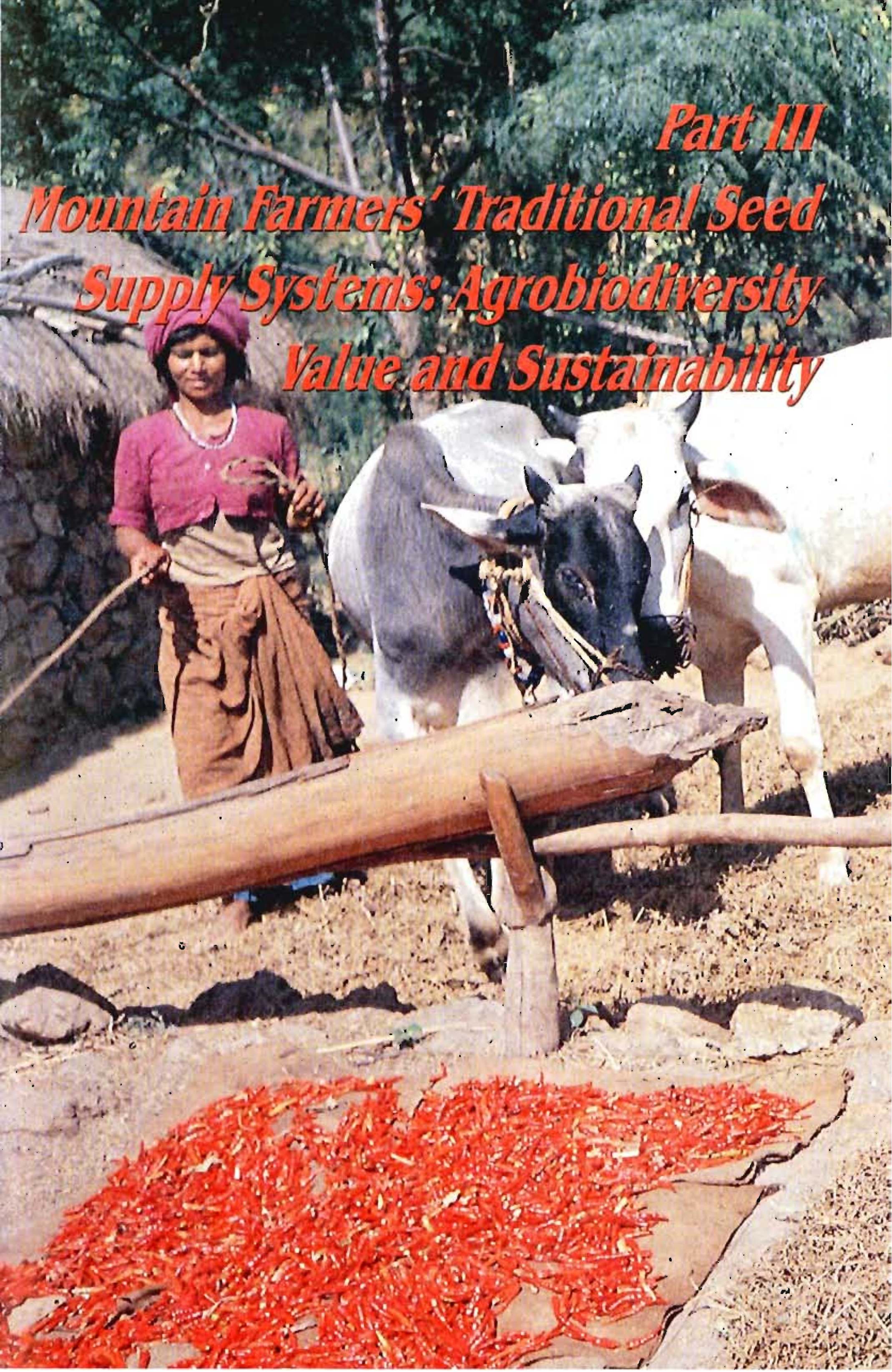
Part III
Mountain Farmers' Traditional Seed Supply Systems: Agrobiodiversity Value and Sustainability



Chapter 14

Gene, Gender and Generation: Role of Traditional Seed Supply Systems in the Maintenance of Agrobiodiversity in Nepal

P.K. Shrestha

Introduction

Seeds, the planting materials used for the production of subsequent crops, have been the continuous source of crop diversity in all farming systems for generations. They carry life in all its diversity as it is built into the genetic structure of individual species and form a bridge between one generation and another. The diversity of seed supplies, however, is increasingly being influenced and controlled by human activities, both *in situ* and *ex situ*. Farmers, from time immemorial, have been observing and selecting their crops and crop varieties, saving and maintaining seeds for the next season as experimenting with new seeds exchanged with neighbours and relatives. These activities constitute *in situ* crop conservation. Increasingly, the public sector has also been instrumental in creating and maintaining crop diversity through *ex situ* activities that involve in nitro genetic restructuring and laboratory gene banking. However, in many mountain areas *ex situ* crop conservation is unaffordable, and the fate of crop diversity is largely governed by the fate of the traditional seed supply systems that exist within local communities. Even where it is possible, *ex situ* conservation alone cannot fulfill the needs of agrobiodiversity conservation, as it does not maintain the evolutionary process through which the present day land races have been created (Brush 1995). For this reason the traditional seed supply systems are very important and irreplaceable.

Traditional seed supply systems contribute greatly to the on-farm conservation of plant genetic resources, which can be defined as the continuous cultivation and management of a diverse set of crop populations by farmers in different agro-ecosystems in which crops have evolved. Traditional seed supply systems have been developed through generations of experience by farming communities to suit their environments and to meet their need for seeds for a variety of crops in a secure and sustainable manner. Most of the seed needs of farming households are met by their own production and preservation, an activity in which women play a significant role. In the low input farming systems that prevail in Nepal, women have traditionally been the managers of crop germplasm and diversity. However, most of the research and development interventions aimed at increasing crop production, through the use of new seed varieties and/or new seed supply systems, have undermined both the importance of the traditional seed supply systems and women's traditional role as custodians of local crop varieties and land races - threatening crop diversity and thus future food security. This paper examines processes in traditional seed supply systems, discusses their contribution to crop diversity and the role of gender, and highlights issues related to policies and programmes for conservation of agrobiodiversity.

Traditional Seed Supply Systems and the Role of Gender

Farming in Nepal is dominated by the subsistence agriculture on which 81 per cent of the population depend. It is determined by the widely varying agro-ecological conditions, which can change drastically within a few kilometres, and the socioeconomic circumstances of farmers. The result is a series of farming systems that are highly complex, diverse, and associated with risks. This diversity in farming systems has helped in turn to maintain and promote agrobiodiversity, through the large numbers of crop and animal species and their varieties and breeds maintained at the household level. The prevalence of subsistence production in Nepal means that, to sustain their livelihoods, farmers grow all kinds of crops, mostly land races, for food, fibre, and shelter, and keep varieties of livestock. As the infrastructure for agriculture is not well developed (irrigation, roads, marketing networks for agricultural inputs and products), the majority of farming households rely on the natural pattern of the seasons and on their traditional systems, both of which are full of risks and uncertainties. To survive in such a situation they mix all possible enterprises and, through years of experience, have selected crops, trees, and livestock varieties that are well adapted to their environments, demand less resources, and provide security against risks and uncertainties.

The traditional seed supply systems in Nepal are characterised by farmers producing and preserving their own seeds for subsequent planting, at times often exchanging with and/or borrowing from other farmers, with very few monitored transactions. It is estimated that as much as 90 per cent of the total seed requirements for cereals and other food crops, and about half of the total seed requirements for vegetables (90% for traditional vegetables), in the country are met by the traditional seed supply systems (Cromwell *et al.* 1993; Joshi 1995). The traditional seed supply systems have a great influence on the existing crop diversity. They have been developed through generations of experience to fulfill the seed supply needs for an extremely large number of crops and crop varieties.

The traditional seed supply systems are dynamic and continuous processes comprised of variety selection, variety adaptation, seed selection, processing, storage, and exchange by farmers. Through these processes, genetic variations in crop varieties have evolved continuously, contributing to the maintenance of on-farm crop diversity. The flow of genetic materials in the traditional seed supply systems in Nepal is shown in Figure 14.1.

There are three areas in the traditional seed supply system through which the flow of genetic material takes place: nature, the farmer's field, and the community. Wild plants and weeds provided the genetic base, through evolutionary processes, for the land races cultivated by farmers. Selection of crop varieties takes place in and from the farmer's field, through mass selection and adaptation, seed selection, processing, and storage. Exchange of seeds produced in the farmer's field takes place in the community from farmer-to-farmer, through neighbours, relatives and friends. Genetic materials from new modern varieties also flow into local crop varieties through these exchanges of seed. In the day-to-day life of farmers, the processes of the traditional seed supply systems revolve around the crop and seed activities undertaken in the farmer's field and in the farm community. Women play a leading role in both of these places.

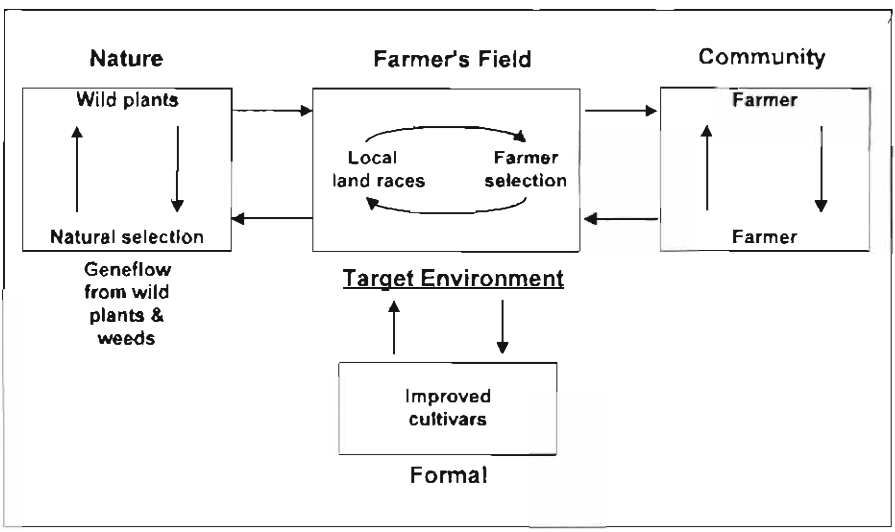


Figure 14.1: *Gene Flow in the Traditional Seed Supply System*

It is well known that women play an important role in the traditional seed supply systems in Nepal. According to Acharya and Bennett (1981), 30 per cent of the decisions on what crop to plant are made by women alone, and only 18 per cent by men. Similarly, 60 per cent of the decisions on what seed to use for planting (own or borrowed) are made by women alone, and only 21 per cent by men (in addition to 11 % by both and 8% dictated by traditional practice). The gender analysis further reveals that women supersede men in decision-making in all seed related activities (Table 14.1).

Table 14.1: **Gender Variation in Decision-making with Regard to Seed Production and Supply**

Activity	Per cent decisions made by	
	Men	Women
Crop selection	40	60
Seed selection	48	52
Storage methods	27	73
Grains to be consumed	27	73
Processing	27	73
Grain selling	49	51

(Source: Compiled in Bajracharya (1994)

Women farmers select good seeds for the next season, and mix them with different locally available preserving materials (ash, herbs, oils) frequently drying them in the sun first, and preserve them using different methods of storage. Women are often the ones who exchange seeds with neighbours, friends, and relatives; carry seeds from different crops and crop varieties from their parents as a gift to in-laws; and add diversity to the local seed banks. In some ethnic groups, grandmothers and mothers pass on their skills in selection of varieties and seeds to their daughters and daughters-in-law. This is quite a strong tradition amongst *Jyapu* farmers in the Kathmandu valley. In Tibeto-Burmese communities, such as the *Gurung* and *Magar*, it is a tradition to give new seeds to relatives when visiting, thus helping seed flow from one village to another. As illustrated in Figure 14.1, these new seeds may become a new source of gene flow to traditional land races. As a result the whole process becomes dynamic, and this helps to maintain crop genetic diversity on farms. Thus women's contribution to the existing richness of on-farm biodiversity is quite substantial. However, the value and the contribution of the traditional seed supply systems and women to on-farm biodiversity have been neglected in agricultural research and development programmes. The consequences of changes in seed-related programmes and policies for seed security on gender relations and ultimately on on-farm biodiversity have hardly been considered.

Efficiency of the Formal Seed Supply Systems

The formal seed sector in Nepal is underdeveloped. The national Agricultural Inputs' Corporation (AIC), the only formal organization to deal with seeds of cereal crops, supplies only 10 per cent of the total national seed requirements (Cromwell *et al.* 1993). The AIC only deals with officially released varieties, and there are not many even for major food crops, and because of this their contribution to enhancing varietal diversity is minimal. The distribution of seeds of commercial (non-traditional) vegetables is done entirely by the private sector and amounts to over 50 per cent of the total seed requirements for these crops. But, in the last few years, increasing efforts have been made to increase the seed supply capacity of the AIC. The result is that modern high-yielding crop varieties, developed by public sector agricultural research systems, are being pushed on to farmers with very little understanding of farmers' crop needs, their environment for growing crops, and the likely implications of such efforts on crop diversity. The policy of subsidising the price of seeds and other inputs for a few modern varieties has artificially increased the benefits from using such varieties. Government and non-government organizations have continued advocating the use of a few modern crop varieties without actually analysing the consequences. These varieties are also being promoted by attaching high social status to their use. The idea that the traditional local crop varieties are inferior and a symbol of backwardness is intentionally conveyed to farmers. The Block Production Programmes undertaken by the government District Agricultural Development Offices in the 1980s for major food crops, especially wheat, maize, and rice, are good examples. Farmers were encouraged to grow a single modern variety of a crop by the provision of production 'packages' comprised of seeds, fertilizer, pesticides, training, and technical advice. Both agricultural training and agricultural fairs have been oriented to encourage the use of modern varieties. As a result of systematic efforts and interventions like these, on-farm crop diversity is being narrowed down continuously. This is evident in the case of crops such as wheat, maize, rice, and potatoes, in some areas, and in the case of indigenous vegetables in commercial growing centres. Shahi and Mathema (1983) reported that, in valleys such as Kathmandu, Chitwan, and Trisuli, 80-90 per cent of the traditional rice cultivars have been replaced by modern varieties. Similarly, formerly very popular scented, quality rice varieties, such as *Samundraphinj, Biramphul, Bayerni,* and *Ramani,* are no longer grown widely throughout the Pokhara Valley (Sthapit *et al.* 1995). Experience also suggests that traditional vegetable crops, such as pumpkin, cucumber, other gourds, and leafy vegetables, are being marginalised and replaced by commercial vegetables. These commercial vegetables are often hybrids, and the source and supply of seeds are highly unreliable and controlled by outsiders. If this trend continues, Nepal will be losing its valuable genetic resources as well as indigenous knowledge about selecting and maintaining seeds of open- and self-pollinating crops at the farm level, a big loss for future generations. Despite international concern, there is still no consolidated initiative for formulating policies and programmes in this direction.

Rea's (1995) argument that some development interventions, such as those linked to new seed varieties or new seed diffusion systems, can dispossess women and cause them to lose their skills has also been found to apply to Nepal. Seed sector activities in Nepal, especially those of government agencies, have hardly considered the gender implications. Despite the heavy involvement of women in the traditional seed supply systems, their roles as a source of information and as custodians of local crop varieties and land races have been greatly undermined. On the one hand, modern varieties are mostly developed with the single objective of increasing production and productivity (whereas farmers have multiple objectives). On the other hand, women are rarely included in the process, and therefore their needs and requirements are ignored. Finally, packaged with attractive incentives, these modern crop varieties are often pushed through men. Men have greater mobility, better access to information, and are the first to receive new seed varieties and associated training opportunities. For example, the dissemination of mini-kits and other packages of improved seed varieties has targetted male farmers (Shrestha *et al.* 1984). Similarly, even in areas in which seed projects have intervened, women comprise only 25 per cent of the official participants in seed-related training (Cromwell *et al.* 1993). The implications of such gender-blind, seed-related development activities are four-fold: first, the resources and efforts spent are missing the target; second, women are being systematically dispossessed of and are losing the expertise inherited through generations; third, the crop diversity base is narrowing down without the consequences properly being understood, resulting in limited choices for women; and fourth, there is a danger of introducing seed-borne diseases that could lead to unpredictable losses of crop production or even in a particular crop industry being wiped out. The problem of bacterial wilt disease in potatoes in the western hills of Nepal is an excellent example.

Issues for Consideration

The traditional seed supply systems of mountain communities are under-explored. There has been very little research into farmers' knowledge about the selection, cleaning, treatment, and storage of seeds. Although it is clear that women are more involved in the traditional seed sector than men, the gender dynamics of the whole process is not well understood. In poverty-ridden regions where the immediate need for increasing food production is more important, on-farm biodiversity conservation has received little attention. National policies and strategies on the conservation of on-farm biodiversity are lacking. Because of this, the value of crop genetic diversity for future generations and the role of women in conserving this diversity through traditional seed supply systems have not been explored. Encouragingly, new initiatives for on-farm biodiversity conservation have been started at different levels. In this context, the following issues related to women's role in the traditional seed sector and their contribution to the conservation of crop diversity need to be considered.

- The traditional seed supply systems possess a great potential for increasing food production as well as for conserving on-farm crop diversity. These systems are adapted to different agro-ecological niches and to the different socioeconomic circumstances of farm communities, and thus they provide a basis for livelihood in diverse areas and communities. However, this has not been explored seriously or systematically. The mechanism of operation and the gender dimension of these systems need to be thoroughly researched to provide a basis for any interventions in the traditional seed supply systems. Care needs to be taken to complement the systems rather than disrupt them.

- Agricultural development in Nepal is being pursued only in terms of producing more than the present level through the use of modern, high-yielding crop varieties. This has certainly led to reduced on-farm crop diversity. Cromwell (1992) describes a similar pattern in Zimbabwe. The issue here is whether the contradiction between agricultural development and biodiversity can be minimised or made more complementary. This might be achieved by: a) evaluating traditional local crop varieties and land races, maintaining an inventory of them, and making them available to researchers and farmers; b) offering farmers a wide range of choice of crops and crop varieties; c) providing suitable new seed varieties to increase the plant genetic resource base for exploiting untapped and unused farm resources; and d) exploring and exploiting the market potential of local crop varieties, which is often high because of the unique and preferred qualities of such crops. In all these processes women need to be provided with opportunities for active participation.

- National policies and strategies in the seed sector can play an important role not only in directing on-farm crop diversity conservation efforts, but also in preventing the short-term profit-oriented exploitation of crop genetic resources at the expense of future generations. Such policies and strategies should make sure that promotion of improved modern crop varieties is not at the expense of local land races. At present, women's opinions, needs, and perceptions are very rarely reflected in national policies (Gurung 1995). Care should be taken to make use of women's role and knowledge in the traditional seed sector instead of marginalising them. Hecht (cited in Rea 1995) used the *Prestige and Knowledge Pyramid* to ask, *"How can biodiversity be saved as long as most knowledge about how to maintain it* *in a particular setting is vested in women at the bottom, and most prestige and policy-making power in men at the top?".*

- Women's skills and dominant role in the traditional seed sector can be used for *in situ* crop conservation activities, including seed banking. The recognition of women's skills and roles in such activities will raise their social status and technical awareness. Market exploration and exploitation of local crop varieties can increase the decision-making power of women by improving cash earnings. Women farmers need to be helped to organize themselves into groups and to acquire the skills and management capacity to grow local land races as seed crops and to start village level gene banking. Women's participation in agricultural training and fairs also needs to be increased by organizing such activities in village settings.

- At present, diffusion of technology and new seed promotion mechanisms, such as extension agencies, training, agricultural fairs, and market promotions, by government and many non-government agencies are entirely biased towards improved modern crop varieties. There is an urgent need to correct this bias by reorienting the present attitude of devaluating the importance and contribution of traditional crop varieties and land races. These mechanisms should include valuable and outstanding local crop varieties so that farmers have a choice of diversifying their crop resources. Agricultural fairs should include, and make awards to, outstanding local crop varieties. Women will obviously benefit from this as their contributions will be recognised and sought in the process.

- The farmer-to-farmer seed distribution mechanisms, in which women play an important role, need to be strengthened. For example, *Pokhreli masino*, a popular rice land race from the Pokhara Valley, has spread to most parts of the mid-hills of Nepal through farmer-to-farmer seed exchange (Green 1987). *In situ* rural gene banks need to be established and a seed distribution network for local crop varieties developed, which can ensure large scale re-emergence of these varieties. The formal seed sector should be decentralized, and local institutions should be promoted and empowered to meet the seed needs specific to their local conditions and requirements. There is no reason why the formal seed sector, such as AIC and NGOs, should not promote outstanding traditional crop varieties.

- In order to promote the acceptability of new crop varieties at the same time as on-farm crop diversity, plant breeding should be decentralized and the breeding objectives reoriented to serve the needs of small farmers (Cromwell *et al.* 1993; Sthapit *et al.* 1995). This would create new crop diversity on farms and conserve genetic variation through traditional seed supply systems. Women's participation in the evaluation of post-harvest criteria has been found to be vital for the success of this approach, thus women should be actively involved in the process.

- Pressure should be continued to ensure that crop genetic resources preserved in the farm communities as common property are not monopolised under legislation related to plant breeders' rights and intellectual property rights. Patenting of life forms will not only put the food security of small farmers at risk, but also put women at an even greater disadvantage than at present.

Conclusion

The traditional seed supply systems in Nepal, which have sustained crop production and contributed substantially to on-farm crop diversity through the generations, have not been well explored or exploited. Modern crop varieties are being pushed indiscriminately, often through men, without analysing the consequences on crop diversity, seed security, and gender relations in farming communities. However, in the light of increasing pressure of development for change, and the urgency of demands to advance the cause of women, it will be difficult to promote on-farm biodiversity in isolation. The question arises whether we can maintain agrobiodiversity by production-led development efforts and by ignoring women's role in local seed supply system, as women are the traditional guardians of agrobiodiversity. It appears that on-farm biodiversity conservation can be better promoted if development and conservation are treated as complementary topics to be exploited with care, and if the question of gender is considered carefully at all stages of the efforts made. Genes, the basis of mountain agriculture, can also be better conserved through proper consideration of gender.

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Chapter 15

The Successful Development of a Cash Crop from Local Biodiversity by Farmers in Sikkim, India

E. Sharma and R.C. Sundriyal

Introduction

The hill farmers of Sikkim are composed of different ethnic groups - *Lepcha, Bhutia, Limbu* and *Nepalis*. They grow varieties of rice, rice beans, peas, beans, turmeric, and cardamon (Table 15.1). The major cropping systems are maize-pulse and ginger, maize-potato, paddy, and large cardamom under tree cover. The main cash crops are large cardamom, mandarin oranges, ginger, and potatoes. The first three are indigenous, whereas potato is an introduced crop.

Table 15.1: **Existing Land Races and New Varieties of Crops in Sikkim**

Crop	Altitude (m)	No. of land races grown	No of New Varieties	Commencing year of crop improvement
Maize	<2400	4	43	1978
Rice	<1800	19	60	1976
Wheat	<2200	0	34	1975
Black gram (urd)	<1000	3	75	1987
French beans	500-1600	5	93	1988
Field peas	<2200	4	230	?
Rice beans	<1800	6	4	?
Barley	800-2800	-	5	1982
Finger millet	500-1600	4	5	1982
Buckwheat	300-2500	1	None	-
Potatoes	300-2500	0	13	1979
Large cardamom	600-2000	5	None	-
Ginger	<1500	4	2	1976
Turmeric	<1500	5	4	1984

This diversity in crops and varieties is associated with specific ethnicity. The large cardamom (*Amomum subulatum*) is a good example. It is native to Sikkim where its five wild relatives, *A. linguiforme*, *A. kingii*, *A. aromaticum*, *A. corynostachym*, and *A. dealbatum*, are still found. The many species of cardamom now grown in Sikkim are all derived and propagated from these wild types. Farmers can recognise different varieties and their special characteristics. The common varieties maintained by farmers are *Ramsey*, *Golsey*, *Sawney*, *Madhusy*, and *Ramla*. The *Lepcha* tribe in the Sikkim mountains was the original custodian of this crop. This tribe identified the large cardamom in forests and domesticated it. Cardamom farming practices developed through innovative experimentation by *Lepcha* farmers. Knowledge about cultivation was gradually passed to the *Bhutia* and *Nepali* people living in Sikkim. Now cultivation of large cardamom has spread to the adjoining hills of Darjeeling, Bhutan, and eastern Nepal. Improving this technology was initiated through a farmer-to-farmer network. This crop has been doing well in terms of both varietal development and crop management without research or extension support from formal institutions.

Cardamom farming is a perennial, low-volume, high-value, non-perishable, cash crop (Sharma and Sharma 1997) and it demands less nutrients and other inputs in comparison to other crops (Sharma *et al*. 1994). By cultivating large cardamom, farmers have harnessed the mountain niche to its greatest advantage. Farmers in Sikkim have provided an example of how indigenous agrobiodiversity can be harnessed for cash cropping and have identified beneficial species, varieties, and farming practices for this crop. The crop domestication process was performed by the farming community, thus ensuring that farmers conserve and manage a large number of cardamom varieties on each farm.

There seems little danger of genetic erosion of the large cardamom as more and more farmers plant cardamom under *Alnus* forest in marginal lands. Since large cardamom is propagated by splitting the rhizomes, there is less concern for varietal loss.

The cases of turmeric and ginger are similar. Nevertheless, genetic erosion of ginger land races is becoming a possibility. The seed requirement for ginger is substantial, and much space is needed for storage. To avoid the problem of space and loss due to soft rot during storage, farmers do not keep seed rhizomes but buy them from the weekly market at planting time. Ginger cultivation requires high fertility and mulching with forest litter. In recent years, forest degradation has forced farmers to discontinue ginger farming, thus the gradual disappearance of ginger land races is a matter of concern.

Threats to Traditional Seed Systems

Sikkim is rich in local germplasms of arable crops (Table 15.1). Crops such as large cardamom and buckwheat are still grown using land races only, whereas hybrids are now used for ginger, turmeric, finger millet and barley. The land area under ginger increased by 191 per cent, and the area under potatoes by 311 per cent, between 1981 and 1992. The trend of switching over from traditional agriculture to cash crop agriculture has become obvious in the last decade. The cultivation of cash crops is leading to a decline in local crops and varieties. At present minor crops are maintained by farming households on a small scale to meet the needs of their traditional religious and food cultures. There is no longer sufficient land available for the cultivation of all crops, and farmers' preference is for expansion of cash crops. The threat to traditional crops will increase as the amount of cropland available per household is reduced.

In marginal and low-input farming systems, women have been the traditional managers of germplasm. The agricultural biodiversity that has been maintained by women, through traditional systems, has diminished with the promotion of hybrid seeds, monocropping, and changes in traditional agricultural practices.

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Chapter 16

Crop Breeding and Varietal Release Policies and Distribution System in China

Jiang Liangcai and Liu Zhongqi

Crop Breeding

The crop breeding programme is the mandate of the Chinese Agricultural Department. Since 1980, the Chinese Science and Technical Committee, which consists of governors and scientists, has been leading the breeding programme. This group has been responsible for the administration of the main crop breeding programme. The Chinese Sci-Tech Committee prepares five-year plans and budgets for economically important crops that have an important impact on food, natural fibre, and oil production in China. Breeders working with the same crop are asked to form a cooperative group. An institute in the Chinese Academy of Agricultural Sciences with proven results is usually appointed as the group leader, and a famous breeder in the Institute is appointed as the director of the cooperative group. Each member of the cooperative group undertakes the task for which they have superior research performance. After five years, the leading group inspects the research progress achieved by each cooperative group and monitors the achievements against a contract signed by the director in the first year of the 'five year plans'. Programme evaluation will eventually determine future funding.

The Research System for Crop Breeding

The Chinese Academy of Agricultural Sciences (CAAS) and provincial academies and their regional institutes of agricultural sciences look after crop breeding. The national breeding programmes are directed by scientists from the CAAS. Agricultural universities also carry out crop breeding programmes. Some crop research institutes are affiliated to universities, for example the Soybean

Research Institute in Nanjing Agricultural University and the Rice Research Institute in Sichuan Agricultural University.

Breeding Objectives

The breeding objectives vary with the crop. Most crop breeding programmes have the following research process.

- Collection, identification, and conservation of germplasm
- Evaluation of parent material for disease resistance, good quality, and yield
- Development of new lines and combinations
- Variety testing, p roduct demonstration, verification, registration, and extension system

The Crop Breeding Method

The Germplasm Research Institute of the Chinese Academy of Agricultural Sciences is in charge of the collection of various plant germplasms in China. Some groups in provincial agricultural academies also collect local plant germplasms. In order to improve breeding efficiency, plant breeders in China have been employing various breeding methods that use local and exotic germplasm. Some of them are listed below.

- Pure line breeding
- Combination breeding
- Recurrent selection breeding for crop population improvement
- Use of heterosis
- Other breeding methods

System to Evaluate Varieties

There are two systems of evaluating new varieties of crops in China. One is based on cultivation and demonstration of production. Another, the main system, is based on regional tests.

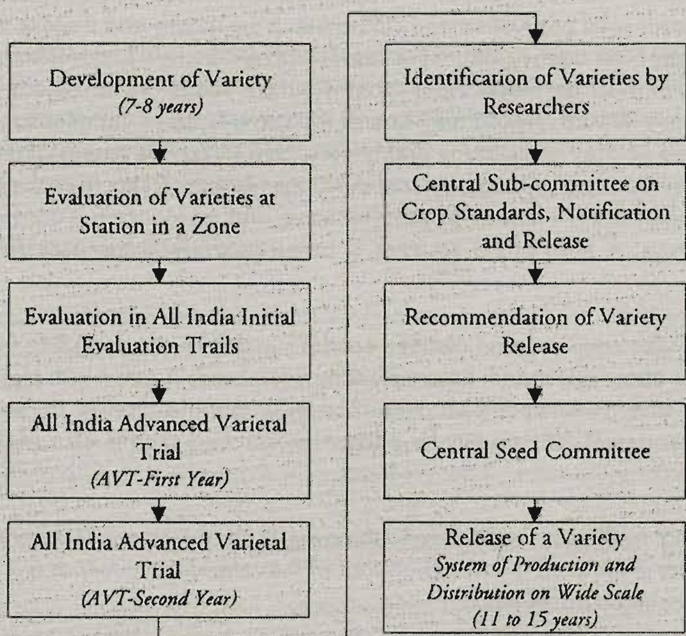
Box 16.1
Variety Testing Procedures in China

Before being registered, all new lines are tested in yield trials organized by the provincial seed company. After 2-3 years of experiments, new cultivars superior to the reference variety in terms of high yield potential and agronomic traits are sent to the variety verification committee for registration. The new lines are tested and demonstrated in different areas for yield advantage and best domains.

Testing of Varieties by Demonstrating Production on Large Plots

This system is used for food crops such as wheat, rice, and maize (Box 16.2). The system has advantages as the extension of new varieties is rapid. However, it exposes farmers to the risk of crop failure in specific areas. There have been examples in which the varietal stability and suitability of some varieties were poor. Good performing varieties are registered by the variety verification and registration committee and then distributed quickly. For example: Yu Kang 2 (a variety of tomato) was grown on 1,800 ha in 1989-1991 and registered in 1992; Gong Ji Zhe (a variety of bean) was registered in 1992 after cultivation on demonstration plots in 1989; and Shan You No. 64 and D You No. 49 (varieties of rice) were released after they were grown on large plots in 1992.

Box 16.2



Testing of Varieties at the Regional Level

The testing of varieties at the regional level means that newly bred or introduced varieties are grown in representative districts to test their distinctness, uniformity and stability. In regional tests, varieties are screened for disease resistance and yield potentials. Preliminary yield trials are conducted at the originating institute (university) for two to three years. Successful varieties in these preliminary trials are tested in national (or provincial) uniform yield trials for a further two to three years. The purpose of regional trials is to assess the degree of adaptation to make full use of potential varieties and find varietal niches in different ecological districts. The demerit of the system is the time taken before products reach farmers.

Regional tests of varieties are divided into national and provincial tests. The Seed Administration Department and the Academy of Agricultural Sciences manage multi-locational regional variety tests. Sites and institutes are selected. An application for variety nomination must be made before the variety is considered to facilitate initial screening.

The application must contain such details as the source of the variety, the breeding process, the results of preliminary two to three year yield trials, the main characteristics (including parental characteristics), and the main points of the techniques for seed production and cultivation. If the quality and disease resistance of the variety have been tested, these results will also be sent to the administrators. Applications must be made three months before seeds are to be sown. Each breeding unit should choose only one of the same types of varieties for regional tests, based on the results of the preliminary yield trials. The results of these trials are discussed annually at regional trial meetings, varieties better than the reference (check) variety in such factors as yield, disease, and resistance are considered for regional tests. A total of 10 varieties is tested in every group trial including a control.

Foundation seed or good certified seed is supplied by the breeding institute to all test sites about one month before planting time. Seeds are sent with a quarantine certificate and a variety introduction. The most popular variety is used as the reference variety. Good quality foundation or certified seed is also used for this variety.

Regional trials usually take two to three years. Varieties are eliminated during the first year if the yield is lower than that of the reference variety and it does not posses special characteristics.

Production and Cultivation Experiments

The purpose of production experiments is to determine the yield potential of elite varieties. Usually production experiments can be carried out during regional tests. If a variety is good in the first or second year of the regional test, it may be lined up for production experiments the following year. The method of experiment is to compare yields over a large acreage. The area for small grains such as rice and wheat is usually more than 0.067 ha, and that for big grain crops, such as cotton, maize, and sweet potato, more than 0.134 ha. Trials are not replicated. The quality of the land used for the experiment and the reference variety are the same as those in the regional test. The cultivation method is chosen on the basis of the characteristics of the variety to be tested and the reference variety. Varieties are inspected and growth compared before harvesting. The production experiments are also used for demonstration and seed multiplication.

Agronomic experiments are carried out at the same time as production experiments, or when extension of a variety is permitted. Agronomic experiments are carried out to investigate the effects of such factors as climate, soil, density, fertilizer, water, and sowing date which depend upon location specificity. The purpose of such experiments is to recommend the best husbandry methods for new varieties on a large acreage.

Summary Report

All cooperating institutions need to submit summary reports of agronomic and regional tests. After completion of testing, varieties are assessed. The administrators will recommend the best varieties to the verification and registration committee, which will verify and register it according to the rules. Agricultural administrators are then free to distribute the new cultivars.

Verification and Registration

Crop variety verification and registration committees exist within each province or autonomous region of China. The committees include representatives from the following: the official for agriculture, the agricultural research institute, the agricultural university, the food department, and the industry committee. The committee members vary according to the needs for the crop. The seed administration unit is responsible for the daily work of the committee.

Functions of the Variety Verification and Registration Committee

The crop variety verification and registration committee is a special organization established to verify and register new crop varieties. Its main tasks are as follow:

- to register and approve of new varieties;
- to evaluate and recommend the agronomic practices and recommended domains for the registered variety;
- to suggest and revise extension messages related to the new varieties;
- to nominate varieties for regional tests; and
- to name and popularise the new varieties.

The following conditions must be met for variety release and registration purposes.

Stable characteristics, a complete set of material from experiments conducted for two to three years, a preliminary yield trial, a regional test, and one to two years of production experiments.

A new cultivar should have a yield at least 10 per cent higher than that of existing reference varieties to be considered superior. If its yield is equal to that of older varieties, then the new variety should be distinctly superior to existing varieties in at least one or more other characteristics (for example quality, maturity, adaptability, resistance) and at least satisfactory in all other important respects, or have a special economic value for some other reason.

Foundation seed should be sufficient for planting on 3.3-6.7 ha. The breeding unit should produce breeder seed.

The Procedure for Verifying and Registering a New Crop Variety

Breeders submit an application containing the following:

- an application form with an illustration of the variety;
- a complete set of materials related to the regional tests and production experiments;
- materials related to the quality and resistance of the variety;
- a picture of the plant, ear, seed, and fruit (or root tuber, tuber);
- a description of parental characteristics and the technique of propagating and producing seed of the hybrid; and
- a suggested name for the variety.

The chair of the committee is responsible for examining the results of the regional test and production experiments and the recommendations of the specialist groups, and verifying and registering the variety.

The Extension System for New Varieties

Usually, in China, the varieties planted by farmers are good. The role of the government is to formulate seed policy. The agricultural departments of the country, province, or county governments are responsible for managing seeds.

Seed Production

Seed production includes production of basic seed, registered seed, and certified seed. There are two channels for producing seed in China. One is the national production base (for example, state owned farms, collectives, or people especially appointed for seed production). This channel is specialised. The other channel is for a village to set up a seed production base to produce seed for themselves. Units for producing commercial seed must obtain a 'seed production permit' from the agricultural administration. The condition for obtaining a 'seed production permit' is that the technological ability and equipment of the unit or person to produce commercial seed must be well-suited to the task of seed production. The unit or person must abide by the technological rules of commercial seed production.

Seed plots are planted on a large acreage to meet market demand. It is common practice for farmers to buy certified seed of new varieties of crops as a seed supply as improved varieties become available. Farmers may harvest seed from their own crop for successive plantings. In practice, many of them buy seed every year or every other year if they cannot maintain the purity of the variety.

Seed Pricing and Costing

The importance of price varies from one market to another and between different segments in the same market. For example, non-hybrid seed, which the farmer can save, will be more price sensitive than hybrid seed. Price will be a more critical factor in marginal farming areas in which spending power is low, but less important where high yields can be obtained and farm produce can be sold profitably

Costs include the cost of the processed and packaged seed and the marketing costs associated with selling and distribution. Costs may be grouped according to the activities involved, notably:

- seed production, involving procurement, processing and storage, quality control, and certification;
- seed marketing, taking into account marketing, market research, advertising and promotion, sales and distribution; and
- administration and finance.

Seed Trade

Usually about 35 varieties are verified and registered in Sichuan, China, annually. Hybrid seeds of the main crops are traded by units appointed by county, provincial, and national governments. Seed is traded through many channels under the guidance of the public sector seed administration. The seed companies of agricultural departments at all levels are a main channel for producing and trading seed. These companies are responsible for planning seed production and providing good varieties. Research and teaching units may sell hybrid seed from their own breeding products. Seed companies belonging to the county agricultural administration may set up seed stations to sell seed to farmers in village areas. Their 'seed trade permit' is handled by a seed company. Seed must be quarantined before it is sold. The marketing channels for seed in China are as follow:

- state-owned corporations;
- state-owned research units and universities;
- private enterprise; and
- agricultural experimental stations.

Chapter 17

Crop Genepools in the North East Indian Himalayas and Threats

R. C. Upadhaya and R. C. Sundriyal

The Indian Himalayas constitute a core area and the centre of origin and diversity for more than 20 major agricultural and horticultural crops (Vavilov 1950). About 160 domesticated species of economic importance and over 325 species of their wild forms and relatives are native to this region and constitute an invaluable reservoir of genes. This diversity is attributed to the wide variation in topography, geographical position, and climatic conditions within the region (Arora & Nayar 1983 Borthakur 1992). The NE Indian Himalayan (NEH) region is also rich in primitive and endemic flora and economically important species. Thus it is a 'hot spot' of variability for many economic crops and their wild relatives. This region as a whole may be an active speciation zone as a result of natural mutation, hybridisation, and floral evolution (Kanjilal et al. 1936, Robinson 1841, Hooker 1854 and 1906). The recent exploration by the Botanical Survey of India (BSI) revealed about 70 new species, belonging to 50 genera, previously unrecognised in the region. It is believed that about 40 per cent of the forest area has yet to be surveyed and the flora classified. The NE Indian Himalayas also have a contiguous border with other countries (China, Burma, Bhutan, and Nepal) and this has helped in mobility as well as micro-speciation. Crop selection is performed by a large number of different ethnic groups, and their traditional farming systems have also helped create the Genetic Diversity of crops (Chatterjee 1939).

This paper highlights the Genetic Diversity of some important crops in the northeastern region. It is based on work done by various research institutes including the Indian Council of Agricultural Research (ICAR) Centres for the NEH region, the National Bureau of Plant Genetic Resources (NBPGR) Centres, the BSI, and other organizations.

Geography and Physical Characteristics

The Indian Himalayas comprise the northwestern region (Jammu and Kashmir, Himachal Pradhesh), central region (hills of Uttar Pradesh), and northeastern region. The North East Indian Himalayas include the Darjeeling district of West Bengal, Sikkim, Arunachal Pradesh, and other North Eastern States (Assam, Manipur, Meghalaya, Mizoram, Nagaland and Tripura). Wide climatic variations are recorded from tropical to sub-tropical, temperate, and alpine zones, but, as a whole, the region is considered to be wet tropical because of its high rainfall and humidity.

Over 90 per cent of the population is rural and engaged in agriculture. Land uses vary from state to state. Wide variations in elevation from area to area contribute to great variations in climate, vegetation types, and agricultural practices. Generally, the valleys are warm and cold temperatures prevail at higher elevations. Annual rainfall varies from 1,300mm in parts of Assam, Sikkim, and Nagaland to over 10,000 mm at Cherrapunji, Meghalaya.

Genetic Variability of Some Important Crops

The crops and their wild relatives mainly confined to the NE Indian Himalayas are *Abelmoschus, Alocasia, Alpinia, Amomum, Brassica, Camellia, Canavalia, Citrus, Colocasia, Corchorus, Cucumis, Curcuma, Digitaria, Dioscorea, Docynia, Erianthus, Eurya, Hedychium, Hibiscus, Mangifera, Momordica, Morus, Mucuna, Musa, Oryza, Prunus, Rubus, Setaria, Sorbus, Trichosanthes* and *Vitis*.

Food Crops

Rice, barley, *Coix*, finger millet, and foxtail millet are native to the region. Rice is the main crop in the region and there are diverse cultivars with useful genes. Of 8,000 land races, about 5,000 come from the NE Indian Himalayas (Shastry et al. 1971). There is wide variability in the rice germplasm collected from different parts of the northeastern region (Table 17.1), but glutinous and japonica forms dominate the endemic types. Some of the cultivars are resistant to diseases and pests and are tolerant to drought and cold. Genetic divergence among the land races of the NE region is classified into nine clusters. Some clusters occupy an intermediate position between *japonica* and *indica*. Noticeable sterility in some crosses of upland/lowland ecotypes led to the conclusion that they might differ by a number of genes. There are a number of wild rice species, including *Oryza granulata, O. rufipogon, O. jeyporensis, O. malampuzhaensis*, and *O. sativa var spontanea* (Table 17.2).

Table17.1: **Distribution of Wild Relatives of Cultivated Crops in India as a Whole and in the NE Indian Himalayan Region**

Crop	Number of Species	
	NE Himalayas	India
Cereals	16	60
Legumes	6	33
Fruits	51	109
Vegetables	27	64
Oil seeds	1	12
Fibre Crops	5	24
Species and condiments	13	27
Miscellaneous	13	26

Source: Authors compilation from ICAR publications

Table 17.2: **Some Characteristics of Assam Rice Collections (ARC) and Variability in Rice Germplasm Collected from the NE Region (as a percentage of total land races in India, showing the traits)**

States	Japonica	Semi dwarf	Glamorous husk	Waxy endosperm	Fine grains	Scented kernel
Arunachal	24	1	11	8	16	2
Assam hills	2	5	1	11	12	4
Manipur	1	0	5	12	16	2
Meghalaya	0	1	2	11	17	5
Nagaland	3	16	22	18	10	6
Tripura	5	0	0	4	11	3

Primitive types of maize have been recorded in the region. Wild relatives of *Digitaria, Coix, Panicum, Setaria,* and *Elusine* are also found. Different finger millet and foxtail millet land races are being cultivated by tribal farming communities in the region. Some wild forms of barley (*Hordeum agricrithon*) are cultivated in parts of Sikkim.

Gene pools of legumes such as perennial types of pigeon pea, rice beans, green gram, winged beans, broad beans, *Dolichos,* and sword beans (Borthakur 1992) are also found in the eastern Himalayas. The genus *Vigna* has more variability and looks like black gram or green gram. There is also a wide diversity in the *Atylosia* species, which are related to the cultivated *Cajanus cajan* (pigeon pea). Wild forms of sword bean are found in the hills of Manipur and Mizoram. Arunachal Pradesh is home to a Genetic Diversity which includes *S. spontaneum, S. longisetosus, S. procerum,* and *S. sikkimenses.* A range of land races of *S. officinarum* are maintained by farmers in the eastern Himalayas.

Indigenous cotton, such as perennial, short staple, and khaki cotton, grows in Mizoram and other hills of the NE Indian region.

Horticultural Crops

The North East Indian Himalayas are home to many horticultural crops including fruits, vegetables, spices and condiments, medicinal plants, and ornamentals. Among the tropical fruits, *Citrus, Musa sp, Mangifera,* and *Artocarpus* exhibit wide variation. Sub-tropical fruits include *Garcinia, Artocarpus, Phylanthus, Anona, Averrhoa, Persia, Aegale, Flacourtica, Passiflora, Avocado, Actinidia, Dillenia laeocarpus, Eugenia, Ficus, Juglans, Vitis, Spondias, and Sygyimum*. Variability is also very high in the region among temperate fruits. A number of species belonging to the genera *Malus, Prunus, Pyrus, Sorbus, Docynia, Rubus, Cotoneaster, Ribes, Fragaria,* and *Actinidia* grow in the wild.

The citrus fruits include oranges, limes, lemons, and pommelo. About 37 citrus species are cultivated in India. Bhattacharya and Dutta (1951) described 17 species, 52 varieties, and seven natural hybrids of citrus fruits that come from Assam. *Citrus indica,* a primitive and endangered species of citrus and the probable progenitor of cultivated species, grows in the Garo hills. About 100 land races have been collected by ICAR. Citrus (C. *medica)* is planted widely in kitchen gardens all through the region and has a wide range of variation in fruit.

Mango, a major fruit in India, grows wild in the northeastern Himalayas. Several land races are available in the region.

The banana is common to the eastern Himalayas. *M. balbisiana* and *M. acuminata* are seedy and grow in the wild. There is a great variability in species, and wild forms are common in the region. Chakravorty (1951) considered that the NE Himalayas were the centre of origin of the banana. The Genetic Diversity is enormous, with tolerance to disease and cold conditions.

Vegetables, Tuber Crops and Spices

The region is rich in cucurbit, *Benicasa hispida, Momordica cochinchinensis, M. charantia, M. dioica, Lagenaria siceraria, Trichosanthes, Luffa acutangula, Cucumis sativus,* and *C. melo*. There are two edible species and many non-edible types of *Trichosanthes*. There are a large number of cultivars of brinjal, and it has much more variability in the region. The other crops are *Cucurbit moschata* and *Sechium edule. Alocasia, Colocasia,* and *Dioscorea* of different shapes and sizes are commonly used in the region as edible roots.

Ginger, turmeric, chillies, cinnamon and large cardamom *(Amomum subulatum)* have wild relatives in the region. The variability is very high in turmeric, chillies, and ginger. Black pepper grows in abundance in the wild in the lower forests of Assam and other parts of the eastern Himalayas.

Bamboo

Bamboos are indispensable for tribal groups in the region because of their many uses in day to day life. They are used for shelter, food, furniture, handicrafts, medicine, and other ethno-religious purposes. Bamboos are also used as a raw material in paper and pulp industries. Of the 136 species available in India, nearly half (63 species) are native to the NE Indian Himalayan region (Kochhar et al. 1992). The commonly available species are *Dendrocalamux hamiltonii, D. hookerii, Bambusa balcoa, B. tulda, B. pallida, B. nulans, Cephalostachyum capitatum*, and *Melocanna baccifera*. The rare and endangered species are *D. hamnei, Teinostachyum helferei*, and *Bambusa mastersei*.

Orchids

Orchids are a unique group of plants with a wide range of variability. The main economic importance of orchids lies in their ornamental value, but some species also have a medicinal and/or aromatic value. Of 1,300 species belonging to 163 genera reported in India, more than 600 are from the eastern Himalayas. Sikkim alone has more than 450 species belonging to 100 genera. Eighteen endemic species are found in Arunachal Pradesh (Hegde 1984). The orchids are found from tropical to alpine zones. As many as 225 orchid species are rare, 12 endangered, 16 vulnerable, and one species, *Paphiopelium wardii*, is nearly extinct.

Mushrooms

There are more than 250 fleshy mushrooms indigenous to the eastern Himalayas, belonging to about 100 species. Many of them are edible.

Scientific concerns

Wild relatives of crop plants and other related species are of considerable importance for meeting the growing demands for food of the increasing population. Wild species can be used for crop improvement and are of great help in studies related to basic information about species' relationships. However, knowledge about the taxonomic, morphological and biosystematic position of various wild relatives of crop plants is poor, therefore these species are not properly used. Furthermore, there have been few detailed investigations of the interrelationships between wild and cultivated taxa of most genera and species. The wild relatives can benefit production by providing genes for adaptability to adverse environmental conditions, disease resistance, cold hardiness, and drought tolerance. They are adapted to a variety of soil types. Such characteristics could make a significant contribution to improving crop genetic resources through breeding programmes. Despite the wide diversity in crops and potential for crops, the average standard of living of the people in the NE region is by and large poor. This is the result of the various constraints in the area. Most of the area is still inaccessible and lacks adequate infrastructure. The low temperatures at higher elevations markedly reduce the growing season. Farmers are not aware of modern technologies, fertilizers, and improved crop varieties. Farmers still collect large quantities of various wild edible plants from natural habitats. There is increasing evidence of indigenous forests and other natural areas being affected by grazing, firing, shifting cultivation, and land conversion for agriculture and other purposes. Thus this region of great Genetic Diversity is under serious threat of rapid extinction or depletion of the germplasm. The governments in the region are thoroughly aware of the problem of depleting natural resources, their solution lies in creating national parks and wildlife sanctuaries (Table 17.3). Research institutions (NBPGR, ICAR, BSI, and universities) are also preserving economically important genetic materials. There is a need to bring a greater area into such a conservation network.

Table17.3: National Parks, Sanctuaries and Biosphere Reserves in the North East Himalayan Region of India, as a Part of Biodiversity Conservation Efforts

State	No of national parks	No of wildlife sanctuaries	Total area (km²)
Arunachal Pradesh	2	4	3699
Assam	1	11	4316
Manipur	2	0	6 ??
Meghalaya	2	3	305
Mizoram	1	0	600
Nagaland	1	2	522
Sikkim	1	4	988
Tripura	0	2	186

Further, gene pools have to be preserved for future use before they become extinct. Systematic collection and proper evaluation of genetic materials are necessary and are of immediate concern. *In situ* and *ex situ* conservation are important in the region.

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Chapter 18

State of Documentation and Collection of Crop Land Races and Wild Relatives in the Indian Himalayas

K. C. Pant

Introduction

The diversity in agricultural crops, land races, and their wild relatives in the Indian Himalayas has been maintained by local inhabitants and tribal groups since ancient times. In India, the endemic species inhabit two areas for the most part; approximately 4,200 species being in the Himalayas and 2,600 species in the peninsular region. In the Indian Himalayas, crop diversity is related to eight groups of crops and 71 species. As a result of the selection pressure exercised within the species by locals over the unrecorded millennium, enormous diversity has evolved in the form of local land races. Two types of agricultural system are followed by local people and tribal groups in the Indian Himalayas: mixed cropping in mountainous regions and intensive cropping patterns in valley areas. In higher altitudinal zones in the western Himalayas, pseudocereals, such as amaranth, buckwheat, and chenopods, and cereals such as barley (hulled and hulless) are the main staple crops. The main crops in the mid-hills in the entire Himalayan zone are minor millet (barnyard millet, proso, foxtail, and finger millet); cereals (paddy, maize, wheat and hulled barley); pulse crops (French beans, soybean, lentils, black gram, peas, and horse gram); and oilseed crops (sesame and mustard). In the eastern Himalayas and northeastern region, Job's tears (*Coix-lacryma jobi*) and *Perilla fruitescens* are also grown in addition to the above-mentioned crops. Thus an enormous diversity exists at special genetic levels (Table 18.1).

Paddy (*Oryza sativa*): Paddy is a staple food all over the Himalayan region and has tremendous diversity in both upland and lowland areas in the western

Table 18.1: **Diversity of Crop Land Races (number) in the Western and Eastern Himalayas**

Crop	No of species	Crop	No. of Land Races		
			Western Himalayas	Eastern Himalayas	Total
Cereals	4	Paddy	1330	1474	2804
		Maize	1185	1114	2299
		Wheat+barley	1043	488	1531
Pseudocereals	6	Amaranth	-	-	-
	2	Buckwheat	-	-	-
	1	Chenopods	-	-	-
	1	Coix			
		All	3080	44	3124
Minor millets	6	Barnyard	-	-	-
		Proso	-	-	-
		Foxtail	-	-	-
		Finger	-	-	-
		All	1308	87	1395
Pulses	17	Ricebeans	-	-	-
		Lentils	-	-	-
		Soyabeans	-	-	-
		Cowpeas	-	-	-
		All	2097	789	2886
Oilseeds	9	All	1002	511	1513
Forage legumes and grasses	22	All	502	-	502
Fibre plants	7	All	0	98	98
Total	71		11553	4605	16158

Himalayas as well as in *jhum*[1] agriculture areas in the eastern Himalayas. In the Uttar Pradesh (UP) hill region, old land races are maintained by tribal communities such as the *Jaunsari, Marcha*(s), *Tolcha*(s), *Nitwal*(s), *Jad*(s), *Johari*(s), *Darmi*(s), *Raji*(s), *Bhotiya*(s), *and Gangwal*(s) (Pant and Negi 1996).

Maize (*Zea mays*): There is a wide diversity of maize in the western Himalayan region in Jammu and Kashmir, Himachal Pradesh, and in small pockets of the Jaunsar and Babar region in the Uttarkashi and Dehradun Districts of the UP hills. Enormous diversity among old land races has been observed In the eastern Himalayas. Variations in plant height, cob size, kernel cob, and seed size, shape, and colour are common. Bhag Singh (1977, 1991) grouped northeastern maize collections into 15 land race groups on the basis of detailed agro-morphological characterisation.

Pseudo-cereals: The amaranth species, *A. hypochondriacus, A. cruentus,* and *A. caudatus* are mainly grain type species. Amaranth is grown in large areas at

1 *The system of long-term shifting (slash and burn) agriculture.*

higher altitudes between 1,800 and 2,700m, but surprisingly only two types are grown: *A. hypochondriacus* and *A. caudatus*. In the mid-hills to low hills all three grain type species, including *A. cruentus*, can be observed in sparse stands. The grains are rich in protein, fat, and carbohydrate and are comparable to wheat, rice, and oats. A wide range of variation is observed in the number of days to flower, the days to maturity, plant height, inflorescence length, spikelet number, 1,000 seed weight, and grain yield. Following multilocation trials, one land race (accession I.C. 42258-1) was selected and released as Annapurna (Joshi 1985). This variety can produce 20-25 t/ha seed yield with 15 per cent protein and has drought tolerance and wider adaptability.

Buckwheat (*Fagopyrum* spp): There are two cultivated species of buckwheat: *F. esculentum* and *F. tataricum*. The latter is mainly confined to higher altitudes. These species can withstand the poor, infertile, and acidic soils prevalent in hilly areas. The NBPGR Regional Station (Shimla) selected a better performing land race and named it *Himpriya*.

Chenopods (*Chenopodium album*): Chenopods are distributed *widely but* sporadically in the western and eastern Himalayas at altitudes between 1,500 and 3,600m. In the eastern Himalayas, cultivation is limited to Arunachal, Manipur, Darjeeling, and the Khasi hills. Annual production in the Himalayan region is nearly 400 tonnes (Partap 1990). Ninety-nine accessions collected from the Himalayas are being maintained at the NBPGR Regional Station, Shimla. Multi-locational trials conducted at four locations in the Uttar Pradesh (UP) and Himachal Pradesh (HP) hills showed that indigenous collections performed better (1.2 t/ha grain yield) than exotics (0.6 t/ha maximum yield).

Minor millets (*Pseudocereals)*: Minor millets are important for the food security of the Himalayan region. Minor millets are are cold resistant and drought hardy. They include *madua* (coarse millet), finger millet (*Eleusine coracana*); white, brown, and purplish/reddish varieties of *kauni*, foxtall millet (*Setaria italica*); *cheena*, proso millet (*Panicum milaceum*); *sawan*, barnyard millet (*Eleusine coracana*); and *kodo (Paspalum scrobiculatum)*, an extremely drought resistant coarse grain millet. Not much Genetic Diversity exists within these species. But they can thrive under extreme conditions and do not require special inputs. In the northeastern Himalayas, *Job's tears (Coix lachryma jobi)* exhibit good variation in leafiness, tiller number, panicle length, compactness, shell thickness, colour (black, creamy, striated or smooth), and kernel size. Another small millet, *raishan (Digitaria cruciata* var. *Esculenta)*, an endemic species in the Shillong region, is tall with long fingers, has edible grains and good tillering, and has a good fodder value.

Pulses: Many land races of black gram *(Vigna mungo)*, (*Vigna unguiculata*), peas (*Pisum sativum* var. *arvensis*), french beans (*Phaseolus vulgaris*), *gahat/kulthi*, horse gram (*Macrotyloma uniflorus*), *gurans*, and rice beans (*Vigna umbellata*) found in the northeastern region in the Garo and Khasi hills of Meghalaya, Manipur, Mizoram, and the western Himalayas. Lentils (*Lens culinaris*) are a crop in Himachal, whereas broad beans (*Vicia faba*) are grown in the eastern Himalayas and *bhatmas*, a black seeded soybean (*Glycine hispida*), is a traditional crop in the western Himalayas.

Oil seed crops: *Brassica campestris* var. *brown sarson*, *B. campestris* var. *yellow sarson*, sesame (*Sesamum indicum*), and linseed (*Linum usitatissimum*) are widely cultivated as oilseed crops in the Himalayas. In some regions, other wild and semi-domesticated plants are also used to provide edible oils. One example is the *Cheuri* or Indian butter tree (*Aesandra butyracea*) which is found in the western Himalayas in Pithoragarh (Negi and Pant 1988), in Almora district, and occasionally in Nainital district in warmer valley areas. Trees can grow under rainfed conditions, but thrive best and fruit in high humidity areas near rivulets. *Perilla fruitescense* is an underexploited oil seed crop with wide variations found in the eastern Himalayas.

Documented Diversity of Land Races of Rice, Wheat and Maize

Rice

Central Himalayas (UP) (100m – 1,500m)

Andi, Anandi, Anjana, Bagari, Bagadia, Bagani, Bamkua, Bankuli, Barik Bagadia, Bhadari, Binduli, Bura, Chamba, Chani, Chaunia, Chinmuri, Chotiya, Dafauti, Dalbadal, Dandunauli, Dangya, Dhania, Dudh, Gadala, Garru, Gyasu, Geemi, Gorakhpuri, Gurdi, Hansi, Hansraj, Jamali, Jauli, Jaulia, Jhumri, Kaladhan, Kalimalali, Kalthuniya, Katuria, Khaja, Khajia, Lal Dhan, Lamadi, Paktauli, Pingla, Rajmati, Ramjawan, Sal, Simanjari, Suriya, Thapachini, Tilakchandan, Lalchandan.

Central Himalayas (UP) (1500m - 2000m)

Anchan, Baguabanapsa, Chawar, Dhur Basmati, Duhia, Garudya, Char Dhan, Ghysu, Lekmal, Chawariya, Jhelda, Kajuri, Roti, Rotinga, Sawa, Shakhulshukhila, Ukhad, Tolia, Chwatu, Almunji, Jhalla-Highly cold resistant.

Western Himalayas (Jammu Kashmir and Himachal)

Baber, Lonazen, Budiji, Mushka Budiji, Niver, Roda, Anri, Bathal, Matali, Sundaru, Mandhole, Kalikalori, Chowartu, Dewal, Seyartu, Peladhan, Ramjawan, Hansraj, Phul Pattas, Lal Nakanda, Dundar, Desi Basmati.

Eastern Himalayas, Assam

Dhumai, Prasad Bhog, Boro I to IV, BAU.

Manipur

Changlei, Phongak, Dumai, Moringphou, Phourel, Karchangphoou, Phouretmbi.

Mizoram

Burma, Buban, Mangbuh, Fazai, Fazu, Farel, Vaibuh, Lalruma, Zongan, Phulbuh, Luangbuh, Liankhuma - grown under *Jhum* cultivation. *Pawnbuh, Vuitawia* - grown under wetland conditions.

Meghalaya

Minel, Minelmakhre, Sapha, Bhog, Mima, Bora, Sarang, Misiken, Miphisa, Kalajira, Mukhidep, Mithanbung, Megachak, Sphang, Jhum cultivation. *Mibisa,* - upland *Manoharsali, Manohar, Joha, Champali, Mulukana, Balam, Kalajoha, Moyanagiri.*

Darjeeling and Sikkim Areas

Dudhey, Attey, Phudunge, Zarey, Chiragey, Jowari, Kelomarsi, Chungthangi, Tapre Tulsi, Chapre - cold tolerant types grown up to 1,900m (Anon 1992).

Nagaland

Uraba, Touzmo, Lakokolak, Nguva, Naguvano, Copia, Nkomemei, Hepet, Kera, Azinme, Hapakaime, Phat, Pakaime, Kemenya, Tevurli, Kezikiwamey, Meide.

Tripura

Dharial, Katakatara, Dhumai, Kamansali, Sonamukhi, Latisalt, Gheegaj, Nizersali, Thakurbhog.

Wheat (Triticum aestivum)

Himachal Pradesh

Sheriun, Lalpuri, Tarmosi, Dharmori, Daru, Bhangaru, Chhiti Kanak, Mundal, Mandalu, Badakanak.

UP Hills

Kathi, suitable for hailstorm prone areas; *Misri*, highly cold resistant; *Rigaliya*, tall, thrives amidst weeds in valleys and mid-hills; *Gazariya*, can withstand stormy winds.

Maize (*Zea mays*)

Eastern Himalayas

Poorvi Botapa, Tirapnag-Sahypung, Arun Tepi, Alok Sapa, Manipuri Chujak, Mayong Saah, Asht Samsung, Shyam Nahom, Cachar Gomdhan, Maidani Makka, Teesta Mendi, Silken Tipang Khasi Riewhadem, Mikir Merakku, Nilip Mekop.

Western Himalayas

Tenta, Tedi

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Chapter 19

Factors and Processes behind the Erosion of Crop Genetic Diversity in Nepal

K.D. Joshi, M. Subedi,
K. B. Kadayat and B. R. Sthapit

Nepal, with the great mountain chain of the Himalayas and its associated hill tracts and wide socioeconomic variation, is rich in plant genetic resources of crop species. Nepal lies along the southern slopes of the Himalayas between 80° and 88° E and 26° and 30°N. The altitude range within which crop production takes place is from 70m to as high as 4,000m. The altitude variation has created diverse climatic conditions. Almost all the climatic conditions of the earth are represented within a small geographical distance (Pandey 1987). The diversity in the agroclimatic and sociocultural setting has given rise to a large number of land races of major crops. The existence of oriental and occidental types of barley in the foothills of the Himalayas, of wild relatives of rice at Ajigara lake in Kapilvastu district, and of thousands of local land races of different crop species are evidence of the Genetic Diversity in Nepal (Vavilov 1926; Takahashi et al. 1968, Gupta et al. 1996). Apart from rice and barley, finger millet, grain legumes, and minor crops also have great Genetic Diversity (Upadhyay and Sthapit 1995).

In Nepal 81 per cent of the population still depend on agriculture for their livelihood. The majority are subsistence farmers, practising mixed farming with a range of crops, livestock, and forestry-related production systems. The strategy of traditional farmers centres on harvest security. This itself signifies the importance of agriculture and agricultural biodiversity for farmers in Nepal.

A lot of genetic erosion of biological diversity appears to be taking place in Nepal, and there are reports that extinctions are not only taking place at the variety level but also at the species' level. Over-exploitation of natural habitats, overgrazing, clearing of natural forest in the *Terai*, introduction of new crop varieties, commercialisation of agriculture, and government policies are held responsible for the replacement and/or erosion of indigenous land races in Nepal. However, there are no scientific studies quantifying the extent of genetic erosion *per se*. This paper highlights the processes influencing agrobiodiversity.

Genetic Diversity and Erosion: Some Examples

Rice (Oryza sativa L.)

In Nepal, rice is grown in all agro-ecological zones from the *Terai* (100-300m), through the valleys and foothills (100-1000m), to the high mountains (2,600m). Double cropping of rice ceases at around 900m, and rice reaches its altitudinal limit at 2,600m. Few countries have such a diversity of both cultivated and wild relatives of rice. Nearly 2,500 land races have been identified in Nepal, although some may be duplicates, and many more are yet to be collected (Gupta et al. 1996).

Four wild *oryza* species, namely, *O. nivara, O. rufipogon, O. officinalis*, and *O. granulata*, and two wild relatives of rice, *Leersia hexandra* and *Hygrorrhiza aristata*, have been reported in 13 districts in the *Terai* from the far west to east

Table 19.1: Distribution of Known Aromatic Rice Varieties in Nepal

S. No	Name of the best aromatic rice variety	District	Altitude range (masl)
1.	*Achhame masino*	Chitin	200-800
2.	*Kalo nimak*	Chitin, Rupendehi, Nawalparasi, Bardia	200-400
3.	*Jogini*	Chitwan	200
4.	*Tulsi Prasad*	Nawalparasi	200-1400
5.	*Basmati*	12 districts	200-800
6.	*Manabhog*	Kailali, Dhading, Rasuwa	200-600
7.	*Hans Raj*	Darchula, Bajhang	600-1100
8.	*Pran Piuli*	Sallyan	1200-1400
9.	*Jhinuwa*	Baglung, Parbat, Kaski, Syangja	400-800
10.	*Pahenli*	Sindhupalchok, Ilam, Kaski, Gorkha, Lamjung, Palpa, Bardiya	600-800
11.	*Jetho budho*	Kaski	600-800
12.	*Pokhreli masino*	Solukhumbu, Sankhuwasabha	200-1400
13.	*Kariya kamod*	Saptari, Morang, Dhanusa	<200
14.	*Gauria*	Myagdi, Sankhuwasabha	800-1400
15.	*Kasturi*	Parsa	<200
16.	*Tulsi Prasad*	Parsa, Dhanusa	<200
17.	*Jirasari*	Panchthar	400-600
18.	*Ram Tulsi*	Panchthar	400-600
19.	*Biramphool*	Morang, Kaski	200-800
20.	*Rajbhog*	Kailali	<200
21.	*Chirakhe*	Dhankuta	<1800

(Source: ADO offices)

Nepal (Shrestha and Vaughan 1989). Anonymous (1991) reported that Genetic Diversity has been maintained in the Karnali area because of the specificity of the land races, undisturbed agriculture, and remoteness; whereas the level of genetic erosion was highest in the Kapilvastu and Banke districts.

Five different types of rice culture method are prevalent that are associated with the food culture of local ethnic groups in Nepal. They are early rice, main season rice, high altitude rice, upland rice, and deep water rice. A few case studies of upland, fine grain and aromatic rice are described in the following passages.

Fine Grain and Aromatic Rice

There is a considerable diversity in varieties of aromatic and fine grain rice in Nepal. These types of rice are grown up to 1,850m, but the majority are distributed below 1400m. A total of 102 different rice varieties has been reported by the District Agricultural Development Offices (DADOs) in different districts. Varieties such as *Basmati, Jhinuwa, Jerneli, Kala nimak, Acchame masino, Atemarsi, Kariya kamod, Kalo masino, Gauria, Pokhreli masino, Rajbhog, Tulsiphool, Ekle masino, Kalo masino, Jeerasari, Biramphool, Barhmukhe, Bange, Anami masino,* and *Anadi* were reported from more than one district indicating their wider adaptation.

Joshi et al. (1996) estimated that 57 per cent of aromatic rice land races are of local origin and 29 per cent are improved; 14 per cent were not defined. This study also indicated that some varieties were introduced from Assam, India. A list of the best local rice varieties in Nepal is presented in Table 19.1. Pokhara Valley is known for many high quality rice varieties such as *Pahenle, Jetho Budho, Ramani, Ekle, Biramphool, Jarneli, Manamuri, Rato Anadi, Seto Anadi, Gurdi, Ruduwa, Tulasi, Mansara, Aapjhutte, Jyagdikhole, Bayarni, Gurdi, Khalte Kholo, Nathani/ Bhangere Tauli, Anga, Marshi, Lamjunge Kalo, Masino, Lahare tulsi, Chhote, Gorkhali, Samundraphinj,* and *Jhinuwa*. Even so, the number of farmers reporting varieties of high quality and fine grain rice other than *Jetho Budho, Pahenle,* and *Gurdi* in Pokhara is very low, and the rate of genetic erosion is increasing with the expansion of *Jetho Budho* and with increasing commercial planting of vegetables. Varieties such as *Samundraphinj, Biramphool, Jhinuwa, Bayarni,* and *Ramani* produce high quality aromatic rice but have poor yields, and these are also gradually being replaced by *Masuli, Jetho Budho, or Pahenle* which have higher yields. *Masuli* is exotic and *Pahenle* and *Jetho Budho* are productive local land races. It is commonly thought that exotic varieties tend to replace local varieties. However, the evidence from Pokhara Valley indicates that the best land races will also replace other local varieties. Some land races, such as *Nathani, Khalte Kholo,* and *Biramphool,* could not be found even through *ex situ* conservation at the International Rice Research Institute (IRRI), and they are now believed to be on the verge of extinction. The Genetic Diversity of rice at both household and community levels seems to be decreasing in comparison with the past two to three decades.

Ghaiya

Ghaiya (upland rice) is grown for both grain and straw as the main staple crop on *tars* (ancient river tan); terraced *bari*[1], and newly cleared forest areas in the hills, mainly as a means of subsistence. This crop is important for those farmers of the *Kumal, Darai, Bote, Gurung, Magar, Damai, Kami,* and *Brahmin/ Chhetri* ethnic groups who have little or no *khet* (bounded irrigated land) where paddy rice can be grown. A great diversity of varieties was observed in *Ghaiya* land races, with the level of diversification varying between locations (Subedi et al. 1993). *Ghaiya* is grown in highly stressed environments where rainfall is low and unpredictable. Farmers use totally traditional husbandry practices to grow this crop. Under such conditions, farmers use more varieties as an insurance against natural risks.

The varietal diversity of *Ghaiya* is concentrated on *tar* land at an altitude ranging between 400 and 500m (Figure 19.1). The *tar* land system, in general, maintains more diversity of *ghaiya* varieties than the *bari* system. The reasons are clear. *Bari* can be used to grow other crops, whereas people with *tar* land depend almost totally on *Ghaiya* for their survival. Indigenous groups, such as the *Darai*

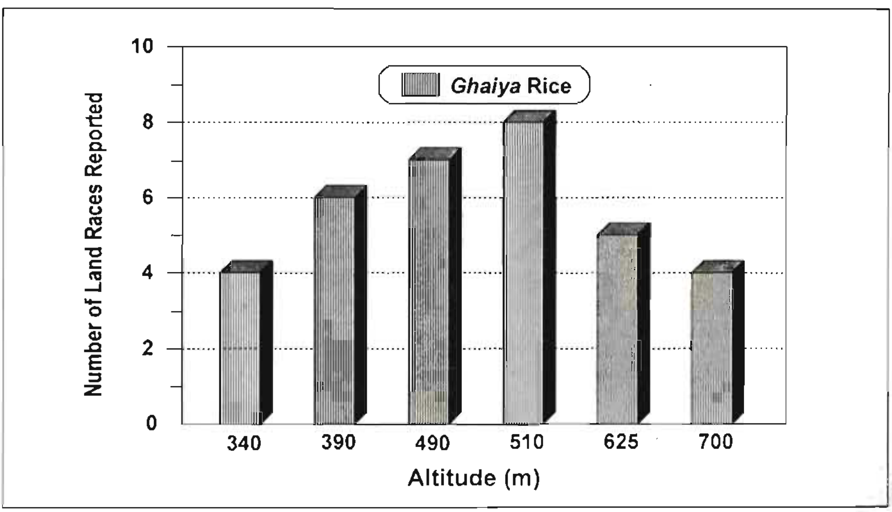

Figure 19.1: Number of Land Races Reported for Ghaiya Rice in the Western Development Region (Source: Subedi et al. 1993)

1 *Upland terraced fields with rainfed irrigation management.*

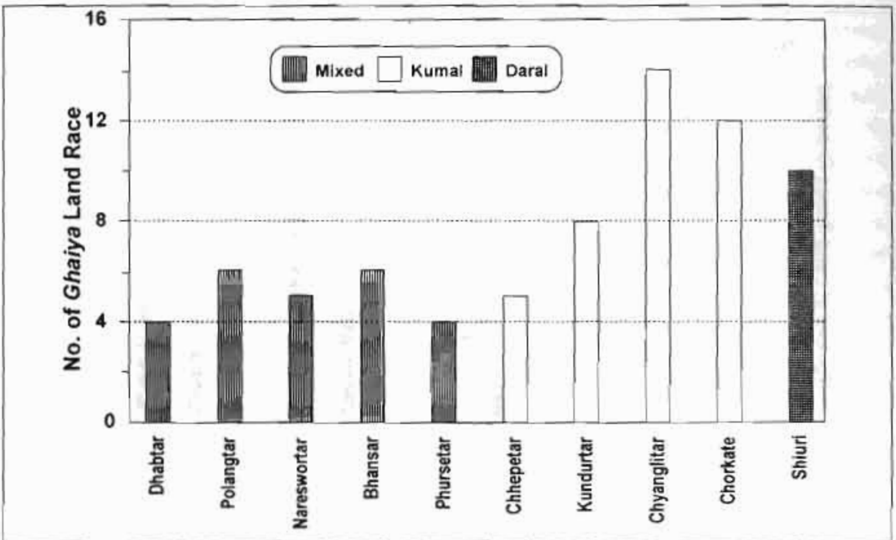

Figure 19.2: Diversity of Ghaiya Rice Maintained by Different Ethnic Groups in the Tar Land-use System of the Western Development Region

and *Kumal,* maintain more land races than mixed communities (Figure 19.2). The majority of farmers maintain at least two varieties with different types of maturity, yield potential, yield stability, adaptation to low fertility, or other important qualities to meet their different needs (Subedi et al. 1993). Some *ghaiya* land races, such as *Pahenle Ghaiya, Bichare, Basmati, Dudhe Marange, Pakhe Masino, Sinduli, Pakhe Sali langre, Jabaka,* and *Charinangre,* have either fine grain or aromatic quality but are low yielding. Because of this farmers are replacing these with high-yielding genotypes.

Barley (Hordeum vulgare L.)

Nepalese barley displays a great variation in qualitative traits. It is argued that a species within its centre of diversity is only highly variable for conspicuous qualitative characteristics, the variation of which is not limited by natural selection (Witcombe and Gilani 1979). The maximum variation is found in awns; ranging from hooded awns, through awnless, to different orientation of awns (Pradhanang and Joshi 1993). Vast areas of traditional land races of barley were replaced by the two-row hulled barley cv. Bonus after its introduction from Sweden in 1975. Though farmers still maintain two land races to avoid risk, varietal diversity is decreasing in several areas in which Bonus is grown. The diversity of covered barley is currently higher than the diversity of naked barley (Figure 19.3).

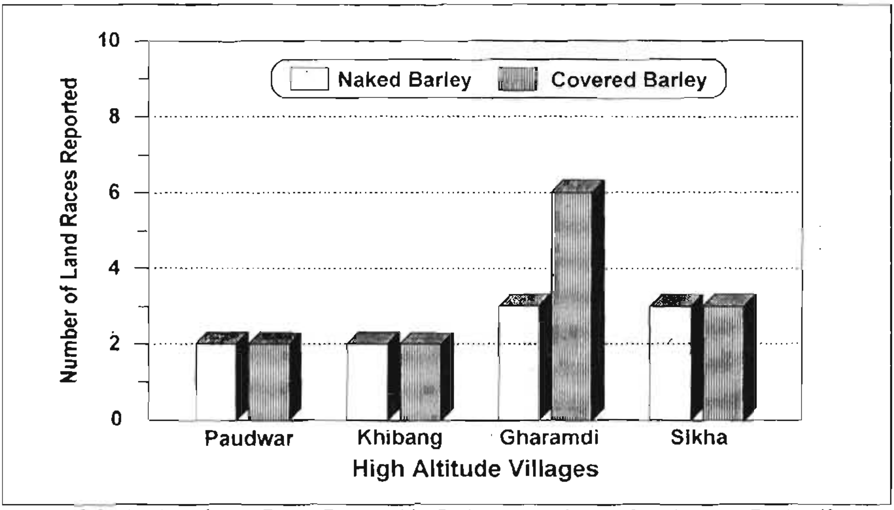

Figure 19.3: Number of Land Races Reported for Barley in the Western Development Region (Source: Pradhanang and Joshi 1993)

Grain Legumes

Traditionally several grain legume species, such as soyabean, black gram, cowpea, pea, common beans, horse gram, faba bean, and rice bean, are grown in hill and mountain farming systems, mainly as a mixed or relay crops, and to some extent on rice bunds.

There is a great variation in varieties, adaptation, growth habit, phonology, productivity, and uses of legume crops. Some legume crops are particularly adapted to low elevations, for example pigeon peas and cowpeas, whereas some, such as common beans, are adapted to higher elevations. However, the majority of legume crops can be grown at different altitudes. There is a diversity among legume crops in terms of photosensitivity. Some varieties of crops are photo-sensitive, whereas others are photo-period neutral. There is a further great diversity in the use of legume crops. Some crops, such as pigeon peas, lentils, and black gram, are grown for the dry bean, while others, such as cowpeas, common beans, and peas, can be grown for both the green pod and the dry bean. Moreover, some legume crops, such as rice beans, soyabeans, and *sesbania*, are also used for manuring fields. But because of the low yield potential and/or poor insect resistance some legume varieties are being lost.

In this paper we present the case of black gram (*Phaseolus mungo*) as an example. Black gram provides the preferred *dal* (curry) of hill people and is the most important grain legume in the *tar* land-use system. Although vernacular names for black gram vary with the location and colour of the grain, the genetic diversity of this crop is limited. It is grown as a secondary crop on marginal lands using residual moisture and fertility and with a minimum of intercultural operations. Therefore, the yield potential of the crop is constrained by environmental stress. The crop is greatly influenced by weather conditions and per unit economic returns are quite low (Sthapit 1990). In recent years the area under black gram has decreased, for two reasons mainly. The first is that, with improvements in irrigation facilities, areas formerly under black gram are taken over by rice or vegetables. The second is that, in unirrigated areas, cowpeas are replacing the black gram crop because farmers can grow a third crop of oil seed rape as a break crop with cowpeas. This is one example in which one species is replacing another for obvious reasons. Replacement of traditionally grown black gram by cowpeas in some parts of the lower hills is an example in which a transformation process is accelerating genetic erosion at the species' level.

Finger millet (Eleusine coracana L. Gaertn)

Finger millet is the fourth major cereal crop in Nepal, but it is considered as *Kuanna* (a low status cereal). It has been grown in highly diverse conditions across Nepal for centuries, and as a result there is a wide variability in the Nepalese finger millet gene pool. The diversity is more concentrated between 900 and 2,400m where over 50 different types of germplasm have been reported, and greater diversity is found in the western to mid-western region of Nepal (Baniya et al. 1992). Rapid Rural Appraisal carried out in a few sites recorded between five and nine different finger millet land races per location.

Nepalese farmers maintain more than two varieties of finger millet for various reasons — including:

- to confer greater yield stability on overall farm production,
- to diversify fodder and food availability,
- to use different varieties for different production systems,
- to adapt to specific edaphic or climatic conditions, and
- because different varieties have different tastes and uses (Subedi 1990).

In the lower hills (300-1000m), late maturing millet, such as Chitwan Local and *Bikase Nala*, is commonly relayed with a long duration improved maize variety. In the middle hills (1,001-2,000m), a number of local millet genotypes are relayed with various maize varieties. They include *Bhalu Kodo, Okhale-1, Kalo Bhunde, Dalle, Nala, Kanchhi Kodo, Bikase Nala, Archaure, Seto Jhapre, Mangsire Urchho, Kirante Kodo, Chitreli Dalle, Deupure Dalle, Bajunge, Bhalu Nala, Seto Urchho, Bhachuwa, Sano Bhachuwa, Mirshali Kodo, Malae Kodo*, and *Juwai or Samdi* Kodo (White). These millet varieties are grown in association with more than ten different maize genotypes (Subedi 1990).

In the higher hills (>2000 masl), millet is rotated in a two-year cycle, and varietal diversity is relatively limited. Land races such as *Dalle, Sano Bhanchuwa, Thulo Bhanchuwa, Bhalu, Chitre Kren, Nala, Okhale-1, Ramcheli, Sano Kodo, Thulo Kodo,* and *Tarali* are some of the millets commonly grown at high altitude.

Green Manure Crops

It is traditional practice in Nepal to use green leaves, twigs, and succulent parts of wild plants as green manure in vegetable and rice nurseries, submerged paddy fields, and as a mulch for potato, turmeric, ginger, and garlic crops. There is no systematic study that documents the number of different plant species that have value as green manure. Eighteen species of plants, most of them wild, are used as green manure in several districts of Nepal's Western Development Region (Sthapit et al. 1988).

Green manures have an increasing appeal as a means of maintaining the level of soil organic matter and reducing soil compaction and erosion while still maintaining economic returns. These factors are vital, particularly in the context of declining soil fertility in the mountain areas of Nepal on both arable land and in fruit orchards (Sthapit et al. 1988, Subedi et al. 1989, Joshi et al. 1994 and 1995). Laboratory analyses and crop performance tests have shown that incorporation of 10 t/ha of biomass of green manure species such as *asuro* (*Adhatoda vasica*) can increase rice yield by nine per cent compared to farmers' normal practices and by 14-49 per cent compared with 60:30:30 N2, P_2O_5 and K_2O/ha. (Sthapit 1990). This implies that farmers' normal practices are also better than NPK fertilizer. These investigations have established the real worth of these organic manures in mountain farming systems. Resource-poor farmers maintain these species with great care.

Farming communities, researchers, and development workers are all aware of the value of these indigenous plant species as green manure, but even so the use of green manure in mountain agriculture is declining. The main constraint to the use of green manure is the scarcity of these species (Joshi et al. 1994).

In the past, when the forest was not too degraded, preferred green manures, such as *ankhitare* (*Walsura trijuga*) and *siplikan* (*Euphorbia royleana*), could be collected from the nearby forest for incorporating in rice fields (Sthapit et al. 1988). Now these resources are so degraded that farmers have to walk a long distance to collect biomass even for nursery beds. Loss of indigenous knowledge about these resources is a serious concern, younger generations cannot even recognise species such as *ankhitare* as the plant has become so rare.

There is a need to promote the growth of these valuable plant species in and around farmlands in order to meet fertility demands. The green manure *asuro* (*Adhatoda vesica*) can be used as a hedge plant and has several other uses apart from being a valuable green manuring plant. There are a few examples in which *asuro* has been planted in mandarin plantations to support orchard fertility.

Causes of Genetic Erosion

No one single cause can be held responsible for genetic erosion. A number of factors independently or in combination may be acting in this process, and variety replacement or erosion is a dynamic process in itself.

Joshi et al. (1995) listed a total of 77 rice varieties grown in the Pokhara Valley until recently. At present only 65 varieties are grown, of which 53 are local and 12 improved varieties. Reports show that 47 local rice varieties have already disappeared from the Pokhara Valley and 14 more are on the verge of extinction (Figure 19.4).

The main reason cited for the disappearance of rice genotypes is the introduction of high-yielding varieties (HYVs), with low shattering, disease resistance, non-lodging, and early maturity, that compare favourably with land races with low yield and late maturity. Some land races have been replaced because they produce poor grain or grain with poor cooking quality, or because they are not suitable for three crop seasons. In many instances, high quality local varieties, such as *Pahenle*

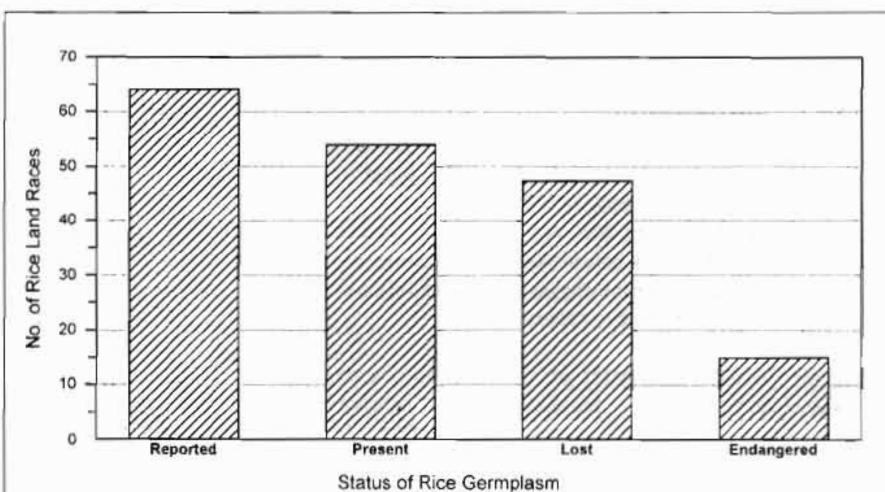

Figure 19.4: Number of Rice Land Races Reported, Presently Grown, Lost and Endangered in Pokhara Valley, 1996

and *Jetho Budho*, are also replacing other high yielding but poor grain quality rices, because they have a higher market price (Joshi et al. 1995). Varietal erosion is also taking place because of the disappearance of specific habitats, for example the marshy areas (*dhab*) needed for *Samundraphinj*, or because of lack of market promotion for high-quality but low-yielding varieties. At present only one farmer is maintaining the *Samundraphinj* variety.

In the past, farmers grew a specific mixture of varieties, known locally as *kaude*, a practice aimed at minimising risk. *Kaude* can be composed of *Aapjhutte* + *Mansara*, *Mansara* + *Tulasi*, *Bhangere* + *Mansara*, or *Jetho Budho* + *Ghaiya*. These varietal mixtures maintained varietal diversity. The farmers found that *kaude* gave better results in marginal conditions. Moreover, *kaude* suffers less infestation of grain moth during storage. The practice was used mainly on marginal land

Box 19.1

Lessons from the Loss of Citrus Land Races of Pokhara Valley, Nepal

Pokhara Valley lies in the middle hills of Nepal in the Western Development Region of the country. The valley was once very famous in Nepal for citrus fruit quality and production, e.g., mandarin, *chaksi*, and, *narayani* (different citrus fruits). In the late sixties, disease killed thousands of citrus trees and resulted in the disappearance of the citrus industry from the valley.

Among the many reasons for the decline of the citrus industry in the Pokhara Valley, the root cause was the mass introduction of citrus planting materials from India in 1960. At that time there were no quarantine regulations in Nepal and many diseases were introduced with this material. The main diseases that caused tree decline were citrus greening disease (CGD), virus and virus like diseases, and fungal diseases (such as foot rot gummosis, root rot, and pink disease). CGD with its active vector citrus psylla (*Diaphorina citri*) devastated the citrus orchards. By the late sixties once highly-valued fruits, such as mandarins, *chaksi*, and *narayani*, had disappeared from the valley.

The disappearance of the citrus industry from Pokhara valley taught a very valuable lesson, that free movement of planting materials could be disastrous and lead to the destruction of valuable indigenous plant genetic resources. In 1972 the Quarantine Act came into force in Nepal. However, this regulation is not strong enough to prevent the transfer of citrus diseases within Nepal and safeguard the livelihood of people dependent on citrus. The main reasons why the regulation is ineffective is that farmers in the villages are not aware of the problem, and local level citrus nurseries are not technically equipped to address it.

Improving local-level awareness and strengthening local citrus nurseries can help to prevent the spread of citrus diseases from one area to another. There is a wide variation in citrus characteristics in Nepal, and the use of local planting materials would also help to conserve these important citrus genetic resources. Local organizations can be given a role to play in this important work. This would help save time and effort in the government sector.

Source: Lama et al. 1996

without irrigation facilities, an environment that is decreasing or disappearing with the improvement in irrigation facilities (Joshi et al. 1996).

The number of land races of *Ghaiya* varieties maintained on-farm is affected not only by the physical environment but also by the sociocultural setting. Aromatic *ghaiya* varieties are no longer grown because of their low-yield potential and lesser tolerance to environmental stress. Such varieties are being replaced by high-yielding local varieties. For example, *ghaiya* varieties, such as *Sindhuli, Charinagre, Pakhe Jhinuwa, and Basmati,* are reported to be disappearing (some may even have become extinct) and the area formally under these varieties is now planted with more widely adopted varieties such as *Chobo, Tauli*, and *Chiuri*.

Local land races of barley are being replaced in areas where Bonus is grown because of the high yield potential, non-lodging, and relatively rust resistant properties of Bonus. In some instances, in recent years, barley has also been replaced by wheat. Local land races are barely used in crop improvement programmes at present.

There is very little research into millet at present, and no adequate efforts aimed at collection, evaluation, or utilisation of local germplasm. Thus the yield potential of finger millet has not been improved in the same way as for other major cereals such as rice, wheat, and maize. One of the main reasons for the erosion of genetic resources of finger millet is its low economic return, which results from the low productivity and high labour requirements. Farmers prefer cultivating rice once irrigation facilities have been established in an area, or they choose cash crops, such as vegetables, which can be marketed.

The Future Implications of On-going Genetic Erosion

Genetic Diversity is important to agriculture for both present and future generations. Farmers are the end users of these diversities. The main concerns of the ordinary farmer are traits of economic importance such as yield and quality. Not all land races are of equal importance to farming communities. Land races deficient in traits of agronomic importance are less likely to be accepted in the community, and farmers may therefore not be interested in maintaining such germplasm as it does not offer them any obvious benefit.

Another issue, which is important, is that the needs of future generations are unpredictable, and conserving Genetic Diversity is necessary. If the immediate needs of farmers are not addressed there will be further erosion or replacement of valuable high quality local land races by medium quality exotic varieties for economic reasons, and the future potential for developing farmer preferred varieties of different crops will be lost for ever. There is a danger that local food security will worsen if these issues are not addressed properly and in time. Often the topics of agrobiodiversity and food security are taken to be opposed to each other. However, in Nepal, most agriculture is still subsistence agriculture, and land races are still used widely. Thus even a small effort made to improve local land races by incorporating at least a few important traits could lead to an increase in output and improve the value of such varieties to the farming community. In this way improvements in food security could be combined with maintaining agrobiodiversity in the form of local land races. In fact there are many such cases (Green 1987; Sthapit et al. 1996), but they need to be studied to demonstrate the economic and social impacts. The need of the hour is to identify some ways and means by which the role of the farming community in conservation and utilisation of agricultural biodiversity can be consolidated. Following the Convention on Biological Diversity of 1992, there is a growing interest among national and international organizations in involving local people in the conservation and utilisation of plant genetic resources. This is one positive step in the process of recognising the role of the community, however, it is not very clear what the best way is of addressing this issue and how the local communities can best be motivated and benefitted. The best approach still needs to be worked out.

While long-term programmes and policies are being developed, there is a need for some immediate action-oriented activities. The first and foremost should be creating awareness among farmers about the situation of our germplasm through such activities as campaigns, meetings, and workshops, and letting farmers know about the present and future importance of plant genetic resources. Traditional land races usually differ in morphological characteristics, and in many cases names of varieties are often related either to the place of origin or the name of the person who made the introduction. The real worth of land races that are known by several different names has not been assessed. It is essential that the real worth of different crop varieties is studied so that their value can be identified and the local community made aware of the importance of such resources. This would be a logical option for making conservation and the use of plant genetic resources attractive to the farming community. Crop varieties that are on the verge of extinction should be collected, rejuvenated, multiplied, and reintroduced into the farming system. Promotion of highly valuable green manure species, such as *asuro*, at the farm level is one of the types of activity needing the attention of organizations at the grassroots' level. Conservation and development-oriented agencies in the country should set a priority agenda for developing an operational framework and calculating resource needs so that these activities can be carried out.

Conclusion

The real worth of agrobiodiversity cannot be realised by the farming community unless such biowealth is converted into income-generating enterprises by identifying and adding value. The potential benefit from these resources has not been exploited in Nepal because of the lack of institutional and financial capabilities. However, there is continuing erosion of genetic resources in the country which will have serious implications for both present and future agricultural productivity unless it is attended to properly in time. There is a need to understand local farming systems, the needs and aspirations of farmers, and the value of biowealth for improving such things as yield and product quality. Consolidating the role of farmers in the conservation and utilisation of plant genetic resources seems to be the most appropriate and sustainable way of managing these resources.

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Chapter 20

Gene Pools of Crop Land Races in Nepal and Threats

M.P. Upadhayay

Nepal possesses a rich diversity of fauna and flora. The fauna of the country includes 175 species of mammal, 850 species of bird, 180 species of fish, 640 species of butterfly, 143 species of moth, and 180 species of dragonfly. Similarly, the diversity in flora is represented by 35 different types of forest, 6,500 flowering plants, 1,500 species of fungi, and 350 species of lichen. The native diversity is further shown by the occurrence of 370 endemic species and 700 species with medicinal properties (Anonymous 1993). The information on lower plants, such as liverworts, algae, fungi, and lichens, is still inadequate. Although the country represents only 0.03 per cent of the total land in the world, it contains approximately two per cent of the world's biodiversity in flowering plants (Ryman 1992).

The conditions of diverse agroclimatic environments with complex and varied farming systems, a broad mixture of ethnicity and races, varied socioeconomic settings, big differences in altitude, and complex topography have created an array of micro-niches in the country in which several food and agricultural crop species have evolved and maintained a high level of diversity. There are estimated to be more than 500 edible species, of which 200 species are cultivated (Regmi 1994). Among the food grains, rice, finger millet, rice beans, barley, and minor crops have a greater Genetic Diversity. Diversity is also found in fruit and vegetable crops. About 120 species of wild relatives of cultivated crops are also found, adding an additional dimension to the variability.

Biological Wealth

Foods:	Rice, maize, wheat, finger millet, pigeon peas, chickpeas, lentils, soybeans, rice beans, rape and mustard, potatoes, tomatoes, cowpeas, cauliflowers, cabbages, squashes, onions, yams, taro, bananas, oranges, mangos, sugarcane
Fodder Plants:	Desmodium, Medicago, Melilotus, Trifolium, Echinochloa, Ficus, Bauhinia
Ornamental Plants:	Anthrocephalus, Ficus, Nyctanthes, Jasminum, Erythrina, Delonix
Medicinal Plants:	Azadirachta, Rauwolfia, Ocimum, Atropa, Swertia, Nardostachys, Centella
Fibre Plants:	Eulaliopsis, Diospyros, Corchorus, Gossypium, Crotalaria, Phyllanthus
Timber Plants:	Shorea, Pterocarpus, Artocarpus, Adina
Pesticides:	Azadirachta, Artemisia, Vitex, Annona, Blumea
Dyes and Tannins:	Acacia, Butea, Erythrina, Mallotus, Symploca, Terminalia.

Threats to Plant Genetic Resources

The threat to biodiversity has been realised by His Majesty's Government and, as a result, all orchids and medicinal plants, 27 mammals, nine birds and three reptiles have been declared protected species. The depletion of genetic resources in food and agricultural crop species is clearly visible in the *Terai* and mid-hills where improved agricultural technologies are popular among farmers. A gradual disappearance of land races/plant species can be observed in all the following.

- Land races of crops such as rice, maize, wheat, cabbage, cauliflower, cowpea, and potato

- *Native cultivated species such* as Paspalum scorbuculatum, Vigna angularis, Lathyrus sativus, Setaria italica, *and* Panicum miliare

- Related wild species of cultivated crops

- *Medicinal plants such as* Cinamonum, Cordiceps, Dactylorhiza, Nardostachys, Rauwolfia, *and* Valeriana

- *Forest trees such as* Shorea, Cedrela, Elaeocarpus, Larix, Magnolia, *and* Rhododendron

Issues Related to Plant Genetic Resources (PGR)

PGR are considered to be the common heritage of mankind, although the Convention on Biological Diversity in 1992 affirms that states possess sovereign rights to the valuable resources; i.e., these are a part of the national heritage of a country. The change in status of genetic resources has raised several issues at national and international levels. The general issues of interest for Nepal are listed below.

- National legislation for access to genetic resources/exchange of germplasm for environmental use

- Management of an international fund for PGR (capacity building)

- Sharing of benefits (local communities/national level)

- Recognition of intellectual property rights/plant breeders' rights/farmers' rights (related to public vs. private sector investment)

- *National PGR system (wildlife protected areas vs. PGR conservation,* in situ *vs.* ex situ *conservation, and conservation vs. utilisation)*

- Breeding is a responsibility for conservation (government, non-governmental organizations, international agricultural research centres, and farmers)

Nepalese Scenario for Plant Genetic Resource/Conservation

- A Plant Genetic Resource Unit (PGRU) was established for food crops in 1984 at the Agricultural Botany Division of the Nepal Agricultural Research Council (NARC), Khumaltar. Collection and evaluation of vegetables commenced in 1972 before the establishment of the Plant Genetic Resources' Unit (PGRU) with the establishment of a Vegetable Development Division. Fruit germplasm has been maintained at 19 agricultural research centres and farms under the NARC and Department of Agriculture (DOA) since the 1960s.

- A Department of Plant Resources (formerly known as the Department of Medicinal Plants, Department of Forestry and Plant Resources) was institutionalised within the Ministry of Forest and Soil Conservation. It is responsible for the countrywide survey and documentation of Nepalese flora at the National Herbarium, Godawari. Medicinal plant species are conserved in situ in ten National Parks and Wildlife Reserves in the country.

- To date, a total of 11 systematic plant exploration missions have been undertaken in Nepal in collaboration with international institutes. The first exploration was carried out in 1938, the most recent one was carried out in 1993.

- A total of 9,124 accessions of cereals, grain legumes, oil seeds, vegetables, and industrial and spice crops are preserved ex situ (Gupta et al. 1996). A total of 6,123 accessions of different crop species from Nepal are conserved at International Agricultural Research Centres, the National Institute of Agrobiological Resources, Japan, and the United States Department of Agriculture, U.S.A.

- Seven hundred and thirteen finger-millet, 680 rice, 322 barley, 216 soybean, 184 buckwheat, 146 lentil, and 35 faba bean species have been characterised.

- One rice, 11 vegetable, five grain legume and two finger millet land races have been released. Commodities' programmes with access to germplasm held at the Consultative Group on International Agricultural Research (CGIAR) have only used land races on a limited scale. Only rice, maize, and wheat breeding programmes have used land races as a parent. The potential of land races has yet to be fully exploited.

- Forest resources are protected by legal arrangements in the Nationalisation of Forests' Act (1956). Decentralization of forest resources was introduced in 1978 by transferring ownership to communities. About 14 per cent of the country's total area is protected by the National Parks and Wildlife Conservation Project.

- There is a rich diversity of medicinal and aromatic plants, and this is particularly high in the mountains of the Far-Western Development Region of Nepal. Twenty species are well-known in trade and another 20 species to a lesser extent. Seven species are listed as endangered species as a result of over-exploitation by farmer traders. The Jatamasi (Nardostachys grandiflora) is on the verge of extinction.

- Nepal has adopted Agenda 21 of the United Nations Conference on Environment and Development.

- A biodiversity profile project has been initiated to assess the state of forest biodiversity.

- Two workshops related to the Convention on Biological Diversity were organized by NARC: Conservation, Use and Management of PGR (November 1994) and Appropriate Policy in PGR (April 1995).

- A biodiversity action plan and PGR conservation projects are being developed.

- Nepal is a new member of the FAO Commission on PGR established to discuss issues related to PGR conservation, use, and management in an international forum.

General Considerations

Safeguarding crop germplasm must receive high priority. The management, use, and conservation of these valuable resources require a commitment at policy and scientific levels to ensure their safety and maintenance in order to meet both current needs and the expectations of future generations. Nepal needs to:

- develop a PGR system to suit the needs of the country;

- evolve national legislation on the exchange and accessibility of germplasm to restrict uncontrolled movement of germplasm;

- harmonise Intellectual Property Rights (IPR), Plant Breeders' Rights (PBR), and farmers' rights to improve cooperation with developed and friendly countries to attract investment for strengthening on-farm conservation of crop genetic resources through *in situ* and *ex situ* approaches;

- encourage farmers and non-government organizations to play a role as well as introducing and supporting participatory approaches in the mainstream of PGR conservation; and

- increase participation in international efforts by such bodies as IPGRI, IARC, IUCN, WWF, and the FAO Commission on PGR.

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Chapter 21

Indigenous Horticultural[1] Crops of the Indian Himalayas

B. D. Joshi

Horticulture, which includes vegetables as well as fruit species, covers a wide diversity of crops such as fruits, vegetables, root and tuber crops, spices and condiments, medicinal and aromatic plants, and ornamental plants. The relevance of these crops to the agricultural economy is becoming evident with strong shifts towards diversification of agriculture in favour of horticultural crops.

The Genetic Diversity of horticultural crops is well represented in India, which is a centre of diversity. Arora and Nayar (1984) have listed 66 genera in fruits, vegetables, and spices and condiments comprising 899 species, of which 190 species have economic importance (109 fruits, 54 vegetables, and 27 spices and condiments). The highest concentration of the wild relatives of fruits, vegetables, spices, and condiments is found in the northeastern region, followed by the western Himalayas.

In the northeastern Himalayas diversity is found in fruits such as citrus, mango, and banana (Arora and Nayar 1984, Ghosh 1984). *Citrus lemon, C. medica, C. jambhiri, C. ichengensis, C. latipes, C. macroptera, C. assamensis, C. indica* and *C. aurantium* are indigenous to this region. The Indian wild orange, *C. indica*, is native to the Naga Hills, the Garo Hills of Meghalaya, and the Kaziranga forests in Assam. The wild forms of *Mangifera indica* and its allied species, *M. sylvastica*, also occur in the forests of this region and there is a rich diversity in *Musa, Pyrus, Sorbus, Rubus, Ribes* and *Prunus* (Box 21.1). The Shillong plateau of the Khasi

1 *Horticulture, as used here, does not refer to gardening — its correct definition in English. It rather refers to cultivation of vegetables, fruits, and others as cash crops.*

Box 21.1

Popular HYVs of Vegetables in the Indian Himalayas

Vegetable	Varieties
Egg plant	Pusa Purple Long, Pusa Purple Cluster
Cabbage	Pusa Drum Head, Golden Acre
Cauliflower	Pusa Snowball-1, Pusa Snowball K-1
Okra (lady finger)	Pusa Makhani, Perkin's Long Green
Spinach	Virgina Savoy, Australian Green
Capsicum	California Wonder, Yolowonder
French bean	Pusa Parvati, Contender
Onion	Brown Spanish
Tomato	Roma, Sioux, Best of All, Marglobe
Radish	Pusa Himani, Japanese White, Tipped
Turnip	Pusa Swarnima, Pusa Chandrima, Purple Top, White Globe
Pea	Early Giant, Lincoln
Palak	Pusa Harit
Carrot	Pusa Yamdagini
Garden beet	Crimson Globe, Detroit Dak Red

Hills in Meghalaya has many *Prunus, Sorbus, Pyrus,* and *Cydonia* species. There is a sizeable variability in vegetable and tuber crops such as *Alocasia, Abelmoschus, Amorphophallus, Colocasia, Dioscorea, Luffa, Cucumis,* and *Tricosanthus* in different parts of the region. *Alpinia speciosa, A. glauca, Amonum aromaticum, Curcuma zeodoaria, C. amada, Zingiber officinale, Piper longum,* and *P. peepuloides* are the main species of spices and condiments. The region is home to several species of medicinal plants, the most important being species of *Berberis, Cassia, Coptis, Gynocardia, Litsea, Paedesa,* and *Solanum.*

The northwestern Himalayas also have a rich diversity of fruits such as *Pyrus, Prunus, Sorbus, Malus, Rubus, Ribes, Hippophae, Holboellia, Juglans, Corylus, Myrica, Lonicera,* and *Vibernum* (Randhawa 1987, Joshi and Rana 1994, Negi and Gaur 1994). Other wild and semi-domesticated fruits found here include *Zizyphus, Citrus, Ficus, Morus, Aesandra,* and *Emblica*. Vegetable and tuber crops reported include diverse land races of pumpkin, bottle gourd, snake gourd, ridge gourd, bitter gourd, sweet gourd, peas, *Vicia,* and tomato, as well as different types of leafy vegetables such as *Brassicae*, spinach, and fenugreek. Amaranth, buckwheats, and chenopods are maintained by mountain farmers. Farmers also maintain a variety of land races of potato, *Colocasia*, ginger, *Dioscorea*, and turmeric. There is a range of diversity in medicinal plants such as *Aconitum, Podophyllum, Taxus, Gentiana, Swertia, Rheum, Saussurea, Inula, Nardostachys, Ephedra, Potentila, Berberis, Artimissia, Onosma, Carum, Picrorhiza,* and *Mucuna*. Ornamental diversity is represented by *Rosa, Rhododendron, Gerbera, Bergenia, Hypericum, Anemon, Impatiens, Acer, Primula, Ilex, Woodfordia, Lonicera, Buddlia*, and *Gloriosa*.

Fruit Diversity in the Himalayas

Overall the Himalayas are endowed with a wide range of diversity in fruit plants (Box 21.2). They include *Malus* (4), *M. baccata, M. sikkimensis; M. baccata var. hinalaina; dirangensis, P. pashia var.kumaoni, P. communis, P. khasiana, P. pyrifolia, P. polycarpa, P. griffthi, P. thomsoni, and P. Jacumontiana; Sorbus (10) S. insignis, S. foliolosa, S. microphylla, S. acuparia, S. cuspidata, S. ursina, S. verrucosa, S. granulosa, S. lantana, and S. rhamnoides; Prunus (13), P. cerasoides, P. armeniaca, P. persica, P. rufa, P. cornuta, P. salicina, P. nepaulensis, P. Jenkensii, P. wallichi, P. jacumontiana, P. prostrata, P. tomentosa, P. sp. (Behmi), and wild cherry; Cotoneaster (8), C. bacillaris, C. multiflora, C. Microphylla, C. accuminata, C. frigada, C. rotundifolia, C. nummularia, and C. vulgaris; Crataegys (2), C. Crenulata and C. oxycantha; Ficus (8), F. carica, F. hispida, F. nemoralis, F. odorta, F. cunix, F.foeolata, F. palmata, and F. rumphii; Vitis (5), V. lanata, V. parviflora, V. himalayana, V. divaricata, and V. capreolata; Viburnum (5), V. corianum, V. corianum, V. cotnifolium, V. foetens, V. lanata, and V. stettulatum; Rubus (19), R. niveus, R. paniculata, R. biflorus, R. lasiocarpus, R. macilentus, R. calcinus, R. accuminatus, R. hexagynus, R. hamiltoni, R. assamensis, R. insignis, R. ferox, R. moluccans, R. birmanicus, R. lucens, R. biflorus, R. opulifolius, R. lasiocarpus, and R. rosaefolius; Ribes (3), R. glaciale, R. nigrum, and R. rubrum; Fragarua (3), F. indica, F. nilgerrensis, and F. vesca; Myrica (3), M. nagi, M. hookerina, and M. farquhariana; Docynica (2), D. indica and D. hookerina; Elaegnus (3), E. conferta, E. latifolia, and E. umbellata; Hippophae (2), H. rhamnoides and H. salcifolia; Persea edulis; Corylus (2), C. avellana and C. macrophylla; C. oblonga and C. mas; Zizyphus (3), Z. jujuba, Z. oxyphylla and Z. vulgaris; Actinidia* (2), *A. callosa and A. strigosa; Emblica (2), E. officinalis and E. urinaria;* and a number of accessions including elite material in pomegranate, walnut, *Prunus, Pyrus, Pinus gerardiana,* and *Rosa (3), R. macrophylla, R. serice,a and R. moschata.*

Some pockets of the Himalayas maintain useful temperate fruits and their wild relatives. For example *Prunus prostrat* and *Prunus tomentosa* are restricted to Kinnaur in Himachal: *Prunus cornuta* occurs in the higher reaches of the Shimla hills, specifically at the two sites of Narkhanda and Khadrala. *Malus baccata* is also found in Kinnaur and in the Rohru area of Himachal Pradesh. It is known locally as *dhak* and in Kinnaur farmers use it as a root stock for apples cv. such as Royal. *Malus sikkimensis* occurs in the Lachun and Lachung areas of North Sikkim. *Pyrus communis* is planted widely by Western Himalayan farmers, mostly in Kashmir. *P. kumaoni* is localised in the Kinnaur (Kochli, Powari) hills, *Pyrus jacumontiana* is confined to the Shimla and Uttarakhand, and *P. pyrifolia, Pyrus khasiana,* and *Pyrus thomsoni* are confined to northeastern Himalayan regions. *Rubus* species also have a special distribution pattern; *R. fruiticosa* is confined to the western Himalayas and *R. ineatus* to the northeastern Himalayan

Box 21.2

Plants of Minor Fruits in the Indian Himalayas

S. N.	Botanical Name	Altitude	Places Collected
1	*Prunus undulata*	1000-1900	Khasi hills, Meghalaya
2	*Prunus jenkinsii*	< 900	Sibsagar, Assam
3	*Prunus accuminata*	700-1500	Khasi hills and Goalp
4	*Prunus punctata*	1200-1500	Khasi hills, Meghalaya
5	*Prunus rufa*	200-3500	Sikkim
6	*Prunus jacquimontii*	2000-3000	Kinnaur, Himachal
7	*Pyrus vestita*	1500-1600	Khasi and Jiantia hills
8	*Pyrus khasiana*	1300-1500	Khasi and Jiantia hills
9	*Pyrus granulosa*	1500-1800	Khasi hills
10	*Pyrus cuspidata*	1200-1400	Khasi and Jiantia hills
11	*Fragaria indica*	2500	Mashobra, Shimla
12	*Fragaria vesca*	2800	Pangi, Chamba
13	*Fragaria nilgerrensis*	1000-1500	Khasi hills
14	*Juglans regia*	2800	Pangi, Chamba
15	*Myrica nagi*	1500-200	Shimla
16	*Myrica farquhariana*	1200-1500	Khasi hills
17	*Myrica hookeriana*	1200-1500	Khasi hills
18	*Ribes glaciale*	2100-3500	Hatoo peak, Shimla
19	*Ribes nigrum*	2100-3500	Hatoo peak, Shimla
20	*Ribes rubrum*	2500-3500	Narkanda, Shimla
21	*Rubus niveus*	1800-3000	Shimla
22	*Ribus paniculatus*	900-2100	Glen, Shimla
23	*Rubus biflorus*	2100-2700	Shimla
24	*Rubus lasiocarpus*	2000-3000	Shimla
25	*Rubus macilentus*	600-2100	Mashobra, Shimla
26	*Rubus calcinus*	1300-1700	Cherrapunji, Sohrar
27	*Rubus accunminatus*	1300-1800	Khasi hills
28	*Rubus hexagynus*	up to 1300	Upper Assam and Garo hills
29	*Rubus hamiltoni*	1000-1500	Khasi hills
30	*Rubus assamensis*	1500-1800	Khasi hills
31	*Rubus insignis*	1100-1500	Assam and Khasi hills
32	*Rubus ferox*	1200-1500	Khasi hills
33	*Rubus moluccans*	< 1950	Assam
34	*Rubus birmanicus*	1500-2000	Khasi and Gari hills
35	*Rubus lucens*	900-1200	Khasi hills and N. Assam
36	*Rubus biflorus*	1600-1950	Khasi and Jiantia hills
37	*Rubus opulifolius*	1600-1950	Khasi hills
38	*Rubus lasiocarpus*	700-1950	Assam and Meghalaya
39	*Rubus rosaefolius*	900-1800	Upper Assam & Meghalaya
40	*Docynia indica*	1000-1500	Khasi hills
41	*Elaegnus conferta*	1400-1800	Jeori, Shimla

Box 21.2

Plants of Minor Fruits in the Indian Himalayas (Cont'd)

S. N.	Botanical Name	Altitude	Places Collected
42	*Elaegnus umbellata*	1000-1200	Jeori, Shimla
43	*Elaegnus latifolia*	3400-3800	Khasi hills
44	*Hippophae rhamnoides*	2800-3000	Chitkool, Kinnaur
45	*Hippophae salicifolia\Vitis lanata*	1400-1800	Sangala, Kinnaur
46	*Vitis parvifolia*	900-1800	Jeori, Shimla
47	*Vitis himalayana*	1800-3100	Hatkoti, Shimla
48	*Vitis divaricata*	1200-2100	Hatkoti, Shimla
49	*Vitis capreolata*	1200-2100	Mashobra, Shimla
50	*Cornus macrophylla*	1500-2000	Mashobra, Shimla
51	*Cornus oblonga*	1200-2400	Mashobra, Shimla
52	*Cornus capitata*	900-2100	Narkanda, Shimla
53	*Viburnum cotnifolium*	1800-3300	Hatoo, Shimla
54	*Viburnum coriaceum*	1200-3600	Raksham, Kinnaur
55	*Viburnum nervosum*	2500-3000	Summerhill, Shimla
56	*Viburnum mullaha*	2500-3000	Narkanda, Shimla
57	*Viburnum stellulatum*	1800-3300	Bahli, Shimla
58	*Viburnum foetens*	2800-3000	Mahasu, Shimla
59	*Sambucus nigra*	2300-2700	Narkanda, Shimla
60	*Zizyphus jujuba*	1400-2100	Nichar, Kinnaur
61	*Zizyphus oxyphylla*	300-2100	Shimla
62	*Pistacia integerimma*	600-2400	Shimla
63	*Flacourtia sapida*	900-1200	Shimla
64	*Flacourtia cataphracta*	1000-1500	Sunni, Shimla
65	*Olea cuspidata*	1200-1800	U. P. Hills
66	*Olea glandulifera*	1000-1500	Shimla
67	*Phyllanthus fraternus*	500-900	Basantpur, Shimla
68	*Phyllanthus urinaria*	500-1000	Sunni, Shimla
69	*Cotoneaster affinis*	1200-1500	Shimla
70	*Cotoneaster aitchisonii*	2700	Mashobra, Shimla
71	*Cotoneaster obtuse*	3000	Kilba, Lahaul
72	*Cotoneaster prostratus*	3200	Shimla
73	*Cotoneaster rosea*	2900	Kalpa, Kinnaur
74	*Cotoneaster simonsii*	1000-1600	Chini, Kinnaur
75	*Eriobotrya bengalensis*	1300-1650	Khasi hills
76	*Eriobotrya japonica*	1300-1500	Assam and Meghalaya
77	*Eriobotrya angustissima*	1300-1500	Assam and Meghalaya
78	*Sorbus insignis*	2150	Assam and Meghalaya
79	*Sorbus foliolosa*	3000-3800	Tiger hill, Darjeeling
80	*Sorbus microphylla*	3000-3800	Sandakpu, Darjeeling
81	*Sorbus ursina*	3000-3800	Sandakpu, Darjeeling
82	*Sorbus granulosa*	1500-2000	Sandakpu, Darjeeling

Box 21.2

Plants of Minor Fruits in the Indian Himalayas (Cont'd)

S. N.	Botanical Name	Altitude	Places Collected
83	*Sorbus acuparia*	3000-4000	Cherrapunji
84	*Corylus avellana*	3500-4000	Koksar, H. P.
85	*Corylus columa*	3500-4000	Pangi and Satl???.
86	*Berberis vulgaris*	2500-3500	Pangi and Satl???
87	*Berberis brachybotrys*	2800	Narkanda, Shimla
88	*Berberis aristata*	1800-2200	Shimla
89	*Berberis coriania*	2200-3100	Sarahan, Shimla
90	*Berberis hycium*	900-2800	Narkanda, Shimla
91	*Berberis chitria*	2500-3000	Shimla
92	*Berberis edgeworthiana*	2700	Kotgarh, Shimla
93	*Berberis jaeschkeana*	3000	Bagi
94	*Berberis kunawarensis*	2800-2900	Chitkool, Kinnaur
95	*Berberis lycium*	2500-3000	Kalpa, Kinnaur
96	*Berberis lycium var. fascicularis*	2800	Narkanda, Shimla
97	*Berberis pachyacantha*	2500	Jeori, Shimla
98	*Berberis umbellata*	3000	Matiana, Shimla
99	*Berberis zabeliana*	2900	Sangla, Kinnaur
100	*Schisandra grandiflora*	1500-300	Narkanda, Shimla
101	*Dillenia indica*	up to 1200	U. P. hills
102	*Miliusa velutina*	up to 500	U. P. hills
103	*Holboellia latifolia*	1500-3000	U. P. hills
104	*Podophyllum hexandrum*	3000-4500	U. P. hills
105	*Capparis zeylanica*	*????*	U. P. hills
106	*Saussauria nepaulensis*	1500-2000	U. P. hills
107	*Shorea robusta*	up to 1200	U. P. hills
108	*Grewia optiva*	up to 1500	U. P. hills
109	*Glycosmis cochinchinensis*	1200	U. P. hills
110	*Zanthoxylum armatum*	up to1500	U. P. hills
111	*Picrasma quassioides*	2000-3000	U. P. hills
112	*Garuga pinnata*	up to 1200	U. P. hills
113	*Olax nana*	up to 1500	U. P. hills
114	*Streblus asper*	up to 1200	U. P. hills
115	*Ficus auriculata*	up to 1500	U. P. hills
116	*Morus serrata*	1200-2000	U. P. hills
117	*Artocarpus lakoocha*	up to 1200	U. P. hills
118	*Corylus jacquimontii*	2500-3000	U. P. hills
119	*Castanopsis tribuloides*	900-2500	U. P. hills
120	*Pinus gerardiana*	2000-4500	Kinnaur, H. P.
121	*Ephedra gerardiana*	3500-4500	U. P. hills and H. P.
122	*Taxus wallichiana*	2000-3500	U. P. hills and H. P.
123	*Calamus tenuis*	up to 2000	U. P. hills

Box 21.2

Plants of Minor Fruits in the Indian Himalayas (Cont'd)

S. N.	Botanical Name	Altitude	Places Collected
124	*Phoenix acaulis*	up to 2000	U. P. hills
125	*Celastrus paniculatus*	up to 2000	U. P. hills
126	*Sageretia thea*	up to 3000	U. P. hills
127	*Ampelocissus latifolia*	up to 1800	U. P. hills
128	*Leea crispa*	up to 1200	U. P. hills
129	*Schleichera oleosa*	up to 1000	U. P. hills
130	*Rhus javanica*	900-2800	U. P. hills
131	*Rhus parvifllora*	500-1300	U. P. hills
132	*Spondias pinnata*	up to 1500	U. P. hills
133	*Coriaria nepaulensis*	1500-2500	U. P. hills
134	*Duchesnea indica*	600-1500	U. P. hills
135	*Fragaria rubicola*	2000-4000	U. P. hills
136	*Stranvaesia nussia*	up to 1500	U. P. hills
137	*Ribes alpestre*	2000-3500	U. P. hills
138	*Careya arborea*	up to 1500	U. P. hills
139	*Melothrina heterophylla*	1500-2500	U. P. hills
140	*Mukia maderaspatana*	up to 1800	U. P. hills
141	*Angelia glauca*	2500-3500	U. P. hills
142	*Dendrobenthamia capitata*	1000-2500	U. P. hills
143	*Lonicera augustifolia*	2500-3500	U. P. hills
144	*Catunaregum spinosa*	up to 1500	U. P. hills
145	*Gardenia turgida*	up to 1200	U. P. hills
146	*Pavetta tomentosa*	up to 1200	U. P. hills
147	*Rubia manjith*	up to 3000	U. P. hills
148	*Gaultheria trichophylla*	1500-3000	U. P. hills
149	*Ardisia floribunda*	up to 1500	U. P. hills
150	*Maesa argentia*	600-2100	U. P. hills
151	*Aesandra butyracea*	300-1500	U. P. hills
152	*Diospyrus tomentosa*	utp 900	U. P. hills
153	*Carissa opaca*	up to 1800	U. P. hills
154	*Ehretia acuminata*	up to 200	U. P. hills
155	*Erycibe paniculata*	up to 1200	U. P. hills
156	*Physalis minima*	up to 2000	U. P. hills
157	*Withania somnifera*	up to 900	U. P. hills
158	*Callicarpa microphylla*	600-1500	U. P. hills
159	*Gmelina arborea*	up to 1200	U. P. hills
160	*Scurrula cordifolia*	300-2000	U. P. hills
161	*Bridelia retusa*	up to 1200	U. P. hills
162	*Debregeasia longifolia*	600-2000	U. P. hills

region; whereas *R. lanatus, R. lasiocarpus, R. moluccans, R. niveus,* and *R. reticulatus* are widespread in the Himalayas. *Corylus* is restricted to North Sikkim and the Darjeeling district of West Bengal. Similarly, *Prunus rufa* seems to be endemic, but is confined to the Tonglu and Sandakpur areas of Darjeeling only. *Prunus prostrata, P. tomentosa, P. spp (Behmi), and Prunus jacumontiana* are endemic to cold dry zone areas in Kinnaur and Ladakh. *Sorbus microphylla, S. ursina, S. insignis, and S. foliolosa* are confined to the Darjeeling hills, *S. acuparia* to Koksar Vlue valley, and *S. lanata* to Khadrala, the Shimla hills, Pangi Valley and the Munshiyari area of Pithoragarh (Joshi and Rana 1994). *Sorbus verrucosa* and *S. granulosa* seem to be endemic in the Cherrapunji hills of Meghalaya. The wild germplasms of temperate fruits resistant to various diseases prevalent in the Himalayas are listed in (Table 21.1). The exotic germplasms introduced, evaluated, and conserved in the field gene bank in Shimla are listed in Table 21.2

The populations of wild relatives and land races of temperate fruits endemic in the Himalayas are potential resources of genes for resistance to drought, cold, frost, and hailstorms. These species do not have any patronage for protection in the forests and some of them can only be saved now through ex *situ* conservation.

Table 21.1: Diversity through Introduction: Current Cultivars of Major Fruits in the Himalayas

Fruit	Varieties	Remarks
Apples	Tydeman's Worcester, Golden Delicious, Red Gold, Stark of Pippins, Early Shan Burry	Delicious, Mcintosh, Rymer
Pears	Max Red Bartlett, Flemish Beauty, Kieffer, Hardy, Gola	
Peaches	Elberta, Red Top, Candor, Flordasun, Red Haren, Kanto-5	Supplement apples in farm economy
Plums	Greengage, Santa Rosa, Golden Drop, Starking Delicious	
Apricots	*New Castte*, Charmagz, Nugget, Royal, Sakarpara, Saffaida, Shipley Early	Has a specific niche in the middle hills of the Himalayas
Cherries	Stella, Merton, Napolean, Sun Burst, Bing, Star, Royal Ann, Compact Stella	Important crop in some pockets
Pomegranates	Bedana, Kandhari, Muskat White	
Grapes	Thompson Seedless, Kali Sahebi, Katta Anab-e-Shahi	
Kiwi Fruit	Allison, Bruno, Hayward, Monty, Abbott	
Strawberries	Gilbert, Gorella, Polka, Canoga, Belrubi, Arking	
Almonds	Non-Pareil, Drake, Ne-Plus-Ultra, California Paper Shell, Dhebar	Promising, but yet to become popular with farmers
Walnuts	Hartley, Lake English, Payne, Pedro	
Pacan	Mahan, Desirable, Nellis, and Stuart	Valuable crop for Kashmir farmers

Table 21.2: Source of Disease Resistance in Some Wild Relatives of Temperate Fruit Germplasm

Name of Species	Resistance to	Natural Habitat
Malus baccata var. himalaica	Collor rot (CR), root rot, and wooly aphis	Jahlma, Lahaul Valley (3000 m) Himachal
sikkimensis	Powdery mildew and CR	Lachun, Sikkim (1970m)
Pyrus jacumontiana	Powdery mildew (PM)	Powari, Kinnaur (3500m) Himachal
Pyrus polycarpa	PM and fire blight	Sohriram, Meghalaya (1455 m)
Prunus cerasoides	PM	Shimla (1700m) Himachal
Prunus salicina	PM	Shimla (1700m) Himachal
Prunus spp. (Behmi)	PM	Kinnaur (3-70m) Himachal
Prunus undulata	PM	Upper Shillong (1524m) Meghalaya
Prunus persica	Taphrina deformis	U.P. Hills (1750m)

(Source:Ram and Randhawa 1979; Joshi and Pandey 1996)

Vegetable Crop Diversity in the Himalayas

The western Himalayan region possesses a rich diversity in cucurbits, radishes, carrots, turnips, peas, cowpeas, chillies, brinjal (aubergine), okra (lady finger), spinach, fenugreek, amaranth, *Solanum khasianum*, *S. hirsutum*, *Schium edule*, and *Basella rubra*. In humid areas of the Himalayas in the states of Arunchal Pradesh, Nagaland, Manicure, Mizoram, Tripura, Meghalaya and Sikkim the rich diversity in vegetable crops is represented by cucurbits, radishes, peas, cowpeas, chillies, brinjal (aubergine), okra (lady finger), spinach, beet, amaranth, a number of *Solanum spp*, *Luffa echinata*, and *Schium edule*. The number of collections of different types of vegetable crops collected in the Himalayas and maintained in Shimla, Bhowali, Shillong (National Bureau of Plant Genetic Resources (NBPGR)), Kullu (Indian Agricultural Research Institute [IARI] and Solan (University of Horticulture and Forestry [UHF] are shown in Table 21.3).

Wild Relatives of Vegetables and Related Crops in the Himalayas

The wild relatives of vegetables and related crops include 31 species of legumes, 54 species of vegetables, and 27 species of spices and condiments (Arora and Nayar 1984). They grow in the western and eastern Himalayas (Table 21.3). The important wild plants include *Cicer microphyllum, Trigonella emodi, Lathyrus apheca, Moghania vestita, Mucuna capitata, Vigna umbellata, Abelmoschus manihot, Cucumis hardweikii, C. trigonis, Luffa graveolens, Solanum incanum, Tricosanthus multiloba, T. himalensis, Alocasia macrorhiza, Amorphophallus bulbifer, Colocasia esculenta, Cucumis hystrix, Dioscorea alata, Momordica cochin-chinensis, M. microphylla, Allium relbellum, A. schvenoprasum, A. tuberosum,*

Table 21.3: Vegetable Crop Diversity in the Himalayas Recorded Collections Maintained by NBPGR and Sister Institutions

Name of Crop	Number of Collections	Name of Crop	Number of Collections
Allium	23	French bean	1500
Okra	129	Cowpea	15
Fenugreek	68	Amaranth	2800
Pumpkin	94	Buckwheat	500
Bottle gourd	128	Chenopod	94
Snake gourd	25	Brassica	300
Ridge gourd	14	Ginger	174
Sweet gourd	37	Colocasia	315
Bitter gourd	63	Turmeric	147
Potato	83	Garlic	25
Egg plant	87	Faba bean	15
Spinach	10	Dioscorea	229
Capsicum	35	Moghania	2
Pea	83		

Carum bulbocastinu, Curcuma zeodoria, Phytolacca, Urtica, Asperagus racemosus, Fumeria, Amaranthus hybridus, A. tricolor, Fagopyrum cymosum, and Chenopodium album.

Several mushroom species are found in the forests of the Indian Himalayas. Villagers living around forests collect these mushrooms during March-April and in the rainy season for home consumption and sale. *Morchela esculenta,* locally called *guchhi*, is the most precious and nutritious vegetable found in the forests. *Diplazium esculentum* is a fern collected from the forests and sold in the local markets.

Conservation of Vegetable Genetic Resources

Over 28,000 germplasm accessions are held by the NBPGR, half of which are indigenous collections and include hill types. The variability collected and conserved includes french beans (4,500), cowpeas (34,000), peas (4,000), Dolichos beans (1,100), okra (4,000), egg plant (2,800), onions (1,300), cucurbits (1,100), *Brassicae* (800), faba beans (600), amaranth (2,800) (Joshi and Rana 1991), buckwheat (500) (Joshi and Paroda 1991), chenopods (103) (Partap and Joshi 1996), ginger (175), Colocasia (294), and turmeric (142).

Medicinal and Aromatic Plants

The Himalayas support an enormously rich diversity of medicinal and aromatic plants (Gupta 1986). It is estimated that over a hundred medicinal plants of the region are used in Ayurvedic, Unani, and allopathic medicines, as well as being used in home remedies. In fact, over two dozen medicinal species are collected by local people to earn cash income. Table 21.4 shows the most prominent medicinal plants collected from the Himalayas. The cold dry zone of the Indian Himalayas, covering areas of Ladakh, Pangi, Lahaul and Spiti, is an important gene pool area for valuable medicinal plants such as *Colchicum luteum*, *Onosma bracteatum*, *Carum bulbocastranum*, *Ephedra gerardiana*, *Ferula jeanchkina*, and *Artemisia maritima*. Some medicinal herbs have been declared endangered species. They include *Dioscorea deltoidea*, *Ephedra gerardiana*, *Saussurea lappa*, *Rauwolfia serpentina*, and *Aconitum riolaceum*. These medicinal plants offer opportunities for farming, as for example *Saussurea* in the Ladakh valley. These plants can support the establishment of new agro enterprises and cash crop farming, thus diversifying the base for niche-based cash crops.

Table 21.4: Medicinal and Aromatic Plants from the Indian Himalayas Conserved at Shimla and Bhowali (NBPGR), and Solan and Rallah (UHF)

Name of Medicinal Plant	Distribution	Name of Medicinal Plant	Distribution
Holarrhena antidysenterica	Foothills	*Valeriana wallichii*	Mid and high hills
Mallotus philippensis	Foothills	*Thymus serphyllum*	Mid and high hills
Acacia catechu	Foothills	*Urgenia indica*	Mid and high hills
Alstonia scolaris	Foothills	*Embalica officinalis*	Mid and high hills
Rauwolfia serpentina	Foothills	*Taxus baccata*	Mid and high hills
Urgenia indica	Foothills	*Aconitum heterophyllum*	Alpine region
Adhatoda vasica	Foothills	*Nardostachys jatamansi*	Alpine region
Acorus calamus	Foothills	*Inula racemosa*	Alpine region
Mucuna pruriens	Foothills	*Saussurea lappa*	Alpine region
Gloriosa superba	Foothills	*Orachis latifolia*	Alpine region
Dioscorea deltoidea	Mid and high hills	*Podophyllum emodi*	Alpine region
Gentiana kurroa	Mid and high hills	*Rhem emodi*	Alpine region
Picrorhiza kurroa	Mid and high hills	*Carum bulbocastranum*	Alpine region
Swertia chirata	Mid and high hills	*Ephedra gerardiana*	Alpine region
Berberis aristata	Mid and high hills	*Artimissia maritima*	Alpine region
Alpinia officinalis	Mid and high hills	*Potentilla affine*	Alpine region
Salvia moorecroftiana	Mid and high hills	*Ferula jaeschkena*	Alpine region
Coleus foreskolii	Mid and high hills	*Colchicum luteum*	Alpine region
Viola serpens	Mid and high hills	*Onosma bracteatum*	Alpine region

Himalayan Farmers as Custodians and Users of Native Genetic Resources

Marginal mountain farmers use products from some wild plants as staple foods as a part of their livelihood strategy (Box 21.3 and 21.4). A variety of such products is also sold in the local markets and consumed by urban populations. These include, for example, the fruits of *Myrica esculenta*, *Pyrus*, *Prunus*, *Rubus ellipticus*, *R. lasiocarpus*, *Persea edulis*, and *Pinus gerardiana*; a number of tuber

Box 21.3

Collection of Indigenous Horticultural Crops in the Indian Himalayas

Crops	Number of collections
Fruits	635
Vegetables	893
Tubers	381
Species	75
Medicinal plants	150
Ornamentals	70

There are many wild vegetables and fruits that provide food security to tribal people and wildlife alike. There is a forest in Pithoragarh, in UP, that contain a unique gene pool of pears growing in the wild. It might be possible to domesticate this tree as the size and quality of the fruit is as good as those of commercial varieties. Domestication would make an important contribution to genetic variability in the pear gene pool. Local apples are still found in home gardens in Pangi district in the Shimla hills. There is a wide range of such examples, but little attention is paid in research to efforts to domesticate and promote market opportunities for local fruits. Improvements in the economy and quality of life of farming communities through farming of horticultural crops, particularly of apple and vegetable farmers in Himachal Pradesh, are widely recognised to be a success story of the hills. But more attention should be paid to the utilisation of local genetic resources to support this development. Some fruits have a special ecological niche, for example, and could be used to develop niche based cash crop farming, thereby conserving the pear gene pool through income-generating considerations.

Box 21.4

Do we know the potential value of biowealth: a few examples from the Indian Himalayas

- *Podophyllum hexandrum* and *Taxus baccata* are found in the high mountain forests of the Indian Himalayas. They are anti-cancerous compounds and are being exploited by pharmaceutical and essential oil industries.
- *Cicer microphyllum* found in Lahaul and Spiti is cold and drought resistant and produces 6 to 8 grains per pod, thus it offers useful genes for biotechnological manipulations.
- *Cucumis hystrix* from the North East Indian Himalayas is resistant to mildew and saved the musk melon industry in the USA.
- *Morchella esculenta,* locally called *guchhi*, is a precious mushroom found in the forests. Many poor families depend on its collection and sale for food security.

(Source: B.D. Joshi 1996)

and vegetable crops such as *Colocasia, Dioscorea, Phytollaca, Fumeria, Diplazium esculentum, Morchella esculenta* (mushroom), and *Bauhinia variegata* and spices such as *Carum bulbocastianum, Allium streachii, and Achillea millefolium*. Mountain farmers also collect a number of medicinal plants from the forest and sell them in the local markets; among these are *Embellica officinale, Inula racemosa, Saussaurea lappa, Aconitum ferox, Podophyllum emodi, Ephedra gerardiana, Viola biflora, Picrorhiza kurua, Terminalia balarica, T. chebula, and Swertia chirata* (Arora and Pandey 1996).

Indian Himalayan farming communities have a history of domestication, cultivation, and utilisation of fruit species. This is evident from the existence and cultivation of very old pome, stone, nut, and soft fruit trees. There are a number of fruit trees under cultivation locally resulting from direct utilisation of germplasm. As soon as a farmer identified an outstanding fruit tree it would be planted in the garden and multiplied by vegetative methods or seed and distributed to others. In the past, emphasis on the use of fruit germplasm was on the identification of trees with outstanding fruit characteristics and yield. Locally, much has been done to identify plants for precocity, dwarfedness, and resistance to pests, drought, cold, frost, and hail. There has been little emphasis on selecting wild species for use as root stocks to provide resistance to soil born diseases, but there are some examples of this type of practice. Many of the fruit growers in Kinnaur and Shimla districts use *Malus baccata*, locally known as dhak, as a root stock for royal and red varieties of apple. Similarly, *Prunus behmi* is used as a root stock for almonds in Kinnaur (Table 21.2).

Among the medicinal and aromatic plants of indigenous origin, *Rauwolfia serpentina, Podophyllum hexandrum, Picrorhyza kuroa, Inula racemosa, and Saussaurea lappa* are valuable for the pharmaceutical and essential oil industries. *Hyssopus officinalis*, which is found in Lahaul and Spiti, has industrial potential as a plant yielding essential oils. The principal components of the oil are pinocamphore (38.4%) and pinocarone (11.7%) as a major compound and additional new compounds have been characterised. *Cymbopogon jawarancusa* from Spiti revealed 2.5 to 4.0 per cent oil yield on a dry weight basis. Thirty compounds were identified. Pipertone is the major compound (73.4%) of the 30 components identified, a much higher proportion than reported for Pakistani hyssop oil (64.4%). Thus, these two species also hold great promise for the essential oil industry.

Several initiatives related to genetic resources have absorbed the principal of paying special attention to community knowlege and considering it as a resource to be valued as much as the germplasm itself. The local architects of farming systems have tended to operate with survival-focussed farming strategies, rather than focussing on simple productivity or maximisation of profits. Thus, native communities have gathered valuable knowledge related to the conservation and use of genetic resources. They also know the useful traits of the types of products that they have been growing or gathering from the wild.

Some of the unique ethnic communities in Chamba in Himachal Pradesh and in the Uttarakashi, Chamoli, and Pithoragarh districts of Uttarakhand move to high altitude areas with their sheep and cattle and remain there in the meadows for six to seven months from April to October. Their food comes from available plants such as *Allium, Dendobenthamia, Eleagnus, Epilobium, Fagopyrum, Fragaria, Gautheria, Hippophae, Holboellia, Juglans, Corylus, Malus, Podophyllum, Prunus, Rheum, Rubus, Ribes Sorbus, and Vibernum.* They know which leafy and tuberous wild plants can be used as vegetables and which are toxic, as well as how to use locally available medicinal plants to cure and relieve many illnesses and ailments. They recognise certain plants as having magical effects and use various plants in different rituals.

Many mountain farmers collect wild plants from the forest and plant them near their homes, along field boundaries, or near their village. Examples include fruit trees such as *Ficus palmata, F. racemosa, Morus serrata, Citrus species, Pomegranate, Bauhinia, Pyrus,* and *Prunus*. A few multipurpose plants such as *Morus, Sorbus, Aescendra butrycea, and Persea edulis* are grown for fruits, fodder, farm implements, and fuel.

The wild relatives of *Allium, Apium, Colocasia, Curcuma, Dioscorea, Fagopyrum, Phytolacca, Zingerber* and others are allowed to grow as weeds on farmlands to meet subsistence needs.

Table 21.5 shows various rare and endangered species of wild relatives of fruit crops found at different locations together with their *in situ* conservation sites in the northwestern and northeastern Himalayas. The species requiring immediate attention for *in situ* conservation are *Malus, Pyrus, Prunus, Sorbus, Cydonia, Diospyrus, Actinidea, Corylus, Pinus,* and *Crataegus.*

Conservation

Ex situ conservation, in the form of field gene banks or *in vitro* conservation, should be a major conservation strategy. Table 21.6 shows the research centres in the Indian Himalayas involved at present in the conservation of fruit, vegetable, medicinal, and ornamental plant germplasm. Most of the wild endangered species of citrus in the Garo Hills of Meghalaya need *in situ* conservation on lime to back up *ex situ* conservation in their real home because of the specific ecological requirements of these species. Cryopreservation through pollen, meristem, budwood, and tissue could be explored. The germplasm collected and conserved

Table 21.5: Rare and Endangered Wild Relatives of Fruit Crops in the Indian Himalayas

Name of Species	Altitude (m)	*In situ* Conservation Site
Malus baccata	2100	Rohru, H.P.
M. baccata var. himalaica	3000	Jahlma, Lahaul
M. sikkimensis	1970	Lachen, N. Sikkim
Pyrus serotina	1980	Khasi hills
P. jaquimontiana	1530	Kochli, Powari, H.P.
Prunus salicina	1920	Shimla
P. persica	2000	Tehog. H. P., Shillong
P. sp. (Behmi)	3070	Kinnaur, H. P.
P. wallichii	2000	Darjeeling
P. undulata	1524	Shillong
P. rufa	3550	Passibhanjanj, Darjeeling
P. prostrata	3000	Giabung, Kinnaur
Cotoneaster bacillaris	2000	Mashobra, H. P.
Cydonia	1400	Kashmir
Crataegus oxycantha	2200	Matiyana, Shimla
C. crenulata	2000	Shimla
Diospyrus lotus	1900	Shimla
Sorbus microphylla	3540	Yangthang
S. ursina	3540	Sandakphu, Darjeeling
S. foliolosa	3540	Sandakphu, Darjeeling
S. verrucosa	1690	Cherrapunji
S. granulosa	1690	Cherrapunji
Actinidia callosa	2100	Hiley, S. Skikkim
A. strigosa	2500	Bomdila, Arunachal
Corylus jacquimontia	3000	Joshimath, Chamoli
Pinus gerardiana	3040	Kinnaur, Pangi

in field gene banks at different locations needs to be documented in a centralized information system and the collections coordinated, so that germplasm can be used effectively.

Conservation strategies need to include protection of all the major and minor fruits, vegetables, medicinal and aromatic, and ornamental plants. There are a number of sites in the Himalayas that need surveying and protection. Pin valley in Spiti is a potentially exciting site for *in situ* conservation and protection of a number of wild *Rosa spp*, a few medicinal plants, seabuckthorn, and *Cicer microphyllum*, as these species are all under great pressure from local inhabitants.

The state agricultural universities and state departments of agriculture and forestry may jointly establish a genetic reserve for *in situ* conservation of endangered wild species of fruits, vegetables, and medicinal plants.

Table 21.6: Research Centres in the Indian Himalayas Involved in the Conservation of Fruit, Vegetable, Medicinal, and Ornamental Plant Germplasm

- NBPGR, Regional Station, Phagli, Shimla - 1701004, Himachal Pradesh
- NBPGR, Regional Station, Niglat, Bhowali, Nainital, Uttar Pradesh
- NBPGR, Regional Station, Barapani, Shillong, Meghalaya
- IARI, Regional Station, Amartara Cottage, Shimla, HP
- Regional Fruit Research Station, Mashobra, Shimla, HP
- Regional Vegetable Research Station, Kandaghat, Solan, HP
- Regional Fruit Research Station, Bajaura, Kulu, HP
- University of Horticulture and Forestry, Nauni, Solan, HP
- IARI, Regional Station, Katrain, Kulu, HP
- VPKAS, Almora, UP
- G. B. Pant University of Agriculture and Technology, Hill Campus, Ranichauri, Tehri Garhwal
- ICAR, Research Complex, Gangtok, Sikkim
- National Research Centre for Orchids, Gangtok, Sikkim
- ICAR, Research Complex, Barapani, Shillong
- UP Pharmaceutical Laboratory, Tarikhet, Ranikhet, UP
- Horticultural Experiments and Training Centre, Chaubattia, Ranikhet
- Shere Kashmir Agricultural University, Srinagar, Jammu and Kasmir
- Central Institute for Temperate Fruits, Srinagar, J & K

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Chapter 22

Crop Gene Pools in the Mountain Areas of Pakistan and Threats

M. S. Bhatti

Diverse crops are cultivated in the mountain areas of Pakistan. Wheat accounts for 66 per cent of the total crop area. Wheat and barley are grown to elevations above 3,000m, whereas rice and maize crops are mostly grown below 2,500m. Pearl millet and sorghum are mainly grown on the plains and in the low hills (Table 22.1).These crops account for 97 per cent of the total area used for agricultural crops. Various types of fruits, mainly citrus, guava, banana, and mango, are grown on over 0.43 million hectares. The remaining three per cent of the area is occupied by other food legumes such as faba beans, pigeon peas, cowpeas, and moth beans. Peas, mung beans, urd beans, lentils, and faba beans occupy about 29,000 hectares in the mountain regions of Pakistan. Farmers mostly grow land races of lentils, faba beans, and peas.

Some minor cereal crops are also grown in the mountains in addition to the major food crops(Table 22.1). Foxtail millet (Setaria italica), common millet (*Panicum miliaceum*), barnyard millet (*Echinochloa frumentacea*), oats (*Avena* spp), amaranthus (*Amaranthus* spp), and buckwheat (*Fagopyrum* spp) are common as food crops in the high mountain areas (Anwar et al. 1987). Varieties of these crops have been grown in the mountains for centuries. Substantial quantities of medicinal plants also grow in the mountains.

Temperate fruit such as apples, pears, apricots, walnuts, peaches, plums, grapes, and almonds are grown mainly in the middle to high mountains of Pakistan. Citrus and guava are found in the low to middle mountains.

Table 22.1: **Crops Grown in Pakistan's Mountains, Their Importance and Uses**

Common Name		Botanical Name	Importance	Use
A.	**Cereals**			
	Wheat	*T. aestivum*	xxx	Bread, many other uses
	Rice	*Oryza sativa*	xxx	Boiled and other uses
	Maize	*Zea mays*	xxx	Bread, roasted and others
	Sorghum	*S. bicolor*	xx	Flour, boiled, fodder
	Millet	*P. americanum*	xx	Flour, boiled, fodder
	Barley	*H. vulgare*	xx	Fodder, local food
	Oats	*Avena sativa*	xx	Fodder
	Buckwheat	*Fagopyrum* spp	xx	Bread and other uses
	Foxtail millet	*Setaria italica*	xx	Boiled, bread, fodder
	Millet, common	*P. miliaceum*	xx	Bread, boiled, fodder
	Millet, amaranthus	*Amaranthus* spp	xx	Sweets
B.	**Food Legumes**			
	Mung beans	*Vigna radiata*	xxx	Pulse curry
	Black gram	*Vigna mungo*	xxx	Pulse curry
	Lentils	*Lens culinaris*	xxx	Pulse curry
	Faba beans	*Vicia faba*	xx	Curry and boiled
	Dry beans	*P. vulgaris*	xxx	Curry, boiled, roasted
	Chickpeas	*C. arietinum*	xxx	Many uses
	Peas	*Pisum sativum*	xx	Vegetable, curry
	Pigeon peas	*Cajanus canjan*	xx	Curry
	Cowpeas	*V. unguiculata*	xx	Curry, boiled
	Moth beans	*Vigna acontifolia*	xx	Curry, boiled
	Dry peas	*Lathyrus sativus*	xx	Curry, fodder
	Soybeans	*Glycine max*	xx	Oil, fodder
C.	**Fruit**			
	Tangerines	*Citrus reticulata*	xxx	Fresh and many other uses
	Oranges	*Citrus sinensis*	xxx	Fresh and many other uses
	Guavas	*Psidium guava*	x	Fresh and many other uses
	Apples	*Malus pumila*	xxx	Fresh and many other uses
	Apricots	*Prunus armeniaca*	xxx	Fresh and many other uses
	Peaches	*Prunus persica*	xxx	Fresh and many other uses
	Plums	*Prunus domestica*	xxx	Fresh and many other uses
	Almonds	*Prunus amygdalus*	xxx	Dried fruits
	Cherries	*Prunus avium*	xx	Fresh & other preparation
		Prunus cerasus	xx	Fresh & other preparation
	Pears	*Pyrus communis*	xxx	Fresh and dried
		Pyrus pyrifolia	xxx	Fresh and dried
	Mulberries	*Morus alba/nigera*	xxx	Fresh and dried
	Grapes	*Vitis vinifera*	xxx	Fresh and other preparations
		Vitis jacquemontii	xxx	Fresh and other preparations
	Walnuts	*Juglans regia*	xxx	Dried
	Pomegranates	*Punica granatum*	xx	Dried and used as spice
	Persimmons	*Diospyrous* spp	xxx	Fresh
		Diospyrous lotus	xxx	Fresh and dried
	Hazelnuts	*Coryllus* spp (wild)	xx	Dried

Table 22.1: Crops Grown in Pakistan's Mountains, Their Importance and Uses (cont'd)			
Common Name	**Botanical Name**	**Importance**	**Use**
d. **Medicinal Plants**			
Kanis	*Dioscorea deltoidea*	xxx	Medicinal use
Bankakri	*Podophyllum emodi*	xxx	Medicinal use
Ban javain	*Thymus serphyllum*	xx	Medicinal use
Revand chini	*Rheum emodi*	xx	Medicinal use
Mamekh	*Paeonia emodi*	x	Medicinal use
Afsantine	*Artemisia maritana*	x	Medicinal use
Afune	*Papaver* spp.	x	Medicinal use
Note: xxx Major crop xx Minor crop x Rare crop			

Crop Genetic Diversity

Different crops were introduced into the mountainous regions of Pakistan during early migrations. Varied edaphic, topographic and climatic factors, and different selection pressures over centuries of cultivation have resulted in a pool of variation. The indigenous varieties (population of different land races) have evolved over a span of centuries and are adapted to particular areas. The old varieties (usually termed primitive cultivars or land races) have withstood the rigour of time, have escaped attack by insect pests and diseases, and have tolerated harsh climatic conditions. They possess desired agronomic and genetic traits that can be exploited to give high yield and resistance. The Genetic Diversity of some major crops in the mountains of Pakistan is described below.

Wheat

There is a rich Genetic Diversity in wheat in Balochistan and the Northern Areas - Gilgit, Hunza and Skardu, and Azad Kashmir. Balochistan and the Northern Areas are arid and annual rainfall varies from 100 to 250 mm. The indigenous wheat land races are highly variable in traits such as awn, straw thickness, grain size and colour, and spike density. All the local varieties collected from the region belong to the hexaploid and tetraploid wheats. The different species distributed in the region are listed below.

- *Triticum aestivum - hexaploid*
- *Triticum aestivum spp compactum - hexaploid*
- *Triticum spp sphaerococcum - hexaploid*
- *Triticum durum - tetraploid*
- *Triticum polonicum - tetraploid*
- *Triticum turgidum - tetraploid*

The variation in traits may have been largely caused by differences in aspect, altitude, soil moisture regimes, cultural practices, and social isolation from one valley to the next. Land races such as Shorawaki, Khushkaba, and Dayak in Balochistan, belonging to hexaploid wheat (*Triticum aestivum*), are of great importance because of their salt and drought resistance. Swaminathan (1970) observed that *Triticum sphaerococcum* (*Triticum aestivum* spp, sphaerococcum) from Balochistan and the North West Frontier Province (NWFP) was extremely drought resistant. So far the rate of genetic erosion of these land races is low, largely as a result of the lack of high-yielding varieties (HYVs) that can tolerate drought stress. However, HYVs have replaced the traditional land races in certain locations with supplementary irrigation facilities. In Azad Kashmir, for example, the rate of erosion of land races is enormously high. The area receives heavy rains (over 1000 mm annually), a major factor in the adoption of modern varieties in the area.

Wild Gene Pool

Hexaploid wheat or bread wheat (*Triticum aestivum*) combines three different genomes (genomic constitution AABBDD). *Aegilops speltoides* and *A. squarrosa* are two diploid donars of B and D genomes respectively. McIntoch (1983) observed that the wild relatives of wheat, *Ae. squarrosa* and *Ae. speltoides,* have genes resistant to stem rust and leaf rust of wheat. Similarly, other related genera such as Rye and Agropyron have resistant genes for some wheat diseases (Table 22.2). The Pakistani province of Balochistan has many gene pool areas for the two *Aegilops* species, *squarrosa* and *tricuncialis*. Different wild species of *Aegilops, Agropyron*, and *Secale* are found here notably in Quetta, Kalat, Nushki, Sibi, Ziarat, Chamman, Muslimbagh, and Qila Saifullah, as well as in several other small towns and villages. *Aegilops squarrosa* is distributed widely throughout these provinces, while *Aegilops triuncialis* is restricted to a small area - from Pishin to Khanozai — in the northeast of Quetta. Very large populations of *Aegilops squarrosa* grow along

Table 22.2: **Disease Resistance Genes in Wild Relatives of Wheat**

Source of Resistance Species	Disease	Resistant Gene	
1. *Aegilops squarrosa*	Stem rust	Sr 33	Aegilops
2. *Aegilops squarrosa*	Leaf rust	Lr 21	Aegilops
3. *Aegilops speltoides*	Leaf rust	Lr 28	Aegilops
4. *Agropyron elongatum*	Stem rust	Sr 24	Agropyron
5. *Agropyron elongatum*	Stem rust	Sr 25	Agropyron
6. *Agropyron* spp.	Leaf rust	Lr 24	Agropyron
7. *Secale* spp.	Poundry mildew	Pm 8	Rye
8. *Secale* spp.	Stem rust	Sr 27	Rye
9. *Secale* spp.	Yellow rust	Yr 9	Rye
10. *Triticum speltoides*	Stem rust	Sr 32	Wheat

(Source: McIntoch 1983)

a belt from Khanozai to Ziarat. *Aegilops squarrosa* has also penetrated to the warmer areas south of Quetta. The species occupies disturbed habitats and spreads as a weed in wheat fields, along the boundaries of fields, along water channels, and under trees and shrubs.

Box 22.1

Wild Gram (Cicer spp) Gene Pool in the Mountains of Pakistan

This box presents the findings of an expedition that showed that the Hindu-Kush Himalayan region (HKH) is a valuable resource centre for wild relatives of chickpea. Two provinces of Pakistan, the Chitral and Swat districts of the North West Frontier Province (NWFP) and the Gilgit, Skardu, and Gangche districts of the Northern Areas (NA); were covered by the expedition.

Scientists have identified a number of wild relatives of chickpea at elevations ranging from 2,450m in Chitral to 3,840m in Gilgit. The number of species collected is summarised as follows.

Cicer *species*	***Districts***				
	Chitral	**Swat**	**Gilgit**	**Skardu**	**Gangche**
Cicer microphyllum	7	0	5	5	13
Cicer nuristanicum	2	0	0	0	0
Cicer macranthum	0	5	0	0	0
Total	9	5	5	5	13

The most valuable gene pool for *Cicer* was found in the vicinity of Barmoghlasht and Warsyuzan in the district of Chitral between 2,630 and 2,930m. *C. microphyllum*, a wild chickpea, was found growing on roadside slopes and pasture land under thorny bushes of *Rosaceae* and together with Juniperus. About 80 per cent of the *Cicer microphyllum* populations had a double pod trait that is seldom found in cultivated chickpea. One plant had three pods on a peduncle. The plants were vigorous, tall, and had long pods of up to 40 mm. Locally wild chickpea is called *zangli nakhoay* (*zangli* = wild and *nakhoay* = channa or chickpea), or *kacha nakhoay* [*kacha* = small and *nakhoay* = chickpea). The yield traits, two to three pods per peduncle, of the populations of chickpea have great potential value for improving the yield of chickpea crops. This is a rare trait in chickpea germplasm (Van der Maesen 1972).

A small population of *Cicer microphyllum* was spotted at an altitude of 3,560m in Sust, 200 km north of Gilgit in Gilgit district. The plants were upright and vigorous. The population was on the verge of extinction due to land levelling and development activities, and this may have happened afterwards.

The *Cicer* was locally called *Khukhani* by farmers. Farmers reported that the they used to harvest wild *Cicer* during August-September and store it for feeding during the winter. The threat of genetic erosion to the *Cicer* species varied greatly from one area to another. In general, the populations of *C. macranthum* in Swat and of *C. microphyllum* in Gilgit were severely damaged by grazing cattle. These species were also threatened by land-use changes and habitat destruction. None of these factors is under the control of plant genetic resources' institutions, so they cannot control *in situ* conservation. Thus *ex situ* conservation is necessary.

Rice

Rice is grown in a few areas in the NWFP and Balochistan, and there is a small number of local land races grown widely. A local variety, *Begami*, dominates in Swat; two common groups of land races, *Munji* and *Nali*, are found in Dir and Chitral; a single local land race, *Kalai*, is popular in Kurram agency, an area of 1,970 sq. km.; and a native variety, *Booti*, is popular throughout the Kaghan Valley. All the varieties are coarse grain types and belong to the Japonica category. Genetic resource surveys have recorded rice cultivation up to 2,250m. There are about 65 land races of rice in the NWFP, although rice is only grown in a comparatively small area. Several local rice varieties are found in the terraced rice fields of the remote valleys of Karkh and Mula (Khuzdar district). In Balochistan, rice is grown on smaller areas but about 200 samples of rice have been collected. These indigenous rice land races are highly variable for plant height, panicle length, panicle laxness, awnedness, shattering tendency, grain size, and shape.

The rate of erosion of the indigenous rice varieties in Baluchistan is high. In 1972-73 indigenous rice varieties occupied 40 per cent of the area under rice cultivation, by 1983-84 the area under local varieties had been reduced to eight per cent. The principal cause of genetic erosion in the region is thought to be the shift from subsistence to commercial farming which occurred following the construction of the Pattedar canal.

In the past, agricultural explorations in the northern mountains of Pakistan were mainly concerned with major food and fruit crops. During 1987, the Plant Genetic Resources Programme (PGRP) of the Pakistan Agricultural Research Council (PARC), in collaboration with Kyoto University, Japan, explored the region for the first time to collect minor cereals and some wild relatives of crop species. The mission explored the areas of Chitral, Yasin, Gupis, Gilgit, Hunza, and Skardu, to collect foxtail millet (*Setaria italica*), common millet (*Panicum miliaceum*), and several other minor crops and wild species at altitudes ranging from 700 to 3,540m.

Foxtail millet is cultivated over a vast area from Chitral, through Gupis, Gilgit, and Hunza, to Skardu. In contrast, common millet is confined to the area from Chitral to Gupis and the surrounding valleys. A very interesting pattern of distribution of foxtail millet is seen in the northern areas. Foxtail millet growing on the western bank of the River Indus belongs to the West Asian type, whereas that growing on the eastern side of the River belongs to the East Asian type. Thus the River Indus seems to be the barrier for distribution of the West Asian and East Asian types.

Fruit

Geographically, Pakistan lies between two major centres of fruit diversity, the Caucasus Mountains and China. An ancient trade route from China through

Central Asia to Western Asia passes through the Northern Mountains of Pakistan. Fruit species from along the entire route were brought here and have been cultivated for centuries. These fruit species have been diversified through human selection over hundreds of years. Farmers in the mountain areas of Pakistan are traditionally fruit growers, and fruit crops are a very important source of food and livelihoods. Thus there is considerable genetic variability in the fruit species in these mountains (Bhatti et al. 1982). The pattern of variation and adaptation of fruit species varies greatly in different areas.

Various types of apricots are grown in Skardu, Gilgit, and Hunza, the Northern Areas of Pakistan (Table 22.3). All the local varieties belong to only one species (*Prunus armeniaca*). The apricots vary widely in fruit size, shape, colour, taste, and time taken to mature. The varietal variations may result from the nature of seed propagation. Wide variation exists in the seed size and taste of the fruit, which ranges from bitter to sweet. Total Soluble Sugar (TSS) in the local apricot varieties ranges from 22 to 36 per cent. The local varieties, *Halman* and *Marghulam*, have the best quality for taste, and *Kacha Choli* the best keeping quality.

Apples are an important fruit crop for the mountain farmers of Pakistan. Here, apples are adapted to very diverse climatic conditions. All the cultivated varieties belong to *Malus pumila*. They are grown on the plateau of Balochistan, in the mid to high mountains of the NWFP, and in the high mountains of the Northern Area. Several local varieties are grown in the Skardu area such as *Ambri Kusho, Nas Kusho, Shin Kusho, Skiur Kusho, Mar Kusho*, and *Bong Kusho*. Of these, *Ambri Kusho* is the best apple variety for quality. A large number of local varieties are grown in Gilgit and Hunza. The most common and widespread varieties are *Noor Shah Balt, Mamu Balt, Shakur Balt, Beruit Balt, Alikan Balt, Shikam Balt*, and *Akbaraman Balt*.

To a great extent, the local apple varieties in the NWFP, Azad Kashmir, and Balochistan have now been replaced by a few commercial varieties such as Golden Delicious and Red Delicious. Large scale plantations of improved varieties in Swat and Mansehra (NWFP) and Quetta (Balochistan) during the past few decades have played a vital role in improving the farm economy of these areas but have also led to genetic erosion of native varieties.

The Hunza and Skardu areas have altitudes of 2,450 m and above and a dry and very cold climate. Here local apple varieties have evolved that are winter hardy and adapted to harsh climatic conditions. Farmers in the Swat Valley have developed a double graft technique to cope with some soil-borne diseases of apples. They first graft *Sorbus* on to *Crataegus songarica* (common hawthorn, locally called *chochina*), which is resistant to nematodes and other diseases and

Table 22.3: **Local Apricot Varieties Grown in the Northern Areas of Pakistan**

Local variety	Characteristics	Local variety	Characteristics
Skardu		**Hunza/Gilgit**	
Marpho choli	Red apricot	*Shikanda joo*	-
Karfoo choli	White apricot	*Brum joo*	White
Warfo choli	Pith used for oil	*Surasune joo*	Good quality
Bro choli	Late maturing	*Duda-sanag joo*	-
Khakas choli	Pith partially split	*Koropiam joo*	-
Cho choli	Juicy	*Ali Shah Kakas joo*	Late
Apo choli	Large	*Habi joo*	Very late
Beru choli	Small	*Khanemish joo*	-
Blafo choli	Small, red	*Kartachi joo*	Very early, white
Odumar choli	Partly red	*Dudur joo*	-
Chun choli	Sweet pith	*Ghulam joo*	-
Yakar choli	Reddish	*Rashikin joo*	Early
Gurdalo choli	Like peach	*Alman joo*	Good quality
Pharang choli	For drying	*Koropian joo*	Early
Kartaksha choli	Early, juicy	*Gakateenan joo*	-
Sara choli	-	*Kaka Shikanda joo*	-
Kacha choli	Hard, good to keep	*Moen joo*	-
Halman choli	Best quality	*Ghaka joo*	-
Kazangi choli	Sweet	*Mamoorl joo*	-
Khashanda choli	Good taste	*Brun joo*	
Kho choli	Bad taste, sour	*Gario joo*	
Shakanda choli	Sticky		
Tacho choli	-		
Marghlam choli	Early, good quality		
Shanda choli	Small, early		
Stun choli	Late maturing		
Mamoor choli	-		
Ghom choli	-		
Sara Karfo choli	Early		
Stun kuban choli	-		
Khustar choli	-		
Sapastan choli	Sour, pith used for oil		
Miting choli	Sour, pith used for oil		
Shakar choli	Sweet		
Hongool choli	-		
Brook choli	-		
Halwar choli	-		
Duspaong choli	-		
Yakab yak choli	-		
Snair choli	-		

is compatible with *Sorbus*. When the *Sorbus* has grown an apple variety, such as *Kalam*, the *Utror, Gabrol, or Sorbus* (*Anj*) variety is grafted on to it.

The common pear (*Pyrus communis*) is grown widely in this mountain area. The largest number of local varieties belonging to *P. communis* and *P. pyrifolia* are found in the Swat Valley. The local pears are very diverse in terms of fruit size, shape, taste, and time of maturity (Table 22.4). *Pyrus pyrifolia (syn. P. Lindleyii)* and P. pashia are mainly adapted to the semi-humid to humid regions of the NWFP and Azad Kashmir.

Table 22.4: Local Pear Varieties in Swat (NWFP), Pakistan

Variety	Characteristics	Variety	Characteristics
Parao	Large, pear shape	*Batang*	Large, pear shape, sweet
Sur Tango	Small, round	*Nag Tango*	Large, apple shape, hard
Shin Kulay	Medium, apple shape	*Nak*	Oblong to pear shape
Spin Tango	Small, round	*Shal Tango*	-
Mamusay	Small to medium, round, early	*Khar Nak*	Large, hard
Shakar Tango	Sweet, medium size	*Gadaray tango*	-
Nashpati	Medium to large, sweet	*Bap Tango*	Early
Tang	Large, pear shape	*Khawaga maiwa*	Small, round, sweet
Khan Tango	Small, round	*Khapa*	Sour

The diverse grape varieties (*Vitis* spp) found in the northern mountains of Pakistan include land races of *Vitis vinefera* and *V. jacquemontii* and a wild species, *V. parvifolia*. The adaptation patterns of different species vary from the arid dry to the humid regions. *V. vinifera* demonstrates great diversity in Skardu, Hunza, and Gilgit. *V. jacquemontii* is adapted to the high rainfall areas in Swat and Azad Kashmir. The wild species, *V. Parvifolia*, is distributed sparsely in the Chickar area of Azad Kashmir.

The Swat, Khagan, and Gilgit valleys are major growing areas for walnuts (*Juglans regia*). The walnut land races have a range of variation for size, shape, colour, and shell thickness (varying from a very thin to a very hard shell).

The hazelnut (*Coryllus jacquemontii*) grows in abundance on the north-facing mountain slopes in the high mountains of Swat. In Kalam it is called *'Mizzer'*. A considerable quantity of nuts is collected by farmers and sold to local shopkeepers.

Chilgoza (*Pinus geradiana*) trees grow in Balochistan, the NWFP, and the Northern Areas. The cones are collected, and the seeds extracted and sold.

Exploration Activities and *Ex situ* Conservation

The germplasm collected during these expeditions is conserved in the Pakistan Agricultural Research Council (PARC) gene bank. In addition, duplicate samples have been supplied to international institutions and gene banks for long term ex *situ* conservation.

Table 22.5: Germplasm Expeditions Conducted in the Pakistan Mountains

Expedition Focus	Year	Region explored	No of samples collected
Cereal crops	1981	Balochistan	794
Fruit	1982	Baltistan	96
Vigna	1982	Azad Kashmir (AK)	136
Lentils	1983	Northern Areas (NA)	227
Cereals	1983	NWFP, Punjab and AK	80
Rice	1983	NWFP	79
Rice	1985	Balochistan	200
Aegilops and wheat	1986	Balochistan	105
Wheat	1986	Northern Areas (NA)	150
Fruit	1987	NWFP and AK	205
Minor cereals	1987	Northern Areas	250
Fruit and nuts	1988	NWFP and NA	300

Ex Situ Conservation Priorities

Priority is given to endangered crop species in the area in which the rate of genetic erosion is enormously high. The indigenous wheat in Azad Kashmir and the NWFP and rice in Sindh and Balochistan are being replaced at a rapid rate. Similarly, fruit and other crops in the NWFP, Azad Kashmir, and the Northern Areas are being collected as a priority.

Opportunities in Mountain Agriculture

Temperate fruit, such as apples, apricots, walnuts, pears, peaches, and plums, have great potential in the mid to high mountains of Pakistan. The areas of Quetta Ziarat, Loralai (Balochistan), Swat, Dir, and Mansehra (NWFP) have substantial potential for apple production. Orchards with improved apple varieties such as Red Delicious and Golden Delicious have benefitted farmers and played a vital role in improving the economy of the area.

The areas of Gilgit, Hunza, and Skardu, at altitudes above 2,000m, have great potential for the production of apricots, apples, grapes, cherries, and almonds. The commercial cultivation of these fruits is bringing an economic revolution to the area.

Apricots could be a leading crop in the Skardu and Hunza areas, if proper post-harvest processing and marketing facilities were to be made available. In Gilgit and Hunza, sulphur treatment for drying apricots has increased the quality and price of dried apricots enormously. Planned plantation with proper management and establishment of fruit processing units can certainly bring economic stability and prosperity.

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Chapter 23

The Diversity of (Minor) Fruit Crops and Wild Relatives in the Mountain Areas of Pakistan

Z. Ahmad

The Hindu-Kush Himalayan region of Pakistan is very rich in fruit and nut biodiversity as a result of the wide range in climate. The area lies between the two major centres of diversity in temperate fruit species, the Caucasus Mountains and China. Ancient trade routes from China to Western Asia passed through this region and many fruit species were bought into Pakistan as a result.

The major fruit species cultivated include apples, apricots, peaches, plums, and walnuts. Besides these, there are a number of other minor or neglected species and wild relatives of many fruit species. Some species may have less significance in the present economy of the region, but genetically could be very important for future breeding programmes. This paper focusses on the diversity of minor and wild fruit species in Pakistan.

Pome Fruit Diversity

The minor pome fruit species growing in the region are listed in Table 23.1. They include *Pyrus pashia, Malus domestica, Cydonia oblonga, Sorbus lanata, S. tianshanica, Crotaegus songarica, C. affinis, C. intergerrima, Cotoneaster lindlegi,* and *C. nummularia*. *Pyrus pashia* (wild pear) occurs at elevations between 750 and 2,500m together with *Pistacia chinesis and Diospyros lotus*. The fruits of wild pear are one to two cm long and brown with conspicuous white raised *lenticels*. After harvesting, the fruit is stored and allowed to soften and turn dark brown to make it edible. The domestic apple (*Malus domestica*) is planted widely and produces small to medium-sized early maturing fruits. *Cydonia oblonga* (quince) is not distributed widely in the region and the type of fruit found in the area is

Table 23.1: Minor Fruit Crop Resources of the Pakistan Mountains

Latin Name	English Name	Local Names
Pome fruits		
Pyrus pashia	Wild pear	*Batanji, tanchi khapa*
Malus domestica	Domestic apple	*Chotta, shird*
Cydonia oblonga	Quince	*Behi, chator, charoll*
Sorbus lanata	Sorbus	*Tameez*
Sorbus tianshanica	Sorbus	-
Cartaegus songarica	Cartaegus	*Chochina sinjay*
Cotoneaster affinis	Cotoneaster	*Bedour, kabeshoo*
Cotoneaster integerrima	Cotoneaster	-
Cotoneaster nummularia	Cotoneaster	-
Stone fruits		
Prunus cerasioides	Wild cherry, Carmine cherry	-
Prunus jacquemontii	-	*Jikhn, mabheen*
Prunus prostrata	-	-
Prunus cornuta	Himalayan bird cherry	*Burris, parrt*
Prunus cerasus	Pie cherry, tart or sour cherry	-
Prunus mahaleb	St. Luice cherry, Mahaleb cherry	-
Prunus tomentosa	Manchu downy, Korean cherry	*Shogun, shugun*
Prunus cerasifera	Myrobalan plum, cherry plum	*Alucha*
Other fruit tree species		
Diospyros lotus	Date plum	*Amlok*
Ficus carica	Fig	*Anjir*
Ficus palmata	Wild fig	*Jangli anjir*
Morus alba	White mulberry	*Toot*
Morus nigra	Black mulberry	*Shahtoot*
Morus serrata	-	*Toot*
Olea ferruginea	Indian olive	*Kao*
Zizyphus spp	Jujube	*Ber, anab, markhanay, singli*
Tree nuts		
Corylus jacquemontii	Hazelnut	*Mazeer, jangli badam*
Pistacia atlantica	Wild pistachio	*Toke*
Pistacia chinesis	Wild pistachio	*Shinala, kangar*
Pistacia khingjuk	Wild pistachio	*Saveer, khakaon*
Prunus bucharica	Wild almond	*Jangli badam*
Prunus kuramica	Wild almond	*Jangli badam*
Small fruits		
Duchesnea indica	Indian strawberry	-
Frageria nubicola	Wild strawberry	*Magaroos*
Ribes alpestre	Asian gooseberry	-
Ribes orientale	Wild currant	-
Rubus anatolicus	Wild blackberry	*Kanachi, karwara*
Rubus ellipticus	Golden raspberry	*Guracha*
Rubus hoffmeisterianus	Wild raspberry	*Rumu*
Rubus irritons	Wild red raspberry	*Rutuch*
Rubus macilentus	Wild yellow raspberry	-
Rubus niveus	Black raspberry, Mysore raspberry	*Buganray, bukaran*

Table 23.1: Minor Fruit Crop Resources of the Pakistan Mountains (cont'd)		
Latin Name	**English Name**	**Local Names**
Grapes and related species		
Ampelopsis vitifolia	Crow's grape	*Kawali yatch, grabuch*
Vitis jacquemontii	Wild grape	*Gidar kwar (jackal grape)*
Vitis parvifolia	-	*Kali dhak*
Vitis vinifere	Wine grape	*Angoor*
Source: Bhatti and Anwar 1990; Ishaq and Khatal (1960) Thompson et al. (1988)		

bitter. People use the fruit cooked, boiled and preserved in sugar, and for medicinal purposes. Sorbus *(Sorbus lanata)* occurs at elevations of from 2,000-3,600m. The associated species include *Abies pindrow, Picea smithiana, Cedrus deodara, Pinus wallichii,* and *Juglans regia*. The fruit is round, two to four cm in diameter, and orange with a heavy red blush flesh. The soft fruit is edible and sweet. The fruit can be kept for one month after harvesting. *Cartaegus (Cartaegus songarica)* is known locally as *Cochina* in Kohistan, *Shinjuli* in Kaghan, *Gooni* in Chital, and *Singjary* in Pushtoo. It is common in cultivated areas of Balochistan, the Kurram Valley, Chitral, Swat, Astore, Gilgit, Hazara, the Murree hills, and Kashmir at elevations of from 925-2,800m. Trees are propagated by seeds or suckers. The mature fruit hangs on the tree for several months. As well as being grown for its fruit, *Cartaegus songarica* is also used as root stock for quince and apple. Local knowledge suggests that the root stock is resistant to root rot. The *Cotoneaster* genus is represented in the region by *C. affinis, C. Integerrima, C. lindleyi,* and *C. nummularia*. *C. affinis* is found associated with *Pinus gerardiana, Cedrus deodara, Ulmus,* and *Pyrus pashia* at altitudes of from 1,100-3,000m, whereas *C. integerrima* is found at altitudes of from 2,200-4,000m. All four *Cotoneaster* species have ornamental value and the fruits are edible.

Stone Fruit Diversity

Stone fruits in the Pakistan mountains are represented by 12 species, excluding almonds (Table 23.1). These include four wild and naturally occurring species of cherry (*Prunus cerasioides, P. jacquemontii, P. prostrata, and P. cornuta*). Seven species of *Prunus* apart from sweet cherry (*Prunus avium*), which is a recent introduction, have been introduced into this area at different times in human history. *Prunus cerasioides* is very rare because the region lies at its western limit of distribution. Its distribution (up to 800m) indicates that it has low chilling requirements and is resistant to stone fruit diseases. It produces small, acid fruits and may be useful as a rootstock. *Prunus jacquemontii* is distributed widely from Balochistan to Chitral, Gilgit, and Kaghan at elevations of between 1,250 and 3,700m. Although this species is exposed to heavy grazing, it is still quite common in the wild. It produces juicy, tart edible fruits. Besides having ornamental value, it could usefully be explored as a dwarfing root stock for cherries. *Prunus prostrata* is a spreading shrub and subjected to heavy grazing. The fruits are very small and inedible. It is found on open, rocky, dry, and sunny slopes. It may be a valuable ornamental because of its flowers and the nature of its occurrence. The Himalayan bird cherry (*P. cornuta*) is common in moist, temperate regions at elevations of from 2,100-3,700m associated with *Pinus*, *Alies*, *Juglans*, and *Quercus* species. Although frequently lopped, it is found in the Kaghan Valley because there the fruits are edible. It has good compatibility as a root stock for sweet cherry. *Prunus cerasus* (pie cherry) and *P. mahaleb* (Mahaleb cherry) are introductions in this area, most probably brought in by the British as a root stock for sweet cherry or as ornamentals. Both these species are rare. *Prunus tomentosa* (Korean cherry) is cultivated for both ornamentation and for its edible fruits. *Prunus cerasifera* (*myrobalan mirabello* plum) is distributed widely throughout northern Pakistan at altitudes of from 500-2,300m. It is called *alucha* everywhere. The fruits are edible, 2-2.5 cm in diameter, and available in the market from May to mid-July. Other species of stone fruit such as *Prunus salicina* (Japanese plum), *Prunus persica* (peach), and *Prunus armeniaca* (apricot) are considered as the major fruit trees in this area.

Tree Nuts

Walnuts and almonds (*Prunus dulcis*) are cultivated tree nuts of economic importance to local communities. In addition to these, three species of *Pistacia*, two species of wild almond, and the hazelnut *Corylus jacquemontii* all grow in this area. Three wild species of *Pistacia* (*P. atlantic*, *P. chinesis*, and *P. khinjuk*) grow on dry rocks, in rock clefts, and in places inaccessible to people. *Pistacia chinesis* is mostly found in graveyards together with wild olives. The two species of wild almond are *Prunus bucharica* and *P. kurminica*. (almond). *Prunus bucharica* is very rare, *P. kuramica* grows in the Kurram Valley and in Chitral on dry slopes. Because these species have small trees and are found in areas where there is extreme drought, they may be valuable as root stock for cultivated almonds. Filberts or hazelnuts (*Corylus jacquemontii*) are found in the moist forests of the Kalam Valley, but trees are rare. The nuts are collected by local people and sometimes sold in the local market.

Diversity and Importance of Other Fruit Tree Species

Other minor fruit species occurring in the northern mountain area of Pakistan are listed in Table 23.1. These species have significant economic importance to local people, either for income or as food. Two species of mulberry (*Morus*) are found widely distributed in the area and both fresh and dried fruits are consumed by the local people. *Diospyros lotus* (date plum) is cultivated widely by villagers in the hills at altitudes of between 750 to 2,100m. Small fruits are dried and sold in the market and seedlings are also used as root stock for *D. kaki* cultivars. The wild fig, *Ficus palmata*, is also common in hilly areas. These trees produce small fruits that are edible. This species also has good attributes as a root stock for commercial figs.

Among the small fruits, there are two wild species of strawberry, three species of gooseberry, one species of blackberry, and five species of raspberry native to the area. However, the diversity of these species is threatened by overgrazing of their habitats.

Diversity of Grapes and Their Wild Relatives

There are three wild grape species in the area: *Ampelopsis vitifolia, Vitis jacquemontii,* and *Vitis parvifolia*. *Ampelopsis vitifolia* is found in Chitral, Swat, Kohistan, Hazara, and Muzaffarabad at elevations of from 900 to 2,400m growing either in moist gullies or in regions with substantial rainfall. *Vitis jacquemontii* is found in Swat, Hazara, and Azad Kashmir at elevations of between 600 and 2,400m. The vines are vigorous and climb up trees or hang over river banks. The fruits are black and juicy with tough skins and two to three seeds per berry. The fruits are edible and available in the local markets. *Vitis parvifolia* is found growing in gullies in Swat, Hazara, and Azad Kashmir. The fruits are not edible but the vines are used as fodder.

Management Concerns

Genetic vulnerability in minor fruit species and their wild relatives is pronounced in the Pakistan mountains because of population pressure and the cultivation of commercial cultivars of major fruit species. Woody species are diminishing because they are cut for timber and fuel. Small shrubs and climbers are being grazed. Species with inedible fruit are under threat of extinction. Horticultural Development Programmes by various public sector organizations and NGOs are also causing genetic erosion by introducing exotic cultivars. Some of the indigenous species such as *Sorbus lanata, Cydonia oblonga, Prunus prostrata, Prunus mahaleb, and* Cors are much more common in areas with rainfed farming than in areas where there is irrigation. On average only four crops are grown under irrigated conditions, but 20-30 crops are grown where there is no irrigation. Some crops that are grown under both irrigated and rainfed conditions, such as *Oryza sativa* and *Panicum miliacium*, have different cultivars adapted to the two types of situation. Others, such as *Setaria italica* have a single cultivar used for both conditions. Agroecosystem diversity along an altitudinal gradient is determined by the climatic constraints and farmers' needs. Food security can be achieved by growing a uniform mixture of crops over all the available land, or by growing pure crops in small plots. The coexistence of these alternatives in settled farming in the central Himalayas adds to the agroecocystem biodiversity and complexity. The factors that determine farmers' knowledge and decisions on the choice of mixed or monocropping, and the rationale behind the choice of crops and their proportions in a mixture, need to be thoroughly investigated.

Chapter 24

State of Underexploited Mountain Crops in the Indian Himalayas and Erosion Concerns

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Introduction

Environmental, biological, and sociocultural-economic variations in the Himalayas led to evolution of diverse traditional farming systems. Slash and burn agricultural systems characterised by mixing cropping and linkages with detritus-based swine husbandry are the most extensive land use in the hot and humid climates of the north-eastern Himalayas dominated by tribal populations. In contrast, settled agriculture on terraced slopes with milch cattle, goat, and sheep husbandry predominates in the relatively cold and dry climates of the central and western Himalayas inhabited largely by non-tribal populations (Ramkrishnan et al. 1994). A variety of changes in traditional farming systems has emerged in response to population pressure, technological innovations, market forces and land tenure/ownership policies, economic growth, social welfare, and environmental conservation policies. Negative trends in mountain farming, such as declining crop yields, expansion of agriculture on to marginal land (Eckholm 1975; Toky & Ramkrishnan 1981; Whittaker 1984) forest degradation (Toky & Ramkrishnan 1983), weed infestation (Saxena & Ramkrishnan 1984), loss of crop Genetic Diversity (Maikhuri et al. 1991), soil erosion and hydrological imbalances (Validiya & Bartarya 1991), and soil disintegration (Ramkrishnan 1992) dominate the sustainable development debate on the Himalayas. Yet, looking over the diversity and complexity of farming systems, there are serious limitations to generalising the trends derived from one ecological situation to the other and in formulating sustainable development strategies based on generalisations (Thompson & Warburton 1985 ab; Rao & Saxena 1994).

The neglect of traditional mountain crops and cropping systems in agricultural research and development has been largely due to the minor role of mountain agriculture in the aggregate national economy and a smaller proportion of agricultural land in the mountains. Hardly 20 per cent of the geographical area of the Indian Himalayas is reported to be under cultivation, compared to 46 per cent as a national average. Yet, agriculture is crucial for the 51 million people living in the Himalayas; agriculture being the primary occupation of 92 per cent of the total population of the Indian Himalayas. The Himalayan mountains are a reservoir of large numbers of traditional crops of which the economic and ecological potentials are not yet fully exploited (Maikhuri et. al. 1991). This article deals with the extent of agricultural diversity in traditional settled agroecosystems of the central Himalayas, the impacts of external factors on agrobiodiversity, and ecological and economic opportunities for and constraints in promoting agriculture-based sustainable development in the region.

Farming System - The Ecological and Socioeconomic Setting

Land Holding

Settled agriculture in the central Himalayas (the hill area of Uttar Pradesh Province) is practised on privately-owned land; the ownership rights of which are inherited. The average size of land holding is 0.95 ha. Pressure on land in the Indian Central Himalayas is thus not as severe as in other comparable areas such as Nepal, Bhutan, and Afghanistan (0.13 ha, 0.10 ha and 0.53 ha, respectively).

Fragmentation of Holdings

Field scattering or field dispersion is a common feature of non-commercial agriculture in mountain regions. By planting several dispersed fields rather than a consolidated one, farmers tend to reduce the risks of environmental unpredictability and variability in the productive potential of the site. The degree of fragmentation is generally high on more heterogeneous sloping land (2-6 parcels of land owned by a family) than on homogeneous valley land (1-3 parcels of land owned by a family). Large holdings (1-5 ha) consist of three to seven dispersed fields compared to small holdings of less than one ha consisting of two to three dispersed fields. Fragmentation could be an efficient way of holding land at the cost of inefficiency, resulting from unproductive use of time and energy involved in travelling and transporting materials between distant fields. The degree of fragmentation in the Central Himalayas is much less than in other mountain regions where farmers may cultivate as many as nine-25 dispersed fields.

The most distant fields are often located far away on valley land at a distance of six to eight km from the dwelling in the uplands. Fields in the valley are so small that permanent stay there is not as advantageous as in the uplands where the fields are much larger. These circumstances force cooperation within a farming community. Farmers of a given social group from a hamlet share a common temporary house on valley land as and when needed. However, caste feeling is so strong and deep-rooted that the socially privileged (higher caste) and lower caste (scheduled castes) families never share a common house. Maintenance of irrigation canals is a responsibility assumed by the community. A couple of individuals capable of discharging these responsibilities are identified from a hamlet on a yearly rotation basis. These individuals, who suffer some loss on account of neglect of their upland fields, are compensated by contributions of food grains from each household during the year.

Efforts for consolidation of holdings by the Government were unsuccessful. The unifying government policy for consolidation is based on classification of cultivated land into four categories, viz., land producing rice only, land producing one crop a year other than rice, land producing two crops a year, land subject to fluvial action, and valuation of exchange ratio for conservation from one category to the other. Statutory provisions stipulate implementation of a consolidation package after it is accepted by the village community and not as an enforcement. Consolidation is not acceptable to the people by the village community and not as an enforcement. Consolidation is not acceptable to the people as they value the advantages of raising a variety of crops on fragmented holdings heterogeneous environmentally and, through that, achieving food security at household level, more than the advantage of saving time and energy in cultivating a consolidated holding.

Farm - Forest Linkage

Crop yields are sustained with nutrient, water, energy, and organic matter inputs from the surrounding forests. The farm output thus is a function of direct as well as indirect values of the forest (Rao & Saxena 1996). A sustained supply of nutrients in the agricultural land is managed through organic manure derived from leaf litter collected from the forest floor and excreta from the livestock. Livestock feed requirements are met partly from crop by-products and partly from grazing in the forests. Sustainable agriculture in traditional agriculture meant sustainable use of forest resources.

Farmers' concerns for forest conservation are also reflected in the maintenance of fuelwood and fodder-yielding trees on private farms, particularly in rainfed farming systems. The average density of trees in traditional agroforestry systems falls in the range of from 300 to 400 trees per ha. *Celtis australis* was found to provide the highest amount of green fodder, followed by *Boehmeria rugulosa* and *Grewia optiva*. The traditional value of farm-forest linkages eroded following denial of free access to the people of forests. At present, forests are owned by the Government/State and assertion of ownership rights by the government often leads to forest degradation/deforestation due to excessive biomass removal from the forests or encroachment on forest land by local communities.

Agricultural Development Interventions

Supply of inorganic fertilizers and high-yielding varieties of seeds of wheat/paddy at subsidised prices are the most prominent government-driven development interventions that have induced changes in the traditional agribiodiversity and crop management practices over the last couple of decades in the Himalayas. Absorption of these interventions into the traditional farming system is confined to the easily accessible areas with moderate climates. These interventions have reached high altitude areas characterised by extreme cool climates and high degrees of inaccessibility to a very limited extent.

Environmental Heterogeneity and Crop Diversity

Altitudinal Distribution

Some crops such as *Allium cepa*, *Zingiber officinale*, and *Vigna radiata* are grown at lower altitudes (up to 1,200 masl) characterised by warmer temperatures. The crops with distribution restricted to cool climates at high altitudes include *Chenopodium album*, *Fagopyrum tataricum*, *Fagopyrum esculentum*, and *Secale cereale*. *Triticum aestivum* and *Amaranthus oleracea* are crops that exhibit widest distribution range. The crop diversity, when considered at village or watershed levels, depends upon the altitudinal variation existing in the area under consideration (Table 24.1). In an area in which the altitude varies from 500 to 2,500 masl, one is likely to get about 40 crops.

Irrigation

Irrigation is practised up to an altitudinal limit of 1,800 m. Irrigated farming is largely confined to the valleys and covers only 11 per cent of the total net sown area. Rainfed agricultural practices thus dominate the area. Biodiversity, if looked at as the number of crops grown, is much higher in rainfed farming than in irrigated farming. Only four crops are grown in irrigated conditions, while 20-30 crops are grown under unirrigated conditions. Crops, such as *Oryza sativa* and *Panicum miliacium*, that are grown in both irrigated and rainfed conditions, have different cultivars adapted to two types of situation. On the other hand, the same cultivar is used for irrigated and unirrigated conditions in the case of a crop like *Setaria italica*.

Table 24.1: **Agricultural Crop Diversity Across an Altitudinal Gradient in the Central Himalaya**

Crop species	English name	Vernacular name	Altitudinal range (masl)
Allium cepa	Onion	*Pyaz*	500-1100
Amaranthus oleracea	Amaranth	*Chauli*	500-2500
Avena sativa	Oat	*Jail*	2000 - 2500
A. Frumentaceus	Amaranth	*Chuwa/Marcha*	1500 - 2500
Brassica compestris	Mustard	*Sarson*	500 - 2200
Brassica spp	Mustard	*Toriya*	500 - 2000
Cajanus cajan	Pigeon	*Tor*	500 - 1800
Canabis sativa	Hemp	*Bhang*	1500 - 2500
Chenopodium album	Pig-weed	*Bathuwa*	2000 - 2500
Cleome viscosa		*Jakhiya*	500 - 1500
Colocasia himalayensis		*Pindalu/Kuchain*	500 - 1500
Echinochloa frumentacea		*Barnyard millet (Jhangora)*	500 - 1800
Eleusine coracana	Finger millet	*Koda*	500 - 2000
Fagopyrum esculentum	Buckwheat	*Oggal*	1900 - 2500
Fagopyrum tataricum	Buckwheat	*Phaphar*	1900 - 2500
Glycine soja	Soybean	*Bhatt*	800 - 1800
Glycine spp	Soybean	*Kala bhatt*	1100 - 1800
Glycine max	Soybean	*Soybean*	500 - 1500
Hordeum himalayens	Naked barley	*O-wu-jau*	1500 - 2300
Hordeum vulgare	Barley	*Jau*	500 - 1500
Lens esculenta	Lentil	*Masoor*	500 - 2000
Macrotyloma uniflorum	Horsegram	*Gahat*	500 - 1800
Oryza sativa	Paddy	*Satti*	500 - 1800
Oryza sativa	Paddy	*Dhan*	500 - 1500
Panicum miliaceum	Hogmillet	*Cheena/Bhangna*	500 - 2000
Papaver somniferum	Poppy	*Post*	1200 - 2300
Perilla frutescense	Perilla	*Bajeera*	1000 - 1700
Phaseolus vulgaris	Kidney bean	*Razma*	1500 - 2500
Pisum sativum	Pea	*Matar*	500 - 1500
Sesamum indicum	Sesame	*Til*	500 - 1500
Setaria italica	Foxtail millet	*Kauni*	500 - 1800
Solanum tuberosum	Potato	*Alu*	1000 - 2500
Triticum aestivum	Wheat	*Gehun*	500 - 2500
Vigna aconitifolia	Mat bean	*Bhringa*	800 - 1600
V. angularis	Adjuki bean	*Rains*	900 - 2200
V. mungo	Black gram	*Urad*	500 - 1800
V. radiata	Green gram	*Mung*	500 - 1000
V. unguiculata	Cow pea	*Sonta*	500 - 1800
V. umbellata	Rice bean	*Bhotiya*	1500 - 2000
Zea mays	Maize	*Mungri*	500 - 1800
Zingiber officinale	Ginger	*Adrak*	500 - 1200

Cropping Seasons and Crop Rotations

Two crops in a year can be harvested up to an altitutde of 1,800 m. Farmers, however, take two harvests a year in irrigated conditions and three crops in two years in rainfed conditions. There are two growing seasons in the year - summer/

rainy season (April - October) and the winter season (October-April). Thus, rainfed agricultural land is fallowed in one growing season out of four available over a period of two years. Only one crop can be harvested in a year because of the longer maturity period in cool climate areas above 2,000 masl. Wheat in these areas takes 11-12 months to mature. The cold adapted high altitude cultivar of wheat is different from the one grown at warmer, lower altitudes. Agroecosystem diversity along an altitudinal gradie1nt is thus determined by the climatic constraints and farmers' needs.

Mixed and Monocropping

Food security can be achieved by growing a uniform mixture of crops all over the available land or by growing pure crops in small plots. The coexistence of these alternatives in settled farming in the Central Himalayas adds to the agroecosystem biodiversity and complexity. The factors that determine farmers' knowledge and decisions about the relative areas under mixed and monocropping, and the rationale behind making a choice of crops and their proportions in a mixture, need to be thoroughly investigated.

Genetic Erosion

Table 24.2 shows that the cultivation area for traditional crops declined tremendously during the last two decades (between 1970-74 and 1990-94). The area under *Panicum miliaceum* and *Setaria italica* decreased by 65 per cent. These crops were replaced by high-yielding rice varieties and cash crops such as soybean, the seeds of which are supplied by government agencies. In rainfed agroecosystems the area planted with traditional crops, such as *Avena sativa*, *Fagopyrum* spp, *Vigna* spp, *Hordeum* spp, *Hordeum* spp, and *Macrotyloma uniflorum*, has decreased by 72-95 per cent because of increasing emphasis on cash crops such as potato, soybean, *rajma* (broad beans), pigeon pea, mustard, and amaranth.

Although the area of irrigated and rainfed land under paddy has not changed, the traditional indigenous varieties have been almost completely replaced by the introduced high-yielding varieties China-4, Taichung, Govinda, and Seket-7. The same is true for wheat, traditional varieties have been replaced by high-yielding one. Crops such as *Parilla frutescense, Macrotyloma uniflorum*, and *Vigna* spp are now on the verge of extinction.

It is hard to say to what extent the genetic base has already been eroded, but the supply of inputs such as high-yielding varieties, inorganic fertilizers, pesticides, and irrigation facilities since the 1970s has encouraged replacement of native land races. In the Himalayan Gazettes of 1882, Atkinson listed 48

Table 24.2: **Area in ha/village under Different Traditional Crops in the Summer and Winter Seasons during 1970-74 and 1990-94 (average of about 150 villages in 11 valleys of the Central Himalayas)**

Crop/Cropping Season	Area in ha/village		Replaced by	Redu. in area, %
	1970-74	1990-94		
***Kharif** Season Crops**				
Panicum miliaceum	14.2	4.9	High-yielding rice varieties	65.5
Oryza sativa	14.2	14.2	Traditional rice varieties by HYV	-
Avena sativa	15.8	3.4	Potatoes	78.5
Fagopyrum tataricum	8.6	1.5	Potatoes and *rajma* (broad beans)	82.5
Fagopyrum esculentum	4.1	0.3	Rajma	92.7
Parilla frutescense	1.3	-	Soybeans	100.0
Setaria italica	2.3	0.8	Soybeans	65.2
Oryza sativa	11.2	11.2	Traditional rice varieties by HYV	-
Eleusine coracana	9.6	6.1	Soybeans and amaranth	36.5
Macrotyloma uniflorum	2.1	-	Soybeans and amaranth	100.0
Echinochloa frumentacea	2.5	0.7	Pigeon peas	72.0
Vigna spp	3.3	-	Pigeon peas and amaranth	100.0
***Rabi** Season Crops**				
T.aestivum+B.compestris	14.2	14.2	Traditional wheat varieties by HYV	-
Hordeum himalayens	17.1	4.7	Potato, amaranth and rajma	72.5
Hordeum vulgare	7.0	1.1	Improved mustard varieties	84.3
Brassica compestris	2.0	2.0	No change	-

(Source: Maikhuri et al. 1996)
**Kharif* = summer; *rabi* = winter

varieties of rice and stated that there were thousands of other nondescript varieties. Today only seven or eight of these varieties are cultivated, with only *Ramjawan, Thapachini, Lalmati, and Rikhva* on irrigated land and *Chiyasu* in rainfed areas. Wheat has also lost innumerable varieties and 90 per cent of the crop on irrigated land is planted at present with a single improved variety called *Sonalika*. This is one of the evident effects in cash crops and modern varieties of staple crops found in the study (Maikhuri et al. 1991; Shiva and Ram Prasad 1993; Kothari 1994).

Yield Potential

Fagopyrum + potatoes gave the highest yields followed by *Amaranthus* + *Phaseolus* spp. The monetary efficiency ratio was higher for mixed cropping than for monocropping. The combination of *Macrotyloma* and *Eleusine* (traditional crops) gave the highest yield of all the traditional *kharif* (rainy/summer) season crops at all altitudes. All the traditional crops, whether grown as pure or mixed crops, apart from the combination *Macrotyloma* + *Eleusine* practised at lower altitudes, exhibited a higher monetary efficiency than common crops of wheat and paddy.

Panicum miliacium (perso millet) is adapted to high altitudes and is cultivated exclusively on irrigated land. Its climatic and maturity requirements are such that it can be grown during the short fallow period between the major winter and summer growing seasons. It can be also be grown as a summer crop (Table 24.3).

Table 24.3: **Annual Yield of Grain and By-products (kg/ha/yr) and Monetary Input/Output (Rs/ha/yr) for *Panicum Miliaceum*, A Neglected Crop of the Central Himalayas**

Elevation	Yield (kg/ha/yr)		Monetary input/output per crop (IRS)		Efficiency ratio (IRs/ha/yr)
	Grain	By-products	Input	Output	Output:/input
High altitude (1800-2400 masl) *Panicum miliaceum**	1966	4476	1908	5310	2.8
Lower altitude (500-1000 masl) *Panicum miliaceum***	2102	5152	2303	7510	3.3

* Cultivated during *kharif* season (mid-June to mid-August)

** Intermediate crop grown between *rabi* and *kharif* seasons (May-June)

(Source: Semwal and Maikhuri 1996)

The yield trial experiments conducted by Shiva and Ram Prasad (1993) to compare traditional and modern varieties of paddy show that traditional varieties not only provide better grain yields than modern varieties, they also give better yields of crop by-products. Since crop by-products are used as livestock feed, higher biomass production by traditional crops should mean less pressure on forests to meet livestock fodder requirements. High livestock productivity also implies adequate organic manure and thereby maintenance of soil fertility, as well as provision of draught power in an area in which mechanisation is out of reach for a variety of reasons. These locally available inputs are critical for sustainable agriculture in the mountains where inaccessibility and economic marginality are the crucial problems. However, the superiority of local varieties over introduced breeds cannot be generalised upon broadly because of the fact that there are few comparative studies.

Food Security and Mountain Crops

Dependency on traditional crops is more prominent in high altitude than low altitude areas. Among the traditional crops, millets contribute more than pseudocereals and pulses in the local diet across an altitudinal gradient. The contribution of food energy and protein obtained from animal products (sheep, goats, and wild animals such as wild boar and deer) is much less than that of crops. People in high altitude villages even today are less dependent on markets for their supply of food grains. Purchase of grains is negligible.

Remoteness and isolation in the mountains fostered the evolution of cropping systems that provide variety and avoid risks. Such selective adaptation in land use helped develop self-reliance in respect of food security. The introduction of a public distribution system in the mid-sixties that provided staple food grains at subsidised prices led to a number of changes in traditional agriculture. There was a shift in attitude from considering agriculture as a means of subsistence to considering agriculture as an economic activity. Food habits also changed. So-called 'coarse' grains, such as finger millet (*Eleusine coracana*), *jhangora* (*Echinochloa colunun*), *chinna* (*Setaria italica*), and buckwheat (*Fagopyrum tataricum*), that were locally produced but not available through the public distribution system became of secondary importance. The habit of eating wheat and rice purchased from the market gradually became firmly established as a status symbol. All this led to a reduction in crop diversity, and a change from a system of food security based on local produce to a market dependent system of food security.

Market Economy

Many traditional crops are also exported every year by the locals of high and mid-Himalayan villages in order to earn cash to meet their other basic requirements (Table 24.4). *Amaranth*, kidney beans, and potatoes are the main crops exported. A traditional barter exchange system still operates but is on the wane. The inherent cultural value of the barter system was that food was regarded as the basic requirement for sustaining life, that should be available to all irrespective of their socioeconomic status. This idea is being eroded by the penetration of a monetary

Table 24.4: Export of Traditional and Other Cash Crops (per capita per yr) from Higher and Mid-Himalayan Villages Located between 1,200 and 2,400 masl in the Central Himalayas (prices in 1996)

Traditional and Other Cash Crops	Selling Price in Local Market (IRs/Kg)	Selling Price in Nearest Urban Centre (IRs/Kg)	Net Profit Gained by Middlemen Traders (IRs/Kg)
Amaranthus spp	8.0	15.0	7.0
Fagopyrum esculentum	9.0	18.0	9.0
Fagopyrum tataricum	8.0	15.0	7.0
Phaseolus vulgaris	10.0	15.0	5.0
Vigna angularis	8.0	12.0	4.0
Macrotyloma uniflorum	9.0	20.0	11.0
Cajanus cajan	12.0	25.0	13.0
Cleome viscosa	10.0	40.0	30.0
Solannnnum tuberosum	0.8	3.0	2.2

Source: Maikhuri et al. 1996

economy that has accompanied improvements in accessibility. Poor and uneducated farmers are often forced by powerful alien traders to exchange their high priced traditional crops for low-value crops. The natives of this region are badly exploited by middlemen who earn more than 50 per cent of the profits. Local communities are not sufficiently aware of the market prices and thus are unable to demand the full profit. If proper marketing policies were to be framed and implemented, the food security of mountain people could certainly be improved.

Value of Neglected Mountain Crops

Table 24.5 shows the per capita annual consumption of and amount of energy and protein provided by traditional crops and other foods at different altitudes in the Himalayas.

Table 24.5: **Per Capita Annual Consumption of Different Traditional Crops by the Local Population in Relation to Other Food Items at Different Altitudes in the Central Himalayas during 1990-94**

Food items	Lower altitudes (500-1000 masl)			Middle altitudes (1000-1800 masl)			High altitudes (2000-2500 masl)		
	QuaN. (Kg/lit)	Energy (MJ)	Protein (Kg)	Quan. (Kg/lit)	Energy (MJ)	Protein (Kg)	Quan. (Kg/lit)	Energy (MJ)	Protein (Kg)
Traditional crops	24.9	369.8	3.79	70.4	969.4	8.68	122.8	1730.2	15.7
Common crops	119.9	1942.5	11.7	103.7	1680.0	8.8	49.8	806.7	4.6
Imported/exchanged	68.7	1119.7	7.28	54.4	885.7	5.83	56.1	908.8	4.6
Animal products	50.5	152.7	2.66	74.2	227.8	3.9	102.3	323.6	6.4
Vegetables	20.5	318.8	1.7	26.5	412.5	1.9	40.6	631.3	3.5
Total	284.5	3903.5	27.13	329.2	4169.4	29.1	371.6	4361.6	34.8

(Source: Maikhuri et al. 1996)

The majority of traditional crops possess immense medicinal properties (Box 24.1). The grains of *Setaria italica, Panicum miliaceum,* and *Echinochloa frumentacea* are used to treat diarrhoea and other kinds of abdominal ailments. Soup made from *Macrotyloma uniflorum* is used to dissolve stones.

Traditional, settled mountain agriculture has a considerable potential for meeting local food requirements and also providing cash income for farmers. A variety of interventions is needed to improve the productivity and profitability of these systems and at the same time assure conservation of Genetic Diversity at the crop, cultivar, agroecosystem, and landscape levels. The strategic priorities should focus on the following.

- Improvement in scientific knowledge of the ecological and socioeconomic functions of agrobiodiversity

Box 24.1

List of Traditional Mountain Crops Having Medicinal Properties

Botanical Name	Vernacular Name	Medicinal Uses
Fagopyrum esculentum	*Oggal*	Grains are used to treat colic, choleraic diarrhoea, and all kinds of abdominal ailments
Fagopyrum tataricum	*Phaphar*	Grains are a good source of protein and used by diabetic patients
Macrotyloma uniflorum	*Gahat*	Soup from grains is used as a cure for kidney stones
Panicum miliaceum	*Chena*	Grains cooked with curd are given to patients suffering from jaundice
Avena sativa	Oats	Commercially exploited for ergot, used as a medicine
Setaria italica	*Kauni*	Cooked grains are known to be good for patients suffering from diseases such as typhoid fever and pneumonia.
Echinochloa frumentacea	*Jhangora*	Cooked grains are given to patients suffering from jaundice; grain husks are rubbed on the skin of patients suffering from the same diseases
Parilla frutescens	*Bangjeera*	Oil used to massage newborns

- Improvement of traditional agronomic practices and technologies for soil fertility management, rather than introduction of altogether new technologies
- Recognition of the special status of villages where traditional agrobiodiversity has eroded least
- Linking agrobiodiversity with biodiversity of natural ecosystems
- Establishment of 'crop parks' and 'gardens' analogous to national parks and botanical gardens
- Promotion of village marketing cooperatives through appropriate policies to avoid exploitation by middlemen
- Exploration of avenues for adding value to traditional crop produce and of potential market demand for such produce.

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Chapter 25

Diversity of Land Races and Wild Relatives of the Soybean in China

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The soybean, *Glycine max* (L.) Merr originated in China. Its wild ancestors *G. soja Sieb.* and *G. soja* are distributed throughout China and the adjacent areas of Russia, Korea, and Japan. They grow in fields and hedgerows and along roadsides and river banks. The statistics of the Chinese Ministry of Agriculture show that soybeans are grown over an area of 9.3 million hectares, with a production in 1993 of one million metric tonnes. So far, China has collected more than 17,000 accessions of *G. max*, more than 5,200 accessions of *G. soja*, and two perennial species, *G. tabacinal (Labill.)* Benth and G. tomentella Hayata.

Diversity of *Glycine soja*

G. soja is distributed from Guangdong province (about 24°N) in the south to the Heilongjiang river (52°55'N) in the north. There are many populations, and each of them covers a wide area. Different types of *G. soja* have evolved in different environments. A wild soybean collection has been organized on a national scale since 1979. A lot of new wild types, with wild white flowers, very narrow leaves, and different seed coat colours have been found. A total of 5,200 samples has been characterised on the basis of plant morphological traits. A further 1,000 wild soybean types have also been recorded recently.

The protein content of 5,147 wild soybean germplasm samples was analysed. The mean content of protein was 45.49 per cent for typical wild soybeans and 44.6 per cent for semi-wild types. There was a significant positive correlation between protein content and longitude in typical wild soybean samples ($r = 0.85^{***}$). High protein wild soybeans occurred in the central area and parts of the northeast and Yangtze River regions. Low protein content soybeans occurred in the Yellow River region and the southern part of China, especially in the Ningxia and Tibetan plateau regions. The protein content of wild soybean was higher than that of cultivated soybeans. There were 349 accessions of Chinese wild soybeans with a protein content of more than 50 per cent, one of them was as high as 55.37 per cent.

The mean oil content of wild soybean accessions was 8.38 per cent, the highest content 13.9 per cent, and the lowest 4.8 per cent. The oil content of wild soybeans was related to hilum colour, seed coat colour, bloom on the seed coat, 100-seed weight, leaf shape, and plant height. The mean oil content of wild soybeans was lower than that of cultivated soybeans.

The wild soybean, *Glycine soja,* is believed to be the progenitor of the cultivated soybean, *G. max*. These two species produce fertile offspring upon hybridisation. Evaluating genetic variation in *Glycine soja* will not only help facilitate its use in breeding programmes, but also provide information about conservation needs and strategies.

The Diversity of *Glycine max*

Tens of thousands of soybean varieties were reported. This high number is the result of the large territory, diverse terrain and climate, and long history of cultivation and natural and human induced selection. Different cultivars fit different environments and culture system, and can meet the different needs of people.

A total of 23,000 soybean land race cultivars were collected during surveys made in 1956, 1979, and 1990 and listed in the Chinese Soybean Varieties Resources' catalogue. These soybean land races belong to the erect types (62.6%), semi-erect types (23.81%), and twining and semi-twining types.

The majority of the accessions (60.1%) have a yellow seed coat. The other seed coat colours are black, 8.2 per cent; green, 15.0 per cent; and bicolour, 2.76 per cent. Most Chinese soybeans have small (33%) or medium (43%) sized seeds. Eighteen per cent have large seeds, 3.8 per cent very large seeds, and 1.28 per cent extremely large seeds. The protein content of 49 per cent of Chinese soyabean germplasm ranged from 40 to 48 per cent.

The oil content of most varieties was below 20 per cent; 1,394 lines had an oil content of between 20 and 22 per cent and 113 lines had an oil content between 22 and 28 per cent. Only 38 varieties had more than 23 per cent oil, and these were concentrated in the northeast and north, spring planting soybean areas. The highest oil content found was 24.2 per cent for 'Wu Zhai Huang Dou'.

Box 25.1

Research and Conservation Efforts on Crop Genetic Resources: A Comparison between the Plains and Mountains of China

Gene banks are the most important strategy employed in China to address the conservation of plant Genetic Diversity, Dr. Xu said. They are based on collections of genetic material from centres of crop origin and elsewhere that are stored under controlled conditions and periodically regenerated. China has invested a lot of resources in developing facilities for *ex situ* conservation. To date a total of 20 modern gene banks has been established throughout the country. The Institute of Crop Germplasm Resources, Chinese Academy of Agricultural Sciences, is responsible for the long-term preservation of all crop germplasm resources. Currently a total of 360,000 accessions have been preserved and 80% of them are land races. Seeds of the following crops are preserved (listed in order of priority): rice, wheat, soybean, vegetables, millet, food legumes, oil crops, barley, sorghum, maize, cotton, sugarbeet, bast fibre crops, forage grass, tobacco, buckwheat, amaranths, watermelon, muskmelon, and green manure.

The gene banks cannot conserve all types of on-farm species. China has institutionalised a method for conserving live plants in the field as 'field nurseries' for germplasm resources. Dr. Xu said there is a total of 25 field nurseries that maintains 20,000 accessions of germplasm for perennial and crop species such as tea, fruit trees, wild grapes, mulberry, rubber, and sugarcane.

In recent years more emphasis has been given to the collection of germplasm from mountain regions of China such as Yunnan province, the Tibetan autonomous region, the Shennong mountain chain, Henan province, the Daba mountain chain, and the South Guizhou and West Guangxi regions. The proportion of germplasm diversity conserved from the mountains is relatively very small.

In China, there is more experience of *ex situ* conservation than of *in situ* conservation. There has been only poor institutional support for *ex situ* conservation of agrobiodiversity in mountain agroecosystems, however, as a result of inadequate funding, expertise, and facilities.

(Source: Liu Xu 1996)

Thirty-eight varieties had a linoleic acid content above 60 per cent of the total oil. The highest linoleic acid content reported was 63.4 per cent for 'Long Yao Hei Dou'.

A total of 874 of the soybean land races was resistant to drought, all of them were from the northwest of China where there is less rainfall. Varieties with both sprouting and plant resistance to drought came from Shandong, Henan, Hebei, Shanxi, and Shannxi.

Use of Soybeans

About 400 cultivars have been developed by breeding programmes using elite local varieties and pure-line cultivars as one of the parents. Pedigree analysis shows that the genetic base of Chinese soybean cultivars is tending to become narrower.

Introduced soybean germplasm enriches the Genetic Diversity of Chinese soybean germplasm, and has a great effect on breeding, especially on high yield, disease resistance, and high quality characteristics. The cultivar 'Hefen 27' is a good example. It is highly resistant to frog eye leafspot, a characteristic developed by using 'Rampage', an American cultivar, as one of the parents. 'Liaodou No. 3' and 'Heihe No. 5' cultivars, which have high yields, were derived from 'Amsoy'.

In China, soybean is processed mainly for edible oil and meal (feed purposes) by using different extraction processes. Improvement in yields through improved soybean cultivars has been slow over the past 40 years. Recently, soybean pests and diseases have become an important factor in soybean production, the soybean cyst nematode in particular has become a widespread problem. A critical problem for the breeder is how to use the large number of germplasm lines effectively and find sources for further improvement. Special attention needs to be focussed on the following aspects.

- Collection and evaluation of germplasm of soybean varieties in remote areas
- Collection and evaluation of wild soybean accessions, and studies of the population biology and ecology of natural populations
- Analysis of the Genetic Diversity of soybeans to select cultivars for diverse agroclimates in the mountains
- Conserving the Genetic Diversity of soybean germplasm, especially *in situ* conservation of cultivated soybeans and natural populations of wild soybeans.

Reference

Liu Xu, 1996. 'Research and Conservation Efforts on Crop Genetic Resources: A Comparison between Plains and Mountains of China'. Paper Presented in the ICIMOD Expert Meeting on Agricultural Biodiversity in the Hindu Kush-Himalayan Region; Status and Management Issues in China, Chengdu, June 11-12.

Chapter 26

What is Happening to the Diversity of Rice Genetic Resources in China?

Pei Yanlong, W. Lianzheng,
Gao Li Zhi, and Hong De Yuan

Rice (*Oryza sativa* L.) is the most important grain crop in China. More than half of the population of China depends on this cereal and China takes the first place in the world for total rough rice output and the second place for total rice cultivation area. In 1990 rice was cultivated on about 33.06 million ha, with a total gross rice output of 191.75 million tons.

Box 26.1

The Current Status and Prospects for Conservation of the Genetic Diversity of Rice and Its Wild Relatives in China

China once had a very rich diversity of land races, wild species, and wild relatives. At present, genetic erosion in cultivated rice is reported to be high at both the varietal and the species' levels. This has been caused largely by social factors: technology diffusion, commercialisation, changing preferences, over-exploitation, and government policy. Farmers are increasingly interested in growing hybrid rice because of high yields and the secure government seed supply system. The immediate impact has been seen in the rapid decrease in cultivation of land races. There has been a 46-fold reduction in local varieties within four decades. Land races are not officially promoted and seed is not available through official channels. Knowledge about the proportion of marginal land planted with rice land races is scanty.

The status of wild rice is also not very promising. *Oryza rufipogon* is already considered to be endangered, and the populations of *O. officinalis* and *O. meyeriara* are dwindling fast. The main reason is rapid urbanisation and construction which is destroying the natural habitat of wild rice in China. It is believed that *ex situ* collection of wild rice would be sufficient for breeding purposes if wild rice is lost from the natural habitats. The gene flow from wild rice to land races, and from cultivated rice to wild rice, has been a dynamic process and its value cannot be underestimated.

The Genetic Diversity of Cultivated Rice and Its Wild Relatives in China

The diversity of varieties of cultivated rice in China is shown in the diversity of ecological adaptation characteristics and in the morphological polymorphy. Studies on the classification of cultivated rice have shown its high level of genetic variability and provided scientific evidence for further use and improvement of varieties. The main agronomic traits of cultivated rice in China have been identified and evaluated.

The variability of esterase isozymes was studied in 226 rice varieties and plentiful zymogram types indigenous to Yunnan Province, especially south-west Yunnan (Zhu Yinggno et al. 1984). Two hundred and fifty-two accessions of indigenous rice varieties from Yunnan were investigated using horizontal starch gel electrophoresis, and abundant genetic variability was found at six loci out of seven loci scored. Other studies have confirmed that cultivated rice from Yunnan has the highest level of Genetic Diversity in China, as shown by isozymes (Xiong Jianhua 1987,1988; Cai Hongwei et al. 1992).

Why are Wild Rice Species in Danger in China?

There are two reasons for losing biodiversity, one is natural extinction and the other is human activity. Wild rice, *O.rufipogon,* grows in sunny habitats such as marshes, ponds, and ditches, or on the mountain valley slopes near or under the tropical and/or sub-tropical forests. In these areas the environment has been changing extensively because of the crowded population and growing commercialisation.

Human activities have changed the habitats of O. *rufipogon*. As the habitats became parched, humid plant species and even xerophytes invaded and competed with O. *rufipogon*. Deep water and strong pressures from grazing affected its natural propagation, reducing its superiority in the community. Both the habitat and structure of the O. *rufipogon* community is changing because of the activities of planting wild rice species such as *Zizania* spp and lotus (*Nelumbo nicifera* Gertn). The special natural habitats of O. *officianlis* and O. *meyeriana* have been destroyed as a result of felling trees, reclaiming land, and planting commercial crops such as rubber trees, bananas, and corn. The populations of O. *meyeriana* in Yunnan are threatened by the malignant weed, *Eupatorium coelestrium*, which is fast invading the tropical and sub-tropical forests of Yunnan.

Our investigation shows that the main reasons for the endangered status of wild rice species in China is human disturbance and habitat destruction. However, because of the limited understanding of values and lack of awareness of the results of the loss of Genetic Diversity of wild rice by the government and the public, effective conservation measures have not yet been taken. At the present rate, wild rice will be extinct in China soon unless immediate efforts are taken to save it.

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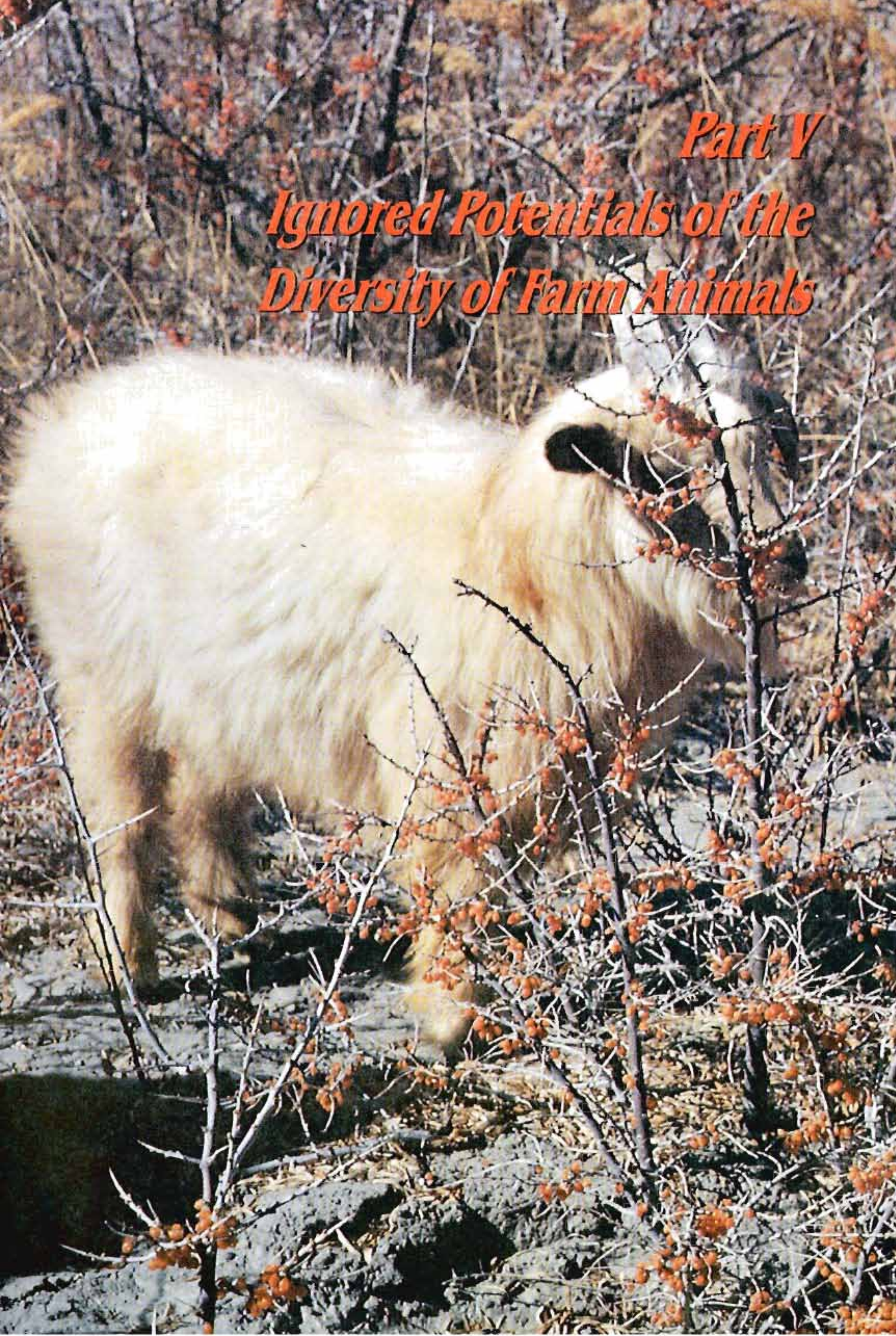
Part V
Ignored Potentials of the Diversity of Farm Animals



Chapter 27

Unique Livestock Resources of Mountain Farmers and the Compatibility of On-farm Conservation Efforts with Livestock Development Approaches

B. R. Joshi and D. P. Rasali

The Unique Livestock Resources of Mountain Farmers

Biodiversity of Farm Animal Genetic Resources in the Himalayas exists in the form of variety and variation in species, sub-species, breeds, types, varieties, strains, and lines, and in some specific population groups and sub-groups, or even at the individual level. All these represent unique genotypes or forms of gene constructs evolved through natural or artificial breeding and selection over generations. These different animals have been evolved over time to serve man for specific purposes or uses according to the needs of specific agroclimatic regions. Description, documentation, development, and conservation of biodiversity of such animal genetic resources should, therefore, focus on their continuous use in an efficient, systematic and judicious way in order to ensure the sustainability of such resources for meeting all sorts of future needs.

The spectrum of farm animal biodiversity in the Himalayan and sub-Himalayan region of the Indian sub-continent is wide, rich, and varied. This is evident from the presence of a number of types or breeds of sheep, goats, horses, cattle, mithun (ox), yaks, and even camels. These types seem to have been developed through breeding and selection over time. Some salient features of the status of farm animal biodiversity in the Himalayas, as well as its changing pattern, are well described in Balain (1996). Some of the different breeds of animals are described in the following.

Yak

The yak or grunting ox (*Bos grunniens L.*) is a native of Tibet and surrounding countries in Central Asia. It is found at elevations of from 4,000-6,000 masl. In

India they are found in the Ladakh plateau, the valleys of Panni, Chini, Lahaul, Spiti and Sangla in Himachal Pradesh, the Garhwal hills in Uttar Pradesh, the West Kameng and Tawang districts of Arunachal Pradesh, and the northern district of Sikkim. About 39,000 yaks are distributed in the above hill states of India, of which 15,000 are present in Ladakh alone. The yak is an excellent pack animal in the hypoxic environment of the high altitude mountains of the Himalayas. The domesticated yaks are relatively small and of variable colour. Yaks provide milk, meat, hair, hide, and wool to the highlanders. At lower altitudes and in valleys, the yak is now being increasingly crossed with local cattle in order to produce different types of hybrids for agricultural operations.

Mithun

The mithun (*Bos frontalis*) is considered to be a ceremonial ox by tribesmen in the north-eastern hill states of India and adjoining areas of Burma, Bhutan, and the Chittagong hills of Bangladesh. They are raised under semi-wild conditions and are generally found at altitudes between 600 and 1,500 masl. The largest populations of mithun are found in Arunachal Pradesh and Bhutan. Mithun crosses are also maintained for milk.

Manipuri Horse

This breed has been found in Manipur and Assam for many centuries. It is very well known for its elegance, shape, and surefootedness on sloping hill terrain. The breed is in great demand for polo, racing, and military transport in the hills.

Spiti Horse

This breed of ponies inhabits the Spiti Valley of Himachal Pradesh. The animals are hardy and sure footed like other hilly horse breeds. The breed thrives in the cold arid region of the Himalayan mountains and can withstand adverse climatic conditions. No more than a few thousand pure-bred Spiti horses survive in the breed tract, and it is now considered to be an endangered breed.

Zanskari Horse

The Zanskari breed of horse is one of the rare breeds that can survive under the hypoxic conditions of Ladakh. It is found in the Zanskar Valley in the Kargil district of Ladakh. The horses are used for transport, riding, and polo. Sure-footedness makes it a useful animal for hill terrain and transport on snow. Only a few hundred horses survive today, and this breed needs to be considered seriously for conservation.

Box 27.1
The Mithun

In areas where the *mithun* is found, it is an indicator or yardstick of social status. The wealth of a person can be ascertained by the number of mithuns in his possession and by counting the number of preserved horns or skulls on public display on the veranda wall or elsewhere near the house. The mithun is the animal of choice for sacrifices made at religious festivals to increase the productivity of crops and livestock, to improve the well-being of the village society, and to save the human race from natural catastrophes such as floods, famines, and epidemics of disease. Every community celebrates their annual religious festivals – the *Nyokun Yullo* by the *Nishi*, the *Mopin* by the *Adi*, the *Dre* by the *Apatani* - and the mithun finds a central place in the ceremonies. Since mithun is the most valued animal in the life of the people of Arunachal Pradesh, it is also a popular gift at marriages, generally made by the groom's family to the parents of the bride.

"*The economic utility of mithun encompasses payment of fines for social and legal obligations, as per the direction of the village elders in settlement of disputes. Mithun has its highest value on the barter table. It finds utility in the purchase of land, property and foodgrains. In the case of costly items such as jewellery and ornaments, a series of Nyeda (number of barter exchange trips) may have to be performed by the buyer to the owner's place to reach the required number of mithuns. In commercial trade, the mithun keepers of Arunachal Pradesh have a relationship with the people of Bhutan. There mithuns are generally utilised for cross breeding with the indigenous Siri cattle to obtain hybrids of economic importance*" Taba Heli, 1993 [sic].

As a result of its overall importance in society and the deep-rooted relationship with it, people have evolved suitable animal husbandry practices for rearing mithuns. The success of the age-old practices are reflected in the fact that nearly 75 per cent of the mithun population in India is found in Arunachal Pradesh. Management alone is of little consequence for healthy proliferation of a species unless a suitable habitat is maintained. The most important component of mithun habitat is the forests. Detailed research work (Heli 1993) has revealed that the mithun browses on leaves from nearly two dozen natural species of trees, shrubs, and bushes. The animals generally do not tolerate heat and retire to the deepest parts of the forest during the noon hours in search of water, particularly that oozing out from salt licks close to small ponds or streams, to quench their thirst. They have a habit of visiting such streams or ponds often after browsing in nearby forests and thus these are an important part of the habitat. Such spots are referred to by different names in different dialects, for example *Shi* in *Nishi*. In the traditional free range system of management the mithun spends a large part of its life in the forest. The owner makes periodical visits, usually once a month, to the forest with a package of salt to feed it. This retains the link between owners and their mithuns. If the owners miss a couple of visits with salt, the mithuns visit them.

There are many salient aspects of biodiversity conservation inherent in the traditional practice of rearing mithuns. The mithun is distributed throughout an altitude range of 500-2,700m and can even be found up to 3,000m, overlapping the habitat of yaks. The mithun has a wide range of preferred fodder species, depending upon the forest type. The need for large shade trees in the mithun habitat has already been mentioned. The delicate question of availability of water in forest streams and ponds and proximity of salt-licks is very much related to the pristine environment of the forest ecosystem sites.

Source: Rastogi and Pant 1996

Asses

About 8,000 small-sized asses can be found in the Ladakh region of the Himalayas. They are mainly located in the Indus Valley of the Leh and Kargil districts and are used for carrying bricks and other building materials for houses in the valley. In body features they appear similar to the Tibetan breed of asses.

Double-humped Camel

About 54 double-humped camels (*C. bacterianus*) are reared by a few nomadic families in the Nubra Valley of Ladakh. These animals are thought to be stock left over from the camels that traversed the silk route from China and Mongolia through the Himalayas.

Chanthangi Goats

The Chanthang region of Ladakh, which lies more than 4,000 masl, is inhabited by the Chanthangi breed of Pashmina goat. About 51,000 animals of this breed are found in this region.

Chegu Goat

Chegu is another Pashmina goat breed found in the Lahaul and Spiti valleys of Himachal Pradesh, Uttar Kaski, and the Chamoli and Pithoragarh districts of Uttar Pradesh bordering Tibet. The estimated population is about 92,000.

Gaddi Goat

This is a medium-sized goat found in the Chamba, Kangra, Kullu, Bilaspur, Simla, Kinnaur, Lahaul, and Spiti districts in Himachal Pradesh, and the Dehradun, Nainital, Tehri Garhwal, and Chamoli districts in Uttar Pradesh. Its numbers have been estimated at 770,000.

Kashmir Merino Sheep

In the last three decades or so, large-scale crossbreeding of local sheep breeds such as Karna, Gurej, and Poonchi of Jammu and Kashmir with Russian Merino and Rambouillet sheep has resulted in a large population of crossbreeds in the state. After several generations of such breeding and selection, a new breed, the Kashmir Merino, has evolved. Its population has been estimated at around 1,050,000. This breed produces fine wool for clothing and is well adapted to the climate of Jammu and Kashmir.

Gaddi Sheep

This breed is found in the Chamba, Kangra, Kullu, Bilaspur, Kinnaur, and Lahaul Spiti districts of Himachal Pradesh and in the Nainital, Tehri Grahwal, and Chamoli districts of the Uttar Pradesh hills. Its numbers have been estimated at around 517,000.

Rampur Bushair Sheep

This breed is found in Shimla and Rampur Bushair and the Kinnau and Lahaul Spiti districts of Himachal Pradesh. Some animals are also found in the Chakra and Nainital districts of Uttar Pradesh.

Changthangi Sheep

This breed is found in the Changthang region of Ladakh. Its population has been estimated to be around 56,000.

Bonpala sheep

This breed is found in the southern districts of Sikkim. Its numbers have been estimated at around 6,000.

Tibetan Type Sheep

These are found in Sikkim and the West Kameng district of Arunachal Pradesh. Some animals are also found in the Ladakh region of Jammu and Kashmir. Its numbers have been estimated at about 19,000.

Siri Cattle

Siri is a prominent breed of cattle in Sikkim, the upper reaches of Darjeeling in West Bengal, and Bhutan. The breed tract lies between 1,300 and 3,300 masl. The Siri breeding tract has steep hills with narrow valleys.

Cattle in the Sikkim Himalayas are either the Siri type or are nondescript and crossbreds. Although the total population of cattle increased by 6.28 per cent between 1982 and 1988, the population of Siri did not show a comparable increase. The population increase resulted from an increase in the number of crossbred animals (by 30.98 per cent) in this period. Crossbreds constituted almost 19 per cent of the total population in 1982, 23.4 per cent in 1988, and 29.7 per cent in 1995. This resulted from the emphasis on crossbreeding of Siri cattle with Jerseys.

Trends

Animal breeding and, for that matter, animal production systems in the entire Himalayan ecosystem need to be looked at and evaluated from a scientific point of view. Breeds should be assessed not only on the basis of morphological attributes, physical fitness, and utility of different types of animal genetic resources, but also on the basis of their economic viability, either as such or as a part of the farming system as a whole. Almost all local or indigenous types or breeds of animals, though better adapted to local conditions of harsh environment and capable of producing under difficult and low input conditions, are fast declining in number. This is by and large the result of the easy availability and introduction of good genes from high producing breeds from various places in the world through cross breeding. As a consequence new, highly productive types of sheep breeds, cattle, and yak have been developed

All such changes need to be assessed in a realistic manner in any study of the present status of biodiversity of animal genetic resources, especially the usefulness of the existing breeds vis-à-vis the role of the new genotypes in present day animal production and farming systems. It would, therefore, be proper to initiate appropriate programmes aimed at conservation as well as improvement of different types of animal genetic resources in a holistic manner.

Indigenous Livestock in Nepal and a Strategy of Conservation

Nepal

The livestock population in Nepal in relation to the arable land per person is one of the highest in Asia (LMP 1993). The estimated livestock population in Nepal is about 6.2 million cattle, 3.1 million buffaloes, 5.4 million goats, 0.9 million sheep, 0.6 million pigs, and 13.5 million fowl. In addition, there are a small number of ducks, equines, yaks (*Bos grunniens*), and *chauries* (the crossbreeds of yak and domestic cattle) (LRMP 1986, DFAMS 1991). Farm animals in Nepal are reared for various reasons, but principally for the livestock products, farm manure, and land tillage. Most crop cultivation is based on farm livestock, which in turn are fed upon crop by-products produced from the fields. Thus the subsistence agricultural system and the livelihood of some 90 per cent of the population is based upon livestock rearing. In economic terms, livestock contribute about 15 per cent of the national gross domestic product, equivalent to about 28 per cent of agricultural GDP (LMP 1993) and about 20 per cent of household cash income in the hill and mountain regions of the country (Nepal

Rastra Bank 1988). It is expected that the share of livestock in agricultural GDP will increase by 47 per cent by the year 2010 (APP 1995), this will require a significant improvement in livestock production in the country.

Despite the large livestock population, Nepal imports a significant amount of dairy products and live animals, and almost all of the wool requirements for the carpet industry (LMP 1993). The reasons for this are numerous, including the subsistence farming system and lack of market orientation, insufficient infrastructure, and average poor productivity of indigenous stock—largely as a result of insufficient nutrition, healthcare, and management. This situation clearly indicates the need to increase livestock production within the country and to establish efficient support services for its development.

In an attempt to boost livestock production in the country, various exotic breeds reported to have high productivity were imported as live animals or as cryopreserved semen to be introduced into the native population. It was expected that, with the introduction of high-yielding, exotic genetic material, livestock production in the country could be increased significantly within a short space of time. Thus, the thrust of national livestock development programmes has been aimed at and geared to the production of crossbreds in almost all species of farm livestock.

The results of this approach have started emerging slowly and gradually. There were some visible impacts in urban and semi-urban areas, but the vast rural areas (almost 90 per cent of the country) remained largely untouched even after the efforts of three decades. Despite the introduction of exotic stocks, the need to import livestock products for the urban population has not decreased. Therefore, it can be said that the introduction of exotic stocks has neither served the rural communities nor satisfied the needs of the small urban population. In other words, the programme of introduction of exotic stocks has been less than successful in meeting the targets set forth by its proponents.

Several other factors have emerged as the principal constraints limiting the productivity of the exotic or crossbred populations. These are sub-optimal nutrition and management, greater susceptibility to prevailing diseases and pests, poor utilisation in other agricultural activities, and lack of an organized marketing structure. Although these constraints were omnipresent in Nepal, their effect became much more evident and obvious with the high value of exotic and cross-bred populations. The result was poor dissemination and adoption of these animals over a wide area. Although milk yield performances of crossbred cattle and buffaloes were marginally better than those of the native population (Rasali *et al.* 1995), farmers complained that it was only at the cost of higher feed intake and health care management. Similarly the performance of exotic or crossbred goats has also been found to be little better than that of the indigenous population (Oli 1987), and, despite a 150 per cent increase in wool increment from the exotic

Polwarth x native Baruwal crossbred sheep, these animals were not adopted in the prevailing management conditions and were eventually rejected by farmers (personal observations). The only enterprise in which exotic germplasm can be regarded as reasonably successful is that of urban poultry production, perhaps because the other requirements, such as health care, nutrition, and marketing, have been met concurrently in this enterprise. The success may also be because the enterprise has been run by the urban people for the urban population, and urban people are more knowledgeable about market economics.

The introduction of exotic stock has not been without its deleterious side effects. As the panacea for increasing livestock production was considered to be the introduction of exotic stocks (which were readily available in the international markets, albeit at a comparatively high price or as charity); no attempts were made to evaluate the genetic potential of indigenous stock in their prevailing environments or under optimum conditions. Thus, the whole livestock population of the country remained neglected and unevaluated, being commonly referred to as 'nondescript breeds with low production potential'. These inferences were drawn by comparing the production performances of high yielding exotic breeds under their optimal nutritional and management conditions with those of underfed indigenous animals. In this way, decisions were always in favour of exotic animals. Thus all exotic stock are referred to as '*bikase*' and all indigenous stock as 'local' or 'undeveloped'.

Indigenous Animal Genetic Resources and Their Potential

The large livestock population of Nepal is composed of various breeds and strains in different livestock species. The naturally isolated areas of the mountainous country have produced many different environments and ecological niches, resulting in a tremendous biodiversity in animal genetic resources across the ecological zones of the country (Pradhan and Rasali 1995). Epstein (1977) described the breeds of domesticated livestock species in Nepal, and later workers characterised some of the breeds (Keshari and Shrestha 1980). It is likely that some additional breeds or strains would be identified if a more comprehensive study were to be made.

The 6.2 million cattle are mainly hill cattle (62%) and *Terai* cattle (30%) (Pradhan and Rasali 1995). Other breeds such as *Lulu*, *Achhame,* and *Siri* constitute only an insignificant proportion of the population. The population of these three breeds, although not known exactly, is thought to be extremely low and on the verge of extinction, largely as a result of negligence and a lack of conservation strategies. Similarly, hill buffaloes (*Lime* and *Parkote*) constitute around 58 per cent of the 3.1 million buffaloes, the rest are *Terai* breeds and crossbreds with different Indian breeds.

The large population of 9.3 million bovines (cattle and buffaloes) is further supplemented by small numbers of yaks/naks (*Bos grunniens*) and chauries (crossbreeds of yaks and zebu cattle), which are reared in the high altitude areas of the Himalayan mountains. Although the combined population of yaks/naks and chauries has been estimated to be about 58,600 (CBS 1994), the population of purebred yaks/naks was estimated to be only about 8,600 animals (Joshi 1982), and this number has further declined at a fast rate (Shrestha 1995). The last remnant populations of wild buffalo, *Arne* (*Bubalus arnii*) and wild cattle, *Gauri Gai* (*Bos gaurus*), are being kept in wild life conservation parks

Half of the national goat population is composed of the *Khari* breed followed by *Sinhal* (35%) and a smaller number of *Terai* goats (9%), *Chhyangra* goats with the fine inner coat 'Pashmina' comprise only about six per cent of the population. Similarly, 63 per cent of the sheep population are *Baruwal* sheep, followed by 21 per cent *Kage*, 12 per cent *Lampuchhre*, and only four per cent of the fine wool breed *Bhyanglung* (LMP 1993). Wild relatives of sheep and goats, including the blue sheep (*Pseudois nayuar*), are found in the high altitude regions of the Himalayan mountain range, but their exact population is not known.

Rasali et al. (1995) estimated that 57 per cent of the pig population consisted of domesticated native hill pigs, which are called *chwanche* by the *Magar(s)*, *sungar* by other people in the western hills, and *pundi* in the eastern hills. The rest of the population is made up of *hurrah* and many local types that have not yet been characterised for their breed types or their production potential (Shrestha 1995). Wild pigs are present in most parts of the country, especially in the protected areas, and their meat is regarded as a delicacy.

The large population of 13.5 million poultry is largely comprised of native birds, called *sakini* (84%), and commercial flocks with various imported breeds that comprise about 16 per cent of the total population (LMP 1993). Although wild jungle fowl are still present in most parts of the country, the numbers are declining steadily as a result of the decrease in the forest areas. Although the population of indigenous poultry is considerably higher than that of commercial birds, the thrust of development strategies is concentrated towards imported commercial birds. This fact was highlighted by the statement of LMP (1993) that "*in the poultry sector, the commercial birds are economically the most important*", which indicates that government programmes will be focussed on commercial exotic birds and the large population of native birds will be neglected. There is a considerable variation in the plumage colour of native birds, and farmers report that birds with a particular plumage colour, for example black, are more productive than others. This possibility, however, has not been investigated so far and needs further study.

In general, the indigenous livestock population is regarded as unproductive or as having a very low production potential, mostly as a result of the reasons already described. However, it has frequently been observed that some animals within the population have a substantially higher productivity than the average; hill buffaloes are a good example. Moreover the productivity of indigenous stock can be improved significantly with better nutrition, management, and health care, as was shown, for example, by a 150 per cent increment in egg production by native chickens provided with adequate nutrition and health care (Oli 1985). Some of these observations indicate that the indigenous livestock population has not been evaluated properly for its productivity potential under optimal conditions, and there is a need for proper evaluation of the potential of indigenous livestock. It must be emphasised, however, that the value of indigenous stock lies not only in its production of milk, meat, or eggs, but also in its ability to thrive under poor nutritional conditions and to withstand and survive the prevalence of various diseases and parasites endemic in Nepal. This fact is well illustrated by the resistance of native cattle against tick infestation to which exotic cattle are very susceptible. Native stock can also be used for agricultural and other activities, for example, the sheep and goats used as pack animals in the Jumla and Darchula areas. This should also be regarded as a special characteristic of indigenous stocks against the background of difficult mountain environments.

Evaluation of the genetic potential of indigenous livestock will also provide an opportunity for the identification of superior genotypes and the development of conservation strategies for those breeds or strains that are known to possess a comparatively high productivity potential but which are threatened by extinction if some immediate steps are not undertaken. The need for proper evaluation has been indicated by a number of researchers (Shrestha 1995, Joshi and Rasali 1996). This threat to the indigenous stock has arisen as a result of the lack of breeding and conservation strategies, changes in the farming environment, and the development of alternative opportunities for employment and income generation. An attempt to conserve rare breeds would not only benefit the survival of genetic material with distinct merit, but also benefit overall livestock development in the country, as these endangered breeds possess some of the important qualities needed for survival in the hills and mountains of Nepal.

The Threats

The changing agricultural and economic environment of the country; opening up of national and international boundaries for trade, tourism, and employment; lack of profitable economic return from the indigenous livestock rearing systems; disinclination of the new generation to maintain the traditional method of livestock husbandry (with its supporting role in crop production); and the lack of any policy and programmes from national institutions for the conservation and development of indigenous animal genetic resources have created the situation of gradual depletion of the indigenous animal genetic resources. All these factors have

Table 27.1 **List of Animal Populations under Threat in Nepal**

Species/Breeds/Strains	Special Traits	Threats
Yaks and **Naks**	• Adapted to high altitude climates • Reasonably high milk yields	• Declining population • Crossbreeding with zebu cattle • Physically difficult and unattractive management system for the new generation
Cattle *Lulu, Siri* and *Achhame*	• Smaller body weight • Somewhat higher milk yields than other breeds • Ability to withstand diseases to a greater extent than exotic stock • Survival even under extremely poor management	• Extremely low population • No attempts or strategies for conservation • Crossbreeding with zebu animals • Lack of identification of commercial value • Other employment opportunities available, like tourism
Buffaloes High yielding hill buffaloes	• Considerably higher milk yield than the average population • Better utiliser of fibrous feed	• The small genetic pool is being diluted in the population • No strategy for identification, conservation, or improvement
Sheep *Bhyanglung*	• Survival ability under extremely poor conditions • Only one fine wool breed present in Nepal	• No information on the population and its dynamics • No strategy for conservation and development
Goats *Chyangra* Highly prolific individual animals in different breeds	• Fine inner coat production • In great demand as meat animals • High productivity	• Small population • No strategy for conservation • No study on population dynamics and its socioeconomic correlation • Small genetic pool rapidly diluted in population • No strategy for conservation and development
Pigs Indigenous domesticated pigs *Chyaunche* and *Hurraah* and wild pigs	• Superior disease resistance • High value meat from wild male pigs, '*Bandel*'	• Low social status • No information on health and management systems • High rate of close inbreeding within the population
Poultry *Sakini*	• High disease resistance • Preferred taste of meat and eggs • Adapted to poor management • Considerable genetic variation • High consumer demand with higher market price than commercial broilers	• High influx of commercial breeds • Lack of conservation and development strategies.

contributed to the decline of the potential genetic pool present within the country. The following are the imminent threats if conservation strategies are not adopted.

- Extinction of the species/breeds/strains which are at present endangered
- Dilution and disappearance of potentially highly valuable genetic material in the population
- Loss of diversity in the indigenous animal genetic pool
- Loss of genetic material for future use, thus limiting the genetic base for facing future challenges
- Increased dependence on exotic stocks for fulfilling the needs of the country
- Increased population of monospecific animals, thus creation of a population susceptible to a common disease

These threats are of considerable importance and signify the need to implement programmes for the conservation of indigenous animal resources for the sustainable development of livestock in the country.

Conservation Issues

The widely accepted definition of 'conservation' is the management of the human use of livestock so *"that it may yield the greatest sustainable benefit to present generations while maintaining its potential to meet the needs and aspirations of future generations"* (Bodo 1990).

In Nepal, conservation is mainly needed for the following.

- Conservation of livestock breeds with populations that have reached an endangered level and which will otherwise be lost forever.
- Conservation of individuals/strains with superior production potential, disease resistance, or other useful traits within a breed; so that the superior genetic pool can be conserved and used for breeding and breed improvement. This is particularly important as these individuals/strains have evolved over centuries under the poor nutritional and health conditions normal in the country and are still able to maintain a significantly better production than the average population. In the absence of any action, the immediate likelihood is that this superior genetic pool will be diluted in the main population, never to be retrieved again.

Considering the above, the main needs are the protection of breeds or species from extinction and the selection and promotion of superior genotypes. Both of these programmes would require a great deal of long-term planning and commitment by national institutions and local-level organizations, as well as the support of international institutions.

Conservation Aims

The importance and need for conservation of domestic animal genetic resources in the form of breeds and individuals will vary according to the situation of a particular country. Henson (1990) has suggested the following primary aims of any conservation programme.

- Conservation of unique and endangered populations as a genetic resource for future livestock breeders and biotechnologists.
- Conservation of historically important, culturally interesting, and visually unusual and attractive populations for education, tourism, and leisure.
- Conservation of non-selected populations for research, or as control populations for comparison with others.

In Nepal conservation should also be aimed at the preservation of hardy and environmentally adaptable breeds and animals.

In competitive environments, breeds or individuals generally become rare or endangered because they cannot compete with commercial breeds (Henson 1990). In Nepal, however, the danger of extinction seems to have arisen more as a result of the lack of proper evaluation of indigenous stock, lack of recognition of the importance of characteristics specifically suited to the difficult conditions of the country, and failure to develop breed improvement strategies. Conservation is needed not only to save animals or breeds from extinction, but also to develop a sustainable broad base for the improvement of the livestock population and its productivity in the country. This approach, though long-term and less spectacular, would be more sustainable in the difficult environment of the country than focussing on the introduction of imported exotic stock.

Hence, the objectives of the ideal conservation programme could be summarised as follows.

- Conservation of the biodiversity of valuable and endangered animal genetic resources

- Development of indigenous animal genetic resources for sustainable livestock development
- Identification, selection, conservation, and development of more productive indigenous livestock breeds

To meet the above objectives, conservation strategies would need to be directed towards the following.

Conservation of Endangered Breeds

Three cattle breeds, namely, *Lulu, Achhame,* and *Siri* and one wild buffalo breed, *Arne* (*Bubalus arnee*), need urgent conservation if they are to be saved from extinction. The small, isolated populations of these three breeds are confined to specific ecozones in the country. *Lulu* is found only in Mustang and *Achhame* and *Siri* are found only in some pockets of Achham and the hill districts of Mechi Zone. There is no population census or record of trends for these breeds because the livestock census is taken according to species not breeds. *Lulu* cattle have been estimated to comprise about 0.2 per cent of the 6.2 million cattle in the country. A recent informal survey carried out by the District Livestock Service Office, Mustang in 1996 showed the total population of these animals to be only 3,301 head, distributed over the 12 village development committee areas (VDC) in the district (Table 27.2).

Although, the alarmingly low population of only 3,300 head of *Lulu* cattle is very worrying, the situation is even more critical for *Achhame* and *Siri* cattle as nothing is known about their current population dynamics. It is thought that 'true

Table 27.2: **Population Distribution of Lulu Cattle in Mustang District**

VDC	Adult male	Adult female	Male calf	Female calf	Total
Marpha	70	85	27	27	209
Jomsom	76	130	26	31	263
Kagbeni	99	133	27	25	284
Muktinath	82	141	26	26	275
Jhong	74	105	23	24	226
Chhusang	65	115	17	33	230
Ghemi	98	150	22	31	301
Charang	94	126	24	38	282
Surkhang	84	130	20	37	271
Lomanthang	181	145	20	35	381
Chhonhup	127	144	22	35	328
Chho-sher	74	126	22	29	251
Total	1124	1530	276	371	3301

Source: District Livestock Service Office, Mustang (1996) to type' populations of these animals might be even lower than that recorded for *Lulu*.

The situation of the wild buffalo *'Arni'* is particularly alarming as it is estimated that the last remnant population consists of only approximately 100 animals, kept at Koshi Tappu Wild Life Reserve in Eastern Nepal (Yonzon 1994); and these may be lost at any time.

Although the need for conservation of all breeds can be questioned; it is reported that all three cattle breeds described above have a higher productivity potential than the more common hill or *Terai* breeds (Rana et al. 1996). The body weight of Lulu cattle is about 32 per cent lower than that of hill cattle, but milk production data recorded under farmers' management show that the milk yield of *Lulu* cattle per body weight is 94 per cent higher than that of hill cattle (Rana et al. 1996, Joshi et al. 1992). The milk yields of the *Siri* and *Achhame* breeds have not yet been recorded, but they are considered to be higher than those of common hill cattle. These three breeds of cattle have a number of characteristics that offer advantages in comparison with exotic cattle and their crossbreeds: superior genetic potential; superior production performances under poor nutritional and management conditions; lower body weight requiring less nutrients for maintenance/production; and better adaptation to steep mountainous and hill regions for both working and grazing. These highlight the urgent need for conservation of endangered cattle breeds. It is thought that the productivity of these breeds could be improved significantly with better nutrition and health care, and this also needs to be investigated.

The critical population size at which breeds should be declared 'endangered' under European conditions has been calculated to be below 1,000 cows or 500 ewes or she-goats or 200 sows (Maijala 1990). In the U.K. the Rare Breeds' Survival Trust classifies breeds as rare when the number of breeding females is below 750 for cattle, 1,500 for sheep, 50 for pigs, 1,000 for horses, or 5,000 for goats (Alderson 1981). The FAO (1989), however, has suggested that the population sizes applied in Europe to classify breeds as endangered need to be doubled or even tripled for developing countries because of the sub-divisions and genetic isolation of nomadic populations, harsh climatic conditions, and big disease risks. The FAO proposes as a working rule that "*when a population size approaches 5,000 breeding females, the survival risk of the breed should be studied and appropriate actions initiated*."

Applying these criteria, all three cattle breeds (*Lulu*, *Achhame*, and *Siri*) come under the endangered category, requiring urgent attention for conservation. Although the last remaining population of some 100 wild buffaloes, *Arni*, are kept for protection in a wild life conservation park, there is a danger that these animals could be lost forever for any of a number of reasons – including a disease epidemic. Application of cryopreservation technology could be particularly useful for the preservation of these animals, and the feasibility of this needs to be explored.

Selection and Conservation of Superior Genetic Material

The superior pools of animals present in most of the species/breeds of farm livestock in Nepal require urgent action for conservation. Although the average productivity of indigenous livestock breeds is very low compared to that of exotic animals under optimum management conditions, a fairly significant number of animals within different species and breeds shows considerably higher productivity. These elite pools of animals within a breed/species could be identified, selected, and conserved for the improvement of the breed. The selection and identification of individuals with superior genetic potential would depend upon the genetic variability present within the breed. The observations so far indicate that considerable genetic variation exists in buffaloes and goats, whereas the situation for other farm livestock is not known. In buffaloes, the breeds identified in the hills and mountains are *Lime* and *Parkote*, both generally regarded as breeds with low productivity. However, some individual animals have been reported to yield more than 10 litres of milk a day (Joshi and Rasali 1996), which is comparable to the productivity of any improved buffalo breeds under village management conditions.

Some female goats of the *Sinhal*, *Khari*, and *Terai* breeds are also known to be very prolific; regularly producing and rearing triplets at intervals of eight to nine months. This level of productivity could be regarded as very satisfactory under the prevailing management conditions in the hills of Nepal. The population is very low, however, and is being diluted rapidly, thus there is an urgent need for action for their conservation.

Rasali and Joshi (1996) have suggested a strategy for buffalo improvement in the hills of Nepal, and a similar strategy could be adopted for the goat breeds present in the country. It is expected that using this strategy it would be possible to develop a long-term sustainable approach for livestock development in the country.

Conservation of Animals with Unique Characteristics

In the diverse ecological environments of Nepal, some animals with typical and unique characteristics require strategies for conservation. These include the yaks/naks reared in the high altitude ranges of the Himalayan mountains, the fine wool sheep, *Bhyanglung*, and the 'Pashmina' goat, *Chhyangra*. These animals have unique production characteristics not present in other populations in the country. This unique and superior productivity potential could be conserved and used for specific outputs. For example, the wool from *Bhyanglung* is in great demand in the carpet industry and *Chyangra* meat is always in very great demand during the *Dashain* period (a Hindu festival). The population of these animals, although not at the endangered level at present, is certainly declining (Shrestha 1995) and thus needs conservation strategies.

Indigenous pigs and poultry have evolved under the continual pressure of the various diseases and parasites prevalent in the country. Thus it is expected that the population has developed a considerable resistance against these diseases. This needs to be investigated and the resistant traits identified so that the superior genetic material can be conserved and used in future.

Conservation Strategy and Methods

Primo (1987) suggested four stages of conservation for animal genetic resources. They are:

- surveys and identification,
- characterisation,
- evaluation, and
- conservation

Surveys and identification would identify risk populations and their dynamics. Proper characterisation is essential to identify the future potential of the animals. It includes morphological description, cytogenetic studies, and even blood typing. It would also be important to identify the genetic distance from the other nearest breeds available. Evaluation of the adaptive and genetic potential would determine the value of the animals for future use. And conservation, either *in situ* or *ex situ*, would depend upon the population size and other available facilities. Turner (1987) and the FAO (1980) further suggested that only genetically distinct groups with a reasonable prospect for a production system should be considered for conservation.

Although in general the method of conservation of a particular breed or individuals should largely depend upon the population size, the only possible conservation approach in the Nepalese situation is the *in situ* method, until facilities for the cryopreservation of embryos or oocysts are developed at a national centre. Smith (1984) estimated the cost of *in situ* and cryopreservation of animal genetic resources and suggested that, although the initial costs of cryopreservation are higher, the maintenance costs are lower. *In situ* conservation needs a long-term commitment; but it might be the only possible approach for the remote villages of Nepal. The successful experience of community forestry and of nature conservation areas are examples of the approach that can be adopted under the Nepalese system. This approach requires the mobilisation and involvement of local communities at every stage of the process and implementation of the programme with the active participation of local communities. Such activities could be carried out effectively by the local-level organizations involved in the conservation of natural biodiversity.

Thus the strategy for *in situ* conservation that should be adopted is as follows.

Surveys and Identification

Survey and identification of the animals/breeds to be conserved is the first step in the *in situ* conservation process. The initial survey should provide baseline information on the population size and dynamics of the existing animal population and record the production environment, current usage of the animals, and socioeconomic status of the human population in the area.. A detailed questionnaire for farmers on the previous population status, management and breeding systems, and other related information would need to be included in the survey. Once included in the conservation process, changes in a given time would also need to be recorded regularly.

It is also important that breeds selected for conservation should be 'true to type' and genetically pure. In general, it is suggested that a population is not worth preserving unless it is pure (Bodo et al. 1984). This concept can be disputed, however, and is sometimes ill-defined. Essentially, it implies that the population should be free from the influence of other populations. However, if the available population has already been influenced by other breeds, 'conservation with purification' would be the suggested strategy. It is essential that the population should not carry more than 20 per cent of foreign blood (Anderson 1981), which should be gradually taken out from the conserved population by selective culling of animals with foreign characteristics.

Characterisation

It is essential to characterise any breed selected for conservation. The minimum essential data set needed for breed characterisation is shown in Box 27.2. This protocol is sufficiently comprehensive for characterisation of a breed to be conserved. Rege (1994) has suggested the need to implement more comprehensive characterisation protocols that include objective measures of both inputs and outputs under the local production environment. He suggested that the initial emphasis should be on phenotypic characterisation, which should be followed by genetic characterisation including estimation of genetic distances between populations and quantification of genetic variation in adaptive characteristics.

Box 27.2

Minimum essential data for breed characterisation

Variable	Time and frequency of measurement
Physical traits	
- linear measurements	across the herd structure
- condition score	seasonal
Performance traits	
- milk yield	monthly
- body weight	weaning, post-weaning, mature
- fertility	
calving interval	two or more calving dates
number born	two or more
number weaned	two or more
- viability	young and mature
- fleece weight	once
Health	
- abortions	two or more calvings
- blood samples for monitoring disease	
- faecal samples	several depending on disease and season
- tick infestation	
- DNA extraction	once
Environment	
- location	farm or village by map reference
- climate	farm or village by map reference
temperature	seasonal
rainfal	seasonal
humidity	seasonal
- feed resources	
feed type	seasonal
feed availability	seasonal
- management	
shelter/housing	once
herding practice	once
watering frequency	seasonal
supplementation	seasonal
health intervention	seasonal
- herd structure	
animal movement in/out of a herd	seasonal and dates
- breeding structure	
number of males	once
number of females	once
castration practice	once
use of artificial insemination	once
age distribution	once

Source: Rege 1994

Evaluation

Most livestock in Nepal are reared under conditions of severe nutritional and disease stress that continue throughout life. Under these conditions animals will not develop their full potential, and the recorded production does not represent the true potential of the breeds/animals. Thus it is essential to evaluate the genetic potential of the animals under optimum conditions of nutrition and health care management. Such an evaluation will determine the true value, and demonstrate the scope for genetic improvement, of indigenous breeds. The failure to show real potential under normal conditions was shown clearly in a study in Ethiopia and Kenya, selected populations of *Boron* cattle achieved an average gain in body weight of about 100 kg compared to unselected populations (Rege 1994). Oli's (1985) findings with indigenous village poultry in Nepal show a similar effect.

Evaluation of the genetic potential of the breeds considered for conservation would be useful to determine their future potential.

In Situ Conservation

Various methods and approaches have been suggested for *in situ* conservation of domestic animal genetic resources. These are based on the success of one or another approach in the country concerned. As an example, national and government funded projects have been very successful in Hungary, whereas non-government organizations like the Rare Breeds' Survival Trust play the key role in the conservation of endangered animal genetic resources in the UK (Maijala 1990, Henson 1990). Living history farms organized at a private level have also been quite successful in some countries. These farms, although initially established by individuals for ethical reasons or for pleasure, later developed into important conservation sites and have also become important tourist centres. Cotswold Farm Park in the UK and Reilly Farm in Swaziland are two of the successful classical examples of this approach (Henson 1990, Setshwaelo 1990). Some rare breeds have been conserved through sponsorship by companies, for example, the Clydesdale horse by the Budweiser company (Henson 1990).

The types of approach outlined above are more appropriate in developed countries where the economic environment for agriculture is more favourable and the aim is to conserve primitive breeds without using them for agricultural production. This approach might not be suitable or successful in Nepal because here conservation has to be associated with improvement and/or development. The best possible approach to *in situ* conservation in the Nepalese situation is through participation of local communities.

The survey of the population structure and its dynamics, and characterisation of phenotype and genetic traits of the population provide the baseline information needed for conservation. Participation of local communities is of the utmost importance for implementing the conservation activities. It may not be easy to convince local communities of the need for conservation if no direct benefit is visible. Considerable effort will need to be put into training, demonstrations, and visits by representative members of the participating community. In some cases, subsidies for the maintenance and production of endangered animals might be an option. However, such an approach should be treated with caution and only used as a last resort. Legal support in the form of a ban on the introduction of other breeds into the conservation area would be an additional advantage, as would creation of awareness in the community about the importance of conservation of rare breeds. Selection of superior individuals from the conserved population and their maintainance on government farms in an optimal production environment would provide an opportunity for evaluation of the productivity potential of the breeds. It would also provide a means of demonstrating to local farmers the real potential of these breeds, and their advantages in comparison with imported exotics. The identified superior stock could be cryopreserved as embryos, oocysts, or DNA if the technology became easily accessible in the near future. The superior stock could later be supplied to other potential areas for breeding purposes and multiplication.

Participating Institutions and Their Responsibilities

Local, national, and international institutions have complementary roles to play in conserving biodiversity. Local-level organizations with a mandate for, and knowledge and expertise about, biodiversity conservation would be the ideal and effective institutions for creating awareness, carrying out surveys, characterising conserved populations, and carrying out community mobilisation programmes. These activities are the ground work or foundation for any conservation programme.

National institutes should support such activities by providing the necessary technical support. The national institutes should also have the responsibility for rearing endangered breeds/strains on farms or stations, so that the production potential of these breeds/strains can be evaluated and for popularising the superior breeds identified through experiments. *Ex situ* cryopreservation should also be undertaken by the national institutes.

Financial support from such international organizations as FAO, UNEP, IUCN, UNESCO, and WWF would be important for the successful implementation and continuity of the conservation programme. International institutions have an obligation to support these programmes as conservation of endangered populations is a common concern of mankind. The useful traits of the conserved population, which otherwise would have disappeared forever, could be shared throughout the planet.

The Current Status of Conservation Programmes for Indigenous Animal Genetic Resources in Nepal

The concept of conservation of indigenous animal genetic resources is fairly new to Nepalese planners and policy-makers. Thus almost all the indigenous livestock population has been neglected since the beginning of livestock development planning in the country. On the other hand, farmers in some areas have always used conservation strategies for superior productive animals in one way or another. This was evident in a field survey in the Kaski and Lamjung district where farmers kept the male calves of very productive buffaloes for breeding purposes (Joshi *et al.* 1996). Such practices, however, are limited to only a few areas and adopted in an unplanned manner.

On the national scale, interest in the evaluation of indigenous livestock populations has begun rather late. Productivity studies have been carried out for some indigenous goat breeds (Oli 1987) and hill cattle and buffaloes and their exotic crossbreeds (Joshi *et al.* 1992, Rasali *et al.* 1995). All these studies have been conducted on a fairly small scale in small isolated pockets of the country and do not represent the situation present in other parts of the country. Some of these studies have indicated that there is a possibility for using the genetic variability present in the indigenous livestock population for livestock development in the country.

Interest in the conservation of indigenous livestock species in Nepal started to emerge recently (Shrestha 1995). However, the only activity in this direction so far has been an informal population census survey of *Lulu* cattle together with attempts to measure their production under farmers' management. This programme has not yet taken off as a result of various logistic problems (Breeding Division, Department of Livestock Services: Personal Communication). There is a particular lack of information on other breeds, such as *Siri* or *Achhame* cattle, or the population trends of yaks and naks. Similarly, there has been no attempt so far to identify and conserve superior strains and individuals of indigenous breeds to improve the production potential of these breeds.

The necessity for conservation of indigenous livestock resources has also been stressed by workers in India (Acharya1990) and China (Yaochun 1990). Acharya (1990) and Yaochun (1990) listed more than 18 and 48 endangered breeds in India and China respectively and indicated the need for their conservation. In India, a conservation strategy for indigenous breeds has been started. Cross breeding with exotic superior breeds will be confined to non-descript, poorly producing animals. Descript breeds will be improved through selection within the breed (Acharya 1990). Embryo transfer technology will be used for conservation of high-yielding animals within the indigenous breeds.

Future Needs

Considering the availability of suitable genetic material adapted to the harsh mountain environment of the country, the subsistence farming conditions, the poor infrastructure available, the unsuitability of exotic stocks to the current climatic and economic environment, and the imminent danger of genetic erosion of some potentially valuable breeds/strains/individuals, it has become necessary to consider seriously programmes for the conservation and use of indigenous animal genetic resources. Such programmes are needed both to protect these breeds/strains and to ensure their sustained use and availability for future livestock development.

The need is thus:

- to identify the animal populations at risk,
- to study their populations and population dynamics,
- to identify superior genetic material for the prevailing environmental and economic conditions,
- to develop strategies for conservation of valuable populations,
- to develop a national conservation policy, and
- to educate communities on the value and use of the indigenous animal genetic resources.

This is the right time to initiate and implement programmes for the conservation of indigenous endangered breeds and the selection and development of highly productive indigenous stock suitable to our environment. The success in the conservation of wildlife and forests through conservation areas, buffer zone concepts, and community forestry have all relied on community participation. With the concerted efforts of international agencies, national institutions, and local level organizations, conservation of domestic animal genetic resources through active community participation appears feasible, and would enrich the biodiversity of the country and help in the development of sustainable programmes for livestock development.

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Chapter 28

The Diversity of Mountain Farm Animal Resources and Conservation Concerns in Pakistan

W. H. Pirzada

The mountain ecosystem in the Hindu Kush-Himalayas, of which the Northern Areas of Pakistan are a part, plays a significant role in the socioeconomic well-being of the people in the region. Mountains constitute 40 per cent of the total area of Pakistan. The northern mountains cover Malakand Division, Hazara Division, the *Murree Kahuta Tehsil*(s) of the District, Rawalpindi, Azad, Jammu and Kashmir, and the Northern Areas of Pakistan. The 96,340 sq. km. area was inhabited by 7.8 million people in 1993 (Anon 1994). Both small and large ruminants and draught animals are kept by farming communities in the area for their subsistence.

Animal Resource and Farming System Diversity

The altitude in this area varies greatly, ranging from 300m in the south to more than 8,600m in the north. In the regions up to 1,500m in elevation the pastures are grazed round the year, while at higher elevations (1500-3000m) grazing is restricted to the summer season. Thus livestock production in the northern area is dependent primarily on the availability of pastures during the summer season, in the winter there is an acute shortage of feed for livestock. During the winter, livestock is fed on hay, dried grass, stubble from cereal crops, and crop residues. The estimated livestock population in the Northern Areas in 1996-97 was 1,603,000, with an annual growth rate of 5.11 per cent. Since land availability for fodder is restricted by the competition between human and livestock populations, fodder is rarely grown as a separate crop and rangelands are used for the production of livestock, mainly cattle, sheep, goats, and yaks. In Diamir and Gilgit districts alone, rangelands cover about 3.5 million hectares, over 50 per

Table 28.1: **Estimated Livestock (Ruminant) Population of Pakistan**

Livestock Species	Population 1995-96 (thousand head)[1]	Growth Rate FAO estimate[2]
Large Ruminants		
Cattle	17,883	2.4
Buffaloes	20,214	1.4
Camels	1,163	-
Small Ruminants		
Sheep *	29,789	2.2
Goats *	45,649	2.7
Total	**114,698**	**2.7**

Source: 1 Ministry of Food, Agriculture & Livestock, Government of Pakistan,
2 FAO, RAPA Publication, 1987
* Dominant in mountain areas

cent of the total area of the Northern Area. Overgrazing has reduced the carrying capacity of the rangelands from 1/10 to 1/2 of the forage potential capacity.

The animal resources in the area are diversified, but because of the lack of feed, productivity is low. Small-statured cattle, possibly of *Bos taurus* origin, are found in the northern areas of Gilgit, Diamir, and Sakardu districts, while in other areas the cattle are mostly non-descript. The sheep found in Gilgit, Damir, and Sakardu are also very small. Both indigenous and crossbred flocks of sheep are found in the rest of the region.

Western Dry Mountains

The uplands of Balochistan are the main area of this mountain ecosystem which is part of an arid zone. The area includes parts of the Kohat and Bannu districts of the North-West Frontier Province (NWFP), accessible parts of Kurram, and North and South Waziristan. The estimated livestock population in Balochistan province in 1996-97 was 31,416,000. Rangeland-based livestock production is the main economic activity in the region.

The main animal resources in the area are cattle, sheep, and goats. *Bhagnari* is the major cattle breed, although *Red Sindhi* is also found in some areas. The indigenous *Lohani* cattle have now been declared an endangered breed necessitating on-farm conservation (Wiener 1990). *Harnai, Birbrik,* and *Baluchi* are the best sheep breeds, they are known for both carpet wool and mutton.

Salt Range Tract

The salt range is part of the rainfed area of Punjab. This area covers hilly districts of Khushab, Chakwal, and Jehlum. The livestock population in the district is dominated by cattle (782,016), followed by buffaloes (285,897), and sheep and goats (3,440). The predominant cattle breed is the *Dhanni*, which is very agile and thrifty. Bullocks are used for ploughing. Camels, donkeys, and mules are used for transportation. This tract is known for coal and salt mines, and draught animals are an important source of motive power.

Indigenous breeds are well adapted to the tropical environment, particularly the ambient temperatures which are sometimes as high as 52°C. They are also more resistant to tick-born diseases than exotic stock.

The only major introductions of exotic origin are Friesian and Jersey breeds of cattle and the Ramboullit breed of sheep. Dairy breeds of cattle from irrigated parts of Punjab and Sindh, namely *Sahiwal* and *Red Sindhi*, have also been introduced to a limited extent. Crossbred animals, particularly cattle and sheep, are also found in both the Northern and Western areas in smaller numbers. Mostly exotic animals have failed to thrive in the mountain ecosystem of the region as a result of scarcity of feed, high temperatures, and high prevalence of disease.

Livestock and the Changing System of Livelihood

There has been no significant or systematic effort aimed at conservation and development of indigenous breeds, rather their role in diversity and sustainable development has remained unappreciated. Diversity remains a tool for survival, and we can hardly afford to lose the diversity of animal resources in the mountain ecosystem.

Many factors must be taken into account for sustainable rural development. These include: social and ecological as well as economic factors; living and non-living resource bases; and the long- and short-term advantages and disadvantages of different actions. The dependence of rural communities on living resources is direct and immediate. The people living in mountain areas of Pakistan depend on natural resources for their survival, their average income is less than 500 rupees (US$ 17) per month. The resources essential for human survival and sustainable development are increasingly being depleted and destroyed. At the same time, human demand for more livestock is growing fast. There is a threat to the sustainable use of livestock resources; the challenge of increasing food production to help keep pace with demand while retaining the essential ecological integrity of the production system is colossal. Livestock diversity and indigenous knowledge and practices should contribute a great deal to solving these problems.

An important change in human settlement during the 20th century has been their rapid urbanisation. Previously, this rapid urbanisation was relatively insignificant in the Pakistan mountains. During the last century, however, a distinct set of forces has generated the growth of specialised urban centres. Urbanisation has been particularly rapid in some of the more economically dynamic areas; e.g., the population in Peshawar (NWFP) has been growing at the rate of 8.4 per cent per annum (Anonymous 1986).

Bullocks are being replaced by tractors in modern agriculture, and this could lead to semi-intensive livestock farming. Bullocks, however, will continue to provide the main motive power in the region as they are genetically suited to the needs of marginal ecosystems.

NGOs and Changing Livelihood Systems

Numbers of NGOs are now operating in the region, for example, the Agha Khan Rural Support Programme (AKRSP), the Sarhad Rural Support Corporation (SRC), and the Balochistan Rural Support Programme (BRSP). The interventions of NGOs have led to a change in the farming systems and the livelihoods of custodians of animal resources. For example, the availability of such things as credit facilities, extension, and training has led to changes in herd size, input levels, and marketing, and these are contributing towards a changing livelihood system. AKRSP/SRC propose better management of resources in the ecosystem, without compromising the diversity of the system. Conservation of agrobiodiversity should thus remain a priority on the development agenda.

Let me conclude with what Mahammed Amin wrote in 'The Last of the Masai': *"The Masai community's entire culture is rooted on cattle in legends, love and even language. In Maa, there are 30 words to describe the shape and hue of cattle"*. Thus conserving animal resources also implies conserving folk heritage and culture.

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Chapter 29

Insect Biodiversity in Nepal and Its Value for Integrated Pest Management Systems

R. R. Pandey

Pests (including insects, diseases, weeds, rodents, and mites) are the major biotic constraints to increasing agricultural production. Infestation by pests has been identified as one of the main causes of low food production. Exact figures are not available, but the National Planning Commission of Nepal has estimated that pests cause a loss in food production of about 15-20 per cent (Baker and Gyawali 1994). Bunting (1972) suggested that, in developing countries, about one fifth of the possible output was lost because of field pests and another fifth because of post harvest pests. Current estimates of loss caused by pests is around 30 per cent of potential food production (NRI 1991). Insects alone cause more than one third of the total damage done by pests. Therefore pest control alone can contribute a lot to food sufficiency. This paper aims to discuss some of the issues related to pest management, in general, and the use and promotion of biological control systems against insects in pest control strategies in particular. Pest control will contribute to ensuring the long-term sustainability of agriculture in mountain areas.

Pests and Pest Control Options

Any organism that interferes with our health and comfort, the quality and quantity of our food supply, our cultivated plants, our forests and buildings, our domestic animals, or any other aspects of the quality of our environment may be considered a pest (Waterhouse and Norris 1987). From the agricultural perspective, we would include among pests organisms that induce disease (fungi, bacteria, viruses, nematodes) or that damage crops in the field or in storage (such as insects, mites, rodents, birds, mammals) or compete with them for space, nutrients, light, or water (weeds).

Traditional agriculture is characterised by the adoption of stabilised land races (low productivity but higher ability to compensate for loss), low external input, low cropping intensity, and long fallow periods. There used to be a wide range of crop diversity within the same piece of land (through mixed cropping), or deliberate use of a mixture of varieties. Pesticides were neither available, nor were they felt to be necessary because of the subsistence nature of production. This further enhanced the role of natural enemies and pests were mostly controlled naturally or by traditional farming operations.

In modern agriculture, efforts have been made to boost productivity by using high-yielding varieties with a high degree of assimilation efficiency, increased cropping intensity, and increasing external inputs such as irrigation, fertilizers and pesticides. Traditional and environmentally adapted practices were replaced and efforts were made to change the environment in favour of the crop variety so as to maximise production. Monocropping replaced mixed cropping, and so called 'miracle varieties' replaced varietal diversity. This practice encouraged some pest species to grow to economically important levels. Application of pesticides to control these pests disturbed the natural balance of the ecosystem, leading to further outbreaks of secondary pests.

Before the discovery of DDT as an insecticide, insect control was largely by nature, cultivation practices, and some biological control agents. Since the development of DDT and other synthetic insecticides, insect control has mainly been based on the use of chemical pesticides. Soon after they became widespread, environmental mishaps began to be observed. Pesticide residues were reported in several foodstuffs, bio-accumulation resulted in the death of animals of higher tropic level, and the whole ecosystem was greatly disturbed. The long-term effects of pesticides on human and animal health were studied in detail. At the same time several insects developed resistance to pesticides and outbreaks of pests became more common than in the past. Awareness of pesticide misuse supported the campaign against pesticides and Stern et al. (1959) proposed an integrated control concept combining chemical pesticides with biological control agents. The idea received wide acceptance and, further developed with wider applicability, was given the name 'Integrated Pest Management (IPM)'.

Pest Control Approaches

There are few problems with insect/pests in natural ecosystems because of the balance between carnivorous and herbivorous insects. Subsistence agriculture supports a slightly lower level of insect diversity. The expansion of crop monocultures worsens insect pest problems considerably because of the decrease in local habitat diversity (Alieteri 1987).

Understanding the role of insects in the ecosystem is necessary before developing a pest management strategy against the important pests. Plants are the universal producers. Herbivore insects constitute the second trophic level, and their parasites and predators the third trophic level. Insects are the largest group of living organisms and are distributed widely throughout all ecosystems. They play a very vital role in agricultural ecosystems as well. Not all insects present in agriculture are economically important. Some insects are identified as good friends because of their economic benefit to farmers (honeybees, silk worms, lac insects, scavenging insects), some are known as notorious pests and disease vectors, and others as their enemies. Most insects may not have any direct significance)

In Nepalese hill agriculture, weeds are managed by cultivation and human labour. Most of the diseases of field crops are controlled by using the host plant resistance through breeding programmes. Insect pests in most crops, and diseases (mostly fungal) in many high-value crops such as vegetables, have become the targets of pesticides. The accumulation of pesticides in the environment, and its effects on the health of humans and livestock, and on non-targetted organisms, have made pesticides more problematic than the pests themselves.

Pest management research receives low priority. In order to promote the adoption of modern agricultural technologies, both for cereals and in high-value commodities, HMG/N has been providing subsidies for pesticides and sprayers (through special programmes). Over-reliance on pesticides is a result of (i) the orientation of technicians and commercial growers towards chemical control because of its quick action, (ii) easy access to pesticides and lack of regulations to control pesticide misuse, and (iii) lack of alternative pest control methods.

Using pesticides can have many advantages if sufficient care is taken (and that is the reason why they are so popular in the developed world). The developed countries are the biggest users of pesticides, but pesticide-related hazards and accidents are most common in the developing countries (Dahal 1995). The most common patterns of pesticide misuse in mountain agriculture have been documented by Baker and Gyawali (1995). They are mostly related to improper selection, storage, handling, dosages of pesticides, and failure to observe the required waiting periods. These problems are caused by the low literacy rate, lack of proper information about pesticide hazards, limited access to safety measures, inadequate legislation and weak enforcement of existing rules, and lack of awareness about pesticides. Less than five per cent of the pesticide applicators wear protective clothing, and none applies masks to cover the mouth and nose (Baker and Gyawali 1995).

There are no properly recorded data on the quantity of pesticides used by hill farmers in Nepal or on their ill effects on human health. This is largely because of the involvement of the private sector, which has no obligation to maintain records, in the pesticide business (Dahal 1995). Nepal imported pesticides worth NRs 42.394 million in 1989, insecticides alone accounted for NRs 42.167 million (Baker and Gyawali 1995), indicating their dominance. Most of the insecticides applied in Nepal belong to the organo-chlorine or organo-phosphate groups. The most popular insecticides are BHC (Class II, moderately hazardous, banned in 28 countries) and metacid (Class 1a, extremely hazardous, banned in five countries) (Dahal 1995). Mountain farmers are ignorant about the unwanted effects of pesticides, and the greater the toxicity, the wider the range of insects killed, and the longer the residual effects of a pesticide, the more likely they are to rate it as 'good'.

Integrated Pest Management (IPM)

Because of the failure of chemical pest control (Box 29.1) and the increasing concerns related to health and environment all over the world, emphasis has been given to research into alternative methods of pest control. IPM has been recognised as the best strategy for pest management. It is defined as a pest

Box 29.1

Failure of Chemical Pest Control in Nepal

- The rice bug *Leptocorisa orotorius* is considered to be a major pest for rice. Farmers use pesticides to control the pest. Outbreaks of brown plant hopper (*Nilapervata lugens*) were observed in Jholunge Phant in Gorkha District and in Rishing Patan in Tanahu District in 1992, following the application of contact insecticides, such as metacid or malathion, to control the bug.

- Citrus green stink bug (*Rhynchocorris humeralis*) is an easily visible pest of citrus which causes fruit drop in mandarin oranges. Several species of scale insects are also associated with mandarin oranges. Application of cypermethrin to control the citrus green stink bug has increased the problem of scale insects in Hyangja in Kaski District and Bandipur in Tanahu District. In both cases the scale insect problem gradually declined once pesticide spraying was abandoned .

- Spring tomatoes are an important off-season vegetable crop in the hills. They suffer from attacks of the fruit borer *Helicoverpa armigera*. Farmers from Tapu, Parbat District, and Dhanubase, Syangja District, have complained that Ripcord (cypermethrin) has failed to control the pest. Later this was found to be associated with the development of pesticide resistance. In Syangja, the pest has developed 56-fold resistance to cypermethrin and 53-fold resistance to Fenvalerate (Armes and Pandey 1995). Field surveys in the following years showed that the indigenous egg parasite *Trichogramma achae* was responsible for damaging a huge proportion of *Helicoverpa* eggs.

Sources: Pandey and Joshi 1996; Pandey and Rana 1992 management system in the context of the associated environment and related to the population dynamics of the pest species which uses all the suitable techniques and methods in as compatible a manner as possible and maintains the pest populations at levels below those causing economically unacceptable damage or loss (FAO 1986). It was only in the eighth five-year plan (1992-1997) that HMGN accepted environmentally friendly methods of pest control as a national guideline. IPM and post harvest loss control are the priorities for research in the eighth plan. The Nepal Agricultural Research Centre (NARC), as the apex body of agricultural research in the country, has also given high priority to IPM research for the development of environmentally friendly and sustainable agriculture in the country. Legislation to regulate the import, sale, and use of pesticides in the country was passed in 1994 and has recently been enforced, but not very effectively.

Because IPM is a combination of several compatible techniques of pest control methods, component technologies have to be identified and developed first. The suitability of component technologies depends on the prevailing agricultural system, socioeconomic factors, and the availability and access to alternative methods. The identification and use of the host plant resistance, modification in cultivation practices against pests and in favour of the crop and natural enemies of the pests, mechanical destruction of pests, use of other control measures such as attractants, mating disruption through pheromone traps and insect growth regulators, application of biological control agents (parasites, predators, and pathogens), and the promotion of less toxic extracts of local plant materials are key features of IPM. Chemical pesticides (either with intrinsic selectivity or selectivity resulting from application techniques) are taken as the last resort in the pest management technique (when all other techniques fail to maintain the pest population below the economic threshold level).

Insect Biodiversity

Biological control in its simplest sense is the use of insect biodiversity (one organism) to suppress pests on agricultural, forest, veterinary, or human health. The first, and very successful, use of biological control was achieved in controlling citrus scale (*Icerya purchasii*) with the help of an Australian ladybird beetle (*Rodolia cardinalis*) in the 1880s in the USA. Since then a variety of biological control programmes has been launched with mixed success. Biological control can be achieved by means of several different types of agents, commonly known as parasites, predators, and pathogens.

In the present context, biological control has become the most important component in the design of Integrated Pest Management strategies, especially those against insects. The IPM approach uses both the natural and the applied aspects of biological control. A diversity of insect species and an understanding of insect-insect relationships are crucial when determining a pest management strategy.

The association between some ants and honeydew secreting insects such as aphids and scale insects may favour the development of the latter to pest status. In contrast, predatory and parasitic insects help suppress pests in fields, and are further assisted by pathogenic organisms. Predators and parasites may themselves be attacked by predators of higher tropic level and hyper-parasites.

The most common species of predators belong to the orders *Coleoptera* (Families *Carabidae, Coccinellidae, Staphyllinidae, Cicindellidae, Cleridae, Lampyridae, Cantheridae, Meloidae, Elateridae,* and *Stylopidae*), *Dictioptera* (Family *Mantidae*), *Diptera* (Families *Syrphidae, Asilidae, Bombyliidae, Rhagionidae,* and *Empididae*) *Hemiptera* (Families *Phymatidae, Reduviidae, Nabidae, Anthocoridae, Pentatomidae,* and *Miridae*), *Hymenoptera* (Families *Vespidae, Formicidae,* and *Sphecidae*), *Mecoptera* (Families *Panorpidae* and *Bittacidae*), *Megaloptera*, *Neuroptera* (Family *Chrysopidae*) and *Odonata*. Wasps of the order *Hymenoptera* (Families *Ichneumonidae, Braconidae, Scelionidae, Eupelimidae, Trichogrammatidae,* and *Mymaridae*) and flies of the order *Diptera* (Family *Tachinidae*) are the major groups of parasitic insects.

Development of a Pest Management Strategy

When developing a pest control strategy, it is necessary to understand the life cycle of the pest and factors affecting its build up. There may be many individual reasons for specific pest build up, but they can be categorised into (i) invasion, by which an organism enters into a new environment more conducive to its growth and reproduction as a result of the lack of natural enemies; (ii) ecological changes, such as adoption of high-yielding varieties, monoculture, pesticide application; and (iii) socioeconomic changes, affecting the priorities and values of the different crops grown (Stern et al. 1959).

Innundative application of biocontrol agents can be compared to pesticide application, a large number of organisms is released at one time to suppress the pest population. This practice is possible only when the cost of production is low. The best strategy against pests that have invaded a new environment, such as the tuber moth, *Phthorimaea operculellea*, in potatoes in Nepal is to search for the most efficient enemies at the place of origin and introduce them in the form of an inoculative release (as was done when *Rodolia cardinalis* was imported into California to control *Icerya purchasii*). The newly introduced species is expected to adapt to the environment and multiply using the pest, ultimately bringing the pest down to a tolerable level. Inoculation can also be practised when more efficient (compared to the indigenous) predators and parasites are available abroad for the control of an indigenous pest.

Box 29.2
Integrated Pest Management In Pakistan

A. I. Mohyuddin

There have been several success stories of IPM in Pakistan for mangoes, apples, sugarcane, and cotton. These were made possible by introducing exotic insects such as *Cotesia flavipes* from Japan, *Apelinus mali* from the USA, *Elasmus zehntneri Ferriere* from Indonesia, *Encarsia perniciosi* from California, *Leptomastix dactylopii* from the West Indies, and *Bracon kikpatricki* from India. The identification and redistribution of natural enemies is also used as a biological control strategy in Pakistan. This approach was found to be successful in enhancing insect biodiversity as well as providing good control over various pests in sugarcane, cabbage, cauliflower, potato, and apple crops. Nevertheless, the most efficient and cost effective strategy is the conservation of natural enemies *in situ*. This requires a clear understanding of local systems and of indigenous crops and plant species and their interaction with insect pests.

The usefulness of conservation of natural enemies to control pests of sugarcane, mango, and cotton has been successfully demonstrated in Pakistan.

There is also a great diversity of insects that perform crop pollination. *Hymenoptera, Diptera, Lipidoptera, Thysanoptera*, and *Coleoptera* are the important groups of insects responsible for pollination. It is reported that more than 250,000 species of flowering plants have a complex relationship with pollinators. In Pakistan, the diversity of pollinators has been improved by the introduction of pollinators such as the honeybee (*Apis mellifera*) which was introduced in 1976 from the USSR and in 1977 from Australia. In contrast to the experiences in China, Nepal, and India, *Apis melliferra* became well established and improved seed production as well as increasing honey production.

When an indigenous pest attains pest status as a result of changes in cultivation practices (as in most vegetable farming practices in Nepal) then a good start would be to look for indigenous biocontrol agents in the same crop cultivated by traditional practice in the surrounding area and to promote these agents through changed cultivation practices or modification of the environment in their favour. This is commonly known as the 'conservation' of natural enemies. When indigenous biocontrol agents exist but are are not effective enough because of factors such as rapid population build up of the pest species, or changes in the environment such as pesticide application, then it is necessary to augment the naturally existing population by introducing additional agents of the same species. Existing insect biodiversity plays a very important role in both techniques (conservation and augmentation).

Some work on insect biodiversity has been carried out in Nepal on butterflies, beetles, and moths because of their fascinating aesthetic value, but efforts have largely concentrated on reporting the existence of a species in a given ecosystem without considering their economic role. Work on parasitic insects is very meagre, although they play a vital role in the ecological balance. The main reason behind this lack of interest is the complicated life cycle, small size, and lack of attractiveness compared to butterflies, moths, and beetles. Furthermore, the study of parasitic insects is more of a professional field for agricultural pest management personnel interested in biological control. Since biological control failed to attract the attention of national policy until recently, because of the focus on pesticides, parasitic insects remained unexplored.

Maintenance of Insect Biodiversity

Insects are the largest group of creatures on earth and are distributed throughout all habitats. Their distribution is affected, however, by the diversity of producers (plants) and other biotic and abiotic factors. Because of the ecological diversity in Nepal, there is a wide variation in natural vegetation and the crops grown (in terms of species, variety, and farming systems). This variation supports the existence of a variety of both pests and their natural enemies. The role of insects is further enhanced by the subsistence nature of agriculture in Nepal, in general, and in the hills in particular, with minimal or no use of chemical pesticides. It is important to conserve and maintain the naturally prevailing insect biodiversity for the development of IPM in hill agriculture. The 'conservation' approach would be useful against indigenous insect pests which change their status as a result of changes in agricultural practices such as a reduction in diversity, use of susceptible varieties, and application of pesticides.

Traditionally, in mixed cropping the low crop used to provide shelter and humidity for such organisms the 'natural enemies of pests'. Different crops provided flowers at different times and this benefitted many parasitic wasps. Each crop also sheltered non-specific predators that attacked the pests of the crops grown. Similarly, in modern farming, the practice adopted in the UK of leaving an unsprayed border around the crop area has not only encouraged game birds but also encouraged the growth of biological control agents (van Emden 1989).

Previously, clean cultivation free from weeds was advocated, and weed vegetation was blamed for harbouring crop pests and diseases. The orientation is now changing and the role of weeds as a home for the natural enemies of pests is receiving consideration. It now known that weedy rather than clean plots of wheat have a greater abundance of predatory beetles, and that the impact of flowers from weed flora in maintaining parasites and predators of crop pests far outweighs the detrimental influence of the weeds (van Emden 1989). Non-crop plants have been used to promote predators to control *Brassica* pests (White et al. 1995). Roadside verges, hedgerows, and nearby forests have provided food and shelter to natural enemies of crops on UK farms (van Emden 1989). It is expected that the weeds and grasses growing on the terrace risers and bunds, and the fodder and forest trees grown around the farm, could play a similar role in mountain agriculture, but this has still to be investigated. If pesticides are applied, care should be taken to choose a selective pesticide (using inherent selectivity or selectivity through the application method) so that the possible harm caused to natural enemies is minimised.

Which Agent - Indigenous or Exogenous

In Nepal, there are two ways to proceed in using insect biodiversity as a basis for finding suitable biological control agents: (a) look for our own indigenous agents and promote them, and (b) import those from abroad. The advantages of indigenous agents are that they are already adapted to the environment and there is no need to investigate their requisites to satisfy quarantine regulations. There may be some doubt as to the availability of such agents in our ecosystem, but several studies suggest otherwise. Field surveys conducted by Lumle Agricultural Research Centre have shown that several parasites exist for *Helicoverpa armigera* and the citrus green stink bug, *Rhynchocorris humeralis* (Pandey et al. 1996). Field observations have shown that a wide range of coccinellids attack aphids and scale insects. Several species of wasps attack aphids, cabbage butterflies, diamond back moth, and even grain storage pests (grain weevil) in wheat. Natural enemies for other pests attacking different crops must have existed (or still exist) in our farming system, a theory supported by the outbreaks of secondary pests following pesticide application.

The disadvantage of indigenous agents may be their efficacy; if they are already present why aren't they effective? This can only be answered by proper studies. Studies of tomato have indicated that pest build up is much faster than parasite build up after the cold winter. Here one possible solution might be to augment the prevailing biological agents, which could be achieved through release of additional agents (*Trichogramma achae* in this case) at an early stage. Such action would also help avoid interspecies competition.

Importing biological control agents from abroad would seem to be easy (because of their easy availability), but disadvantages might include problems of establishment in the new environment, problems arising from interspecies' competition with the native species, and the danger of introducing hyper-parasites and organisms pathogenic to indigenous biocontrol agents. Much more detailed and costly studies will have to be conducted on these organisms, and comparisons made with indigenous agents, if proper introductions are to be done.

Conclusion

The present situation in mountain agriculture is becoming favourable for the development and adoption of IPM. Government organizations (both research and extension), non-government organizations, and the donor community have shown their interest in and commitment to strengthening IPM work in the country. Public awareness about the ill effects of pesticides is increasing (both in consumers and producers). Losses due to pests are being recognised increasingly and solutions sought, and alternative methods are being demanded and accepted. Integrated Pest Management systems will help stabilise yields, increase productivity and economic benefit, and minimise applications of pesticides.

IPM is not a technology in itself but an integration of available and compatible technologies combining different aspects of agricultural science — including plant host resistance, cultivation practices, biological control agents, chemical non-pesticides, and selective (application of) pesticides. IPM can only be promoted if the component technologies to be integrated are available. The main aim of implementing IPM in Nepal is to reduce the use of pesticides. The focus of IPM programmes must be on the management of insects pests, followed by management of diseases. This is because of those farmers who use pesticides, 95 per cent use insecticides, about 41 per cent rodenticides, 38 per cent fungicides, and only 13 per cent weedicides. The insecticides used in Nepal belong to the highly persistent organochlorine group and constitute the largest volume of the total pesticides used (Dahal 1995). The total volume of rodenticides used is relatively small. IPM will help to get rid of a situation in which pest control is synonymous with pesticide, pesticide with insecticide. Rice attracts the largest volume of pesticide, whereas high value crops, such as vegetables, mustard, and cotton, receive the most intensive application (Baker and Gyawali 1994). Pest problems in these crops result from the ecological changes caused by increasing commercialisation (changes further worsened by the application of pesticides, mostly insecticides) and socioeconomic changes (high-value crops). Thus the IPM programme should first concentrate on rice and vegetables.

Insects are attacked by a wide variety of biological control agents (especially in undisturbed ecosystems), therefore emphasis should be given to the understanding of crop ecosystems in terms of pests and their natural enemies. Indigenous biological control agents need to be searched for and promoted through the adoption of various cultivation practices and other control methods that disturb natural enemies the least (such as mixed cropping, trap cropping, food lures/baits, use of pheromone traps, and demoulting hormones). In Rachel Carson's 'the other road' or 'integrated control' as proposed by Stern et al. (1959), or the modern concept of IPM in 'the context of the associated environment', the main emphasis is on the least disturbance to the biodiversity of natural enemies and the use of biological control agents. The development of resistant varieties should continue, as this is likely to be the most successful strategy against field crop diseases (as a result of the availability of vast genetic variability and the involvement of non-profit making international institutes). Identification of critical stages of crops that need special attention for protection, and development of rational spray schedules with selective and safe pesticides against important diseases and insects in commercially important crops such as vegetables, fruits, and cash crops, should also be investigated.

NGOs and environmental activists (especially journalists) have played a significant role in creating awareness against pesticides, and they should also be involved as partners in the development and dissemination of IPM. Thought must be given to managing populations of pests through biological and ecological actions; over-reliance on pesticides alone, which aims only at individual pests (Bunting 1972), must cease.

A national pest management plan needs to be developed without delay by identifying and prioritising the main pests and setting a strategy for their management. The role of different organizations should be identified and their linkages strengthened. The following are some of the areas that need immediate attention to facilitate better understanding, planning, and implementation of the IPM programme in Nepal.

- Creation of an inventory of GOs, NGOs, and other institutions that are involved in and/or can contribute to the IPM programme
- Identification of the roles of these different bodies and proper coordination
- Raising of awareness about pesticide hazards among growers and consumers
- Strengthening and enforcement of legislative measures to control pesticide misuse
- Understanding the functional role of natural enemies in maintaining the ecological balance within a given farming system through agro-ecosystem analysis
- Analysis of agricultural systems to discover the pest priorities from the farmer's perspective
- Identification of the factors affecting pest build up and development of agricultural practices to favour natural enemies
- Study of techniques for production and use of biocontrol agents
- Development of appropriate methods for the transfer of IPM technology

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Part VI

Institutional Innovation: Farmer-led Conservation Management

Chapter 30

Participatory Plant Breeding for *In Situ* Conservation of Crop Genetic Resources: A Case Study of High Altitude Rice in Nepal

B. R. Sthapit and K. D. Joshi

Nepal is one of the world's richest centres of genetic crop diversity, a result of extreme agro-ecological and socioeconomic variations (Upadhyay and Sthapit 1995). Different production systems have evolved for different crops, trees, and animals to cope with the diversity and complexity of the situation. Food security is the primary objective of maintaining diverse food crops and animals. Farmers and farming communities maintain Genetic Diversity in a continuous process of natural and human selection. The crops and cropping systems depend largely on the available natural resources and are adapted to specific environments. This is in contrast to modern agriculture in which environments are adapted to the crops. Genetic Diversity is maintained as a part of the farming systems to enable biotic and abiotic stresses to be coped with naturally. The most important factors that motivated farmers to maintain wide biodiversity in the past were probably ensuring food security and meeting various qualitative preferences and requirements (Roder 1991, Sperling and Berkowitz 1994).

In mountain farming systems, diversity within and between species provides sustainability and a constant ability to adapt to changing environmental conditions through the natural processes of selection. Approximately 60 per cent of global agriculture is performed by subsistence farmers using traditional methods, and this sector provides between 15 and 20 per cent of the world's food (Francis 1986). Plant diversity is the basis of most traditional farming systems. Farmers in the remote mountains of Nepal still depend on the cultivation of land races for their livelihood. This is evident from the fact that in most of the staple crops that have been studied such as maize, rice, and potato, adoption of modern varieties is still below 50 per cent (NAA 1995). This figure would be even lower if neglected crops were included. Extreme agro-ecological diversity and the specific preferences of farmers mean that a large number of location and purpose specific varieties are needed. Until now, this need has been addressed by cultivating locally adapted land races.

On-farm conservation in farmers' fields needs to be continued in future so that it will still be possible to use recombination of useful genes from wild relatives and cultigens with those from widely-grown land races to develop crops adapted to changed conditions. Diversity is an essential genetic resource for future plant and animal breeding. Gene flow from wild relatives to farmers' land races, and from land races to improved cultivars, is a dynamic process and should be maintained if plant breeding is to meet the growing needs of the world's population (Vaughan and Sitch 1991). New land races will continue to evolve under changing environments as long as genetic variation exists. In fact, modern agriculture is based upon the earlier efforts of farmers to maintain Genetic Diversity and knowledge. Farmer experimentation using the naturally existing genetic variation, produced the present day land races. Food security can only be as good as the genetic base supporting it. Therefore, the maintenance of traditional varieties and land races *in situ* should be an essential component of sustainable agricultural development.

Threats

Crop genetic resources are threatened by population growth, environmental and technological changes, and commercial development, making conservation an imperative. With the introduction of new high-yielding varieties and over-exploitation of natural resources, genetic erosion is also taking place in Nepal. Genetic erosion is reported to be high in staple crops, vegetables, fruit, and medicinal plants at both varietal and species' level. There are many examples in Nepal of crops, such as local vegetables, citrus fruit, and aromatic rices, with genetic potential that was only realised after they were lost from their natural habitats (Shahi and Mathema 1983; Sthapit *et al.* 1996). Until our national research system becomes capable of fully understanding and using the germplasm resources, *in situ* conservation of bio-wealth should receive priority on the national research agenda.

Genetic erosion is largely the result of breeding better varieties in productive environments. Selected cultivars gradually replace land races and better cultivars take over from earlier cultivars, until they in turn are replaced by still better cultivars. This process also occurs at the centres of origin which harbour the maximum genetic variation of one or more species. Genetic erosion also occurs as a result of changes in the land-use system or labour constraints. The potential threat of losing local resources forever has not been considered seriously. This threat will persist if the farming communities who maintain land races do not see any benefit from maintaining biodiversity.

Management Models for Germplasm Conservation

There are two ways of conserving germplasm: *in situ*, in the place of origin; and *ex situ*, outside the place of origin (as in zoos, botanical gardens, and gene banks). According to Brush (1995), *in situ* conservation of land races means maintenance in farmers' fields and home orchards in the place where they originated. *In situ* conservation is currently carried out by farming communities. Unfortunately, *in situ* genetic conservation has been described by various international organizations in reference to the conservation of ecosystems and communities. As a result, the objectives of on-farm conservation have been confused with those of various types of protected reserves. *In situ* conservation is now perceived, however, as a possible complementary method to *ex situ* conservation for land races. In the past it was considered the preferred method of conservation for wild species but was never implemented in the international germplasm system (Frankel 1970).

The Limitations of *Ex Situ* Conservation

Gene banks cannot conserve all types of on-farm species. The faults and merits of gene banks are well recognised. The gene bank cannot conserve the biological and social processes of crop evolution in the way that *in situ* (on-farm) conservation usually does. Furthermore, seeds stored in gene banks are not accessible to local communities. Even researchers have less access to gene banks. *Ex situ* conservation is managed and funded by outsiders (international centres) whereas *in situ* conservation is managed and controlled by local farming communities. Even taking into account the problems associated with *ex situ* conservation of germplasm, *in situ* conservation cannot be regarded as the sole panacea for the loss of land races.

It is important to compare the objectives, methods, and needs of the two approaches to clarify the differences between them and to establish their complementarity. *In situ* conservation can be considered an important conservation strategy and a way of making up for the potential faults of *ex situ* conservation, such as loss of seed viability, smaller population samples, genetic drift, and the static nature of gene flow. However, farmers will not continue to grow local land races or species if they do not see any advantage in them. Materials that farmers are not interested in can still be preserved *ex situ*. Therefore, both *ex situ* and *in situ* genetic conservation of agricultural biodiversity should continue and should be seen as complementary, not exclusive, activities.

Options

Various options can be identified in the literature for managing on-farm conservation of agrobiodiversity in farmers' fields. They are:

- protected reserves,
- subsidies,
- compensation,
- community seed banks,
- incentives - market and non-market oriented,
- awareness,
- education and training,
- policy relief,
- improvement of land races through disease elimination, and
- participatory plant breeding using land races as a parent.

Farmers will continue to search for better varieties than existing ones to meet their needs. This is a natural human instinct and should not be stopped for the sake of a 'protectionist' style of *in situ* conservation. Many conservationists agree that systems that rely on farmers' compensation or subsidies and/or result in low production levels will not be successful in conserving biodiversity and genetic resources at the farm level (Roder 1995). While direct compensation to farmers is not intended, it is important that the global investment in farmer welfare, through participatory plant breeding, farmer training, and community seed banks, be seen as indirect compensation in recognition of their role in on-farm genetic conservation. This kind of indirect compensation may reach more farmers and thus be more equitable than a system of payment to a few farmers (Brush 1992).

Strategy

In situ conservation cannot be achieved through 'subsidy' or 'museum' or 'reserve' strategies (Benz 1988, Roder 1995). The essence of successful *in situ* conservation strategies is to encourage farmers to maintain the special habitats that generated and maintained such diversity in the first place. Strategies for *in situ* conservation of agricultural biodiversity will work if they are:

- beneficial to farming communities,
- complementary to *ex situ* methods,
- politically viable and accepted by scientists, conservationists, farmers, consumers, and government officials, and
- implemented through community-based grassroots' institutions (NGOs).

Community participation will enhance the success of on-farm genetic conservation. The ways in which on-farm genetic conservation can be strengthened are described in the following.

Technical Approaches

- Involving the farming community in a participatory way in variety selection and plant breeding
- Researching the real situation by means of case studies
- Pathogen elimination in local land races (for example, potatoes, citrus fruit trees, and cereal crops)
- Training of farmers in seed selection, storage, and seed health
- Introduction of a flexible seed regulatory system to promote participatory plant breeding (PPB)
- Additing value addition to local plant genetic resources (for example improvements in aroma or in disease and stress resistance)

Non-technical Approaches

- Identifying and developing markets for local products
- Facilitating information and seed exchange
- Analysing agricultural policy to identify the incentives and disincentives that influence farmers' decision-making about variety selection and conservation (for example, policies related to seed, inputs, fertilizers, credit, extension services, and marketing)
- Education in schools through curriculum development
- Raising awareness of consumers
- Networking of grassroots' organizations to improve their capability and promote the exchange of information and materials
- Lobbying

A Case Study of Participatory Plant Breeding (PPB) of High Altitude Rice

The Problem

In Nepal, rice cultivation has been less widely adopted in high altitude areas where cold injury is common. Only limited research resources have been allocated to this problem by national and international programmes (LARC 1995, Chemjong *et al.* 1995). Cold tolerant materials from the International Rice Research Institute (IRRI) and the National Rice Research Programme (NRRP) at Lumle (1450m) and Chhomrong (2000m) failed to produce grain because of incomplete panicle exsertion or spikelet sterility (Sthapit 1992). National and international programmes appear to have failed to meet the needs and requirements of this 'difficult' environment. Many formal breeding programmes tend to focus on developing varieties for wide adaptation and with high yield potential for favourable environments. These materials do not adapt well to Nepalese mountain farming systems because of:

- the limited use of land races in the breeding programmes,
- untargetted screening, and
- lack of involvement of farmers.

The formal research system in developing countries is highly centralized and does not reflect the problems of resource-poor farmers. The low rate of adoption of officially released rice varieties in India (Maurya *et al.* 1988, Joshi and Witcombe 1996) and Nepal (LARC 1995, Chemjong *et al.* 1995) is evidence of this. The slowness of the formal procedures and the fact that only a few new varieties are generated every year when the need of farmers is for a basket of varieties to address diverse and complex farming systems have encouraged us to try alternative, participatory methods.

PPB methods are poorly documented, and there are few examples in the literature. Thakur (1995) screened F_2 material in farmers' fields, but subsequent generations were grown by researchers. In Ethiopia, land races have been enhanced by mass selection by farmers in collaboration with scientists from the Plant Genetic Resources' Centre (Worede and Mekbib 1993). In the Philippines, farmers have been involved in selecting from the progeny of crosses between traditional and improved cultivars, but the methods used have not been described in detail (Salazar 1992). A well-documented example of PPB was described by Sthapit *et al.* (1996) and this is the case study described in the following paragraphs. In all methods plant breeders are the facilitators of the research, since they have the essential understanding of the underlying genetics of parental selection and subsequent genetic segregation.

Concept

A participatory plant breeding (PPB) programme was conducted at Lumle Agricultural Research Centre (LARC) for the high altitude areas of Nepal. The purpose of the programme was to examine the potential of PPB for minimising resource use, utilising farmers' knowledge, developing suitable cold tolerant white-grained rice varieties, and enhancing the biodiversity of rice gene pools.

In the PPB, the land race is chosen as a parent to give genes for adaptation, and a released cultivar is chosen to give genes for other preferred traits, for example, high yield potential. When land race x MV cultivar crosses are used, and selection at the early stage of segregating lines is performed by farmers in the target environment, then the breeding strategy most closely resembles *in situ* genetic conservation of land races. In the past, some curious farmers experimented with naturally existing genetic variation in their own environment to produce the present day land races. Nonetheless, it cannot be ruled out that some 'unidentified but useful' genes present in the land race will be lost in the process of selecting crosses. *Ex situ* conservation will still be necessary to conserve the original unchanged land race. *In situ* PPB conserves and creates Genetic Diversity in farmers' fields, whereas *ex situ* conservation preserves genetic resources (Witcombe *et al.* 1996).

PPB is more likely to be successful in producing farmer-acceptable varieties than a conventional breeding programme because:

- negative genotype/location interactions are greatly reduced as selection is always in the target environment and under farmers' actual management conditions,
- at least one parent is well-adapted to the local (target) environment,
- the impact of genotype/year interactions is also reduced,
- large F_2 and F_3 populations are grown to increase the possibility of identifying transgressive segregants, and
- post-harvest evaluation is used to assess the level of farmers' preference.

The basket of choices available to farmers is likely to be larger when PPB programmes exist than when multi-locational testing programmes are used to produce widely adapted cultivars.

Methodology

The detailed methodology of the PPB programme is described in Sthapit *et al.* (1996). Briefly, PRA was undertaken to identify the characteristics considered important by farmers. Genetic variation was created by crossing a locally adapted land race with a variety with a farmer-preferred trait. Three crosses were used: Fuji 102 x *Chhomrong Dhan* (Machhapuchhre), K 332 x NR10157-2B-2 (Himchuli), and Stejaree 45 x *Chhomrong Dhan* (Nilgiri). In all cases, one of the parents was either a land race or a breeding line involving a local land race. Several sister lines of each cross were given local names to make them easier to identify in discussions with farmers.

Farmer participation began at the F_5 stage, with selection by expert farmers at a village workshop. Wives of cooperating farmers were automatically selected to do post-harvest evaluation. Farmers participated in the selection process by growing the selected rice F_5 bulk seed in the target environment. Actual site selection was left to the farmers, and they were later asked for their reasons for selecting a particular site. The expert farmers were also asked to select management practices of the type followed for their local varieties. Decisions on manure, soil type, and agronomy were left to the farmers. At the beginning of the selection, farmers were informed that when two divergent varieties are crossed the material is segregated for traits such as grain colour, plant height, and maturity, thus selection from the F_5 bulk seed for desired traits should be carried out for two to three years until the trait is fixed. The breeder's knowledge of genetics and heritability was offered to farmers to complement the farmers' indigenous knowledge of diverse environments. When the crop had matured, each participating farmer visited all of the plots during a farm walk, and farmers ranked the varieties from best to worst by assessing visual crop performance. Farmers, with the help of researchers, also recorded the positive and negative characteristics of each variety. Post-harvest evaluations were carried out by women farmers three months after the harvest.

The progress of the PPB programme was followed over three seasons in three villages. Five indicators were used to assess the impact of the PPB programme at farm level.

- The rate of adoption of new varieties and varietal spread
- The level of farmers' awareness
- The measure of Genetic Diversity at the village and household levels
- The basket of choices offered
- The perception of the farming community towards the PPB programme

Result

The strategies used by farmers to select test sites for planting are shown in Table 30.1. There were significant differences between farmers' and researchers' strategies for selecting testing sites. It is common practice in formal research systems to use good, uniform land and uniform growing conditions for trials, rather than to select for the target environment (Sthapit 1995). In contrast, farmers avoided risk by first testing the materials on their worst lands (stressed environments), and then growing the variety in better fields (Table 30.1). The heritability of a selected trait under such stress will usually be very high (Ceccarelli 1989). There is growing evidence that, for selection to be most effective, it must be carried out in the target environment. The farmers' strategies show how difficult it is to represent the heterogeneous environments of farmers' fields in uniform on-station conditions.

Simmonds (1991) also reported that selection for low-yielding environments must be conducted in low-yielding environments, and found that alternative strategies were ineffective. Ceccarelli (1989) suggested that, when the stress environment has a much lower yield potential, direct selection in the environment

Table 30.1: **Farmers' Strategies for Site Selection (1993)**				
Farmer	Altitude (m)	F_5 bulk name	Selected site	Decision made
J.N. Devkota	1400	Nilgiri-1	• No rice crop before • Inlet of cold water • High fertility	Confined*
H.B. Gurung	2000	Himchuli-2	• Inlet of cold water • Marginal plot	Rejected
D.J. Devkota	1400	Himchuli-2	• High soil fertility	Promoted
M.K. Gurung	2000	M.puchhre-1	• Upland rainfed conditions	Rejected
R.B. Gurung	2000	M. puchhre-3	• Worst cornered terrace • Cold irrigation water • Shade prevailing	Promoted
* Confined means area not increased cf. to first year planting				

is the most efficient breeding strategy. The most effective way of catering to the needs of low resource farmers is to conduct trials on farmers' fields with farmer level inputs.

The farmers were very willing to participate, and some were very skilful in making selections. There are numerous examples in which farmers were able to identify specific varieties for their niches and cold stress conditions (Table 30.1). Farmer methods of plant selection varied with the farmers' own expert knowledge and circumstances. The segregating line of Machhapuchhre-3 was given to three farmers, but only two of them succeeded in selecting superior types (Sthapit et al. 1996). The farmer who failed to identify superior types from the same F_5 seed had simply concentrated on mass selection for grain colour. Women farmers were particularly skilful in assessing post-harvest traits such as milling recovery, cooking, and eating quality of rice. Male farmers showed more skill in the assessment of standing crops for yield potential, management requirements, and threshing criteria. Breeders and field staff need to interact with farmers frequently and stay in the villages for a considerable time in order to identify such gender differences and any differences between groups in the village.

Farmers evaluate new varieties at different stages of crop growth, particularly close to maturity, and also during threshing, milling, and consumption. Monitoring indicated that farmers continually changed their decisions with the availability of new information. At present, farmers' involvement in formal variety testing in Nepal is limited to preference ranking at maturity, but most farmers make their final decision on retaining or rejecting a variety after milling, cooking, and eating. The post-harvest assessment of various tested varieties compared with the local reference variety is shown in Table 30.2. The decisions about retention or rejection were based on different traits. For example, the area under M-4 expanded because of its good milling recovery, whereas M-6 was rejected because of its peculiar

Table 30.2: **Post-harvest Assessment of Various Rice Varieties Measured in Relation to the Local Reference Variety (check variety) Chhomrong Dhan, 1994**

Traits‡	M-2	M-3	M-4	M-6	M-7
Milling %	50.0	45.0	56.0	45.0	40.0
Broken rice %	1.9	5.0	1.3	5.0	5.0
Water-absorbency capacity	+	+	+	-	+
Elongation capacity	+	=	+	-	+
Aroma	+	-	-	-*	-
Dryness	+	+	+	-	+
Stickiness	+	+	+	-	+
Taste	+	+	+	+	+
Appelite delay	+	+	+	-	+

† Better than local reference variety = equivalent to local reference variety, - Inferior to local reference variety

‡ Assessment was done by farmers after cooking in their own way and relative to local reference variety. Asterisk (*) indicates peculiar smell of rice which was not liked by farmers.

smell when cooked. M-3 was preferred at all stages because of its yield potential and straw height. Nilgiri-1 was first selected by a farmer in Lumle village, who later rejected his plan to expand the variety in the remaining good fields because of the high shattering and poor taste. Finally he decided to grow it in only one plot where an inlet of cold stream-water caused high sterility. Himchuli-2 was rejected by farmers at Chhomrong, Ghandruk, and Lumle where rainfall is very high at the time of maturity and causes pre-germination before harvest. In contrast, it was liked by the farmers in Patlekhet village (1,500-1,700m), where rainfall and humidity were less at the time of maturity. In Lumle, the mother of D. Devkota selected non-sprouted panicles and planted the seed from them in a 100 sq. km. area to see whether the problem of sprouting would continue. Such examples support the decentralization of selection. Such information should be disseminated to extension staff.

The most successful material is now being adopted by farmers. Good varieties selected by farmers spread substantially within three years of their introduction (Figure 30.1). M.B. Gurung, who was given half of the seed from his friend, J.B. Gurung, successfully selected from M-3 (his selection is identified as M-3C) and increased the area under this variety from three sq.m. to 150 sq.m. within a year. Similarly, R.B. Gurung also selected from M-3 (variety identified as M-3G) and increased the area grown from six sq.m. to 50 sq.m in 1994 and 1,250 sq.m in 1995 (Figure 30.1). This variety occupied 2.5 per cent of his rice fields after the first year of selection and 62.5 per cent after the second. Thus farmers from two villages from similar ethnic groups and farming backgrounds selected two different varieties, M-3C and M-3G, from the same F_5 bulk seed. The rate at which the area of cultivation of selected cultivars increased has been high in the first three

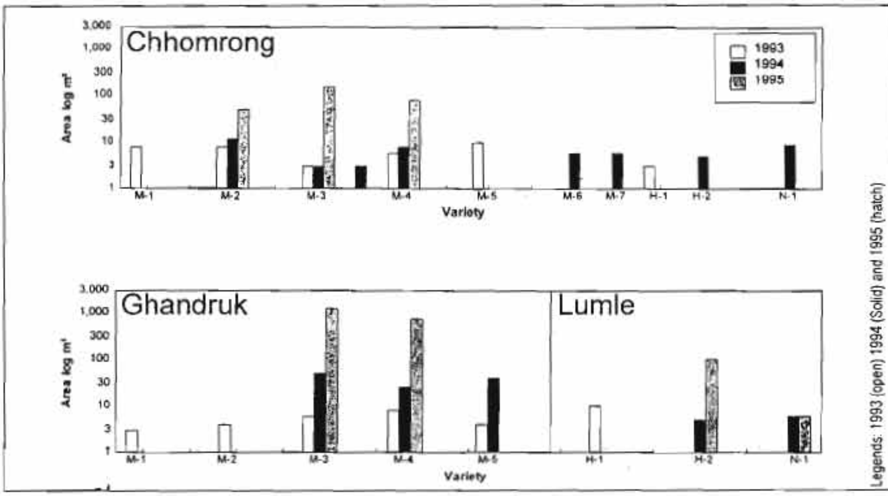

Figure 30.1: The Spread of Farmer-preferred Bulks Measured by Area Increased (log m³ under New Rice Line Since PPB Was Initiated in Chhomrong and Ghandruk Villages

years. This compares with the conventional system in which there is a long period, typically five to six years, before appreciable adoption occurs (Morris et al. 1992). It has been observed that farmers usually fulfill their own needs first and only then supply seeds to other farmers. Some farmers in the programme have already started distributing seed from their preferred varieties to other farmers. We anticipate that M-3G will be cultivated widely in domains similar to those in Ghandruk and Chhomrong by the time the variety is released through the formal system.

Thus PPB successfully produced excellent cultivars which are spreading in farmers' fields. In a conventional breeding system, material such as M-3G and M-3C (at F_7 stages) would have still been at a very preliminary stage of varietal screening in very small plots, and still at least seven years away from being given to farmers for them to grow in minikit tests (Figure 30.2). Even if time is allowed to select for greater uniformity in a farmers' cultivar to satisfy seed certification requirements, a release proposal can be submitted following PPB three years earlier than in the conventional system.

The varieties developed jointly with farmers were far superior and outperformed the best entries from the conventional system (Figure 30.3). The most preferred material, Machhapuchhre-3, has also performed well in the formal trials' system. There were clear advantages in using locally adapted parents and selection in the target environment, compared to introductions from international nurseries which usually perform poorly (Sthapit 1992).

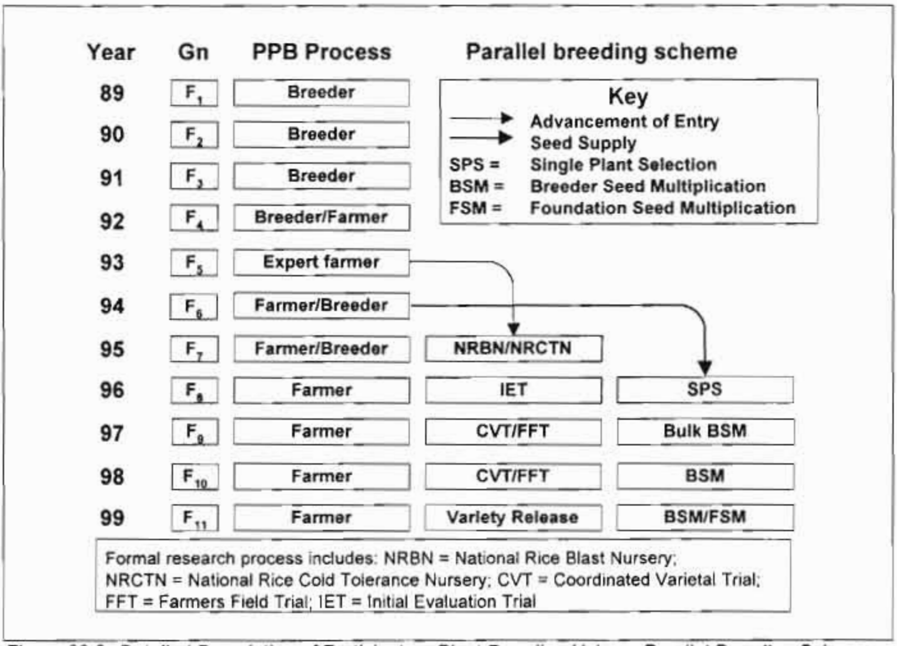

Figure 30.2: Detailed Description of Participatory Plant Breeding Using a Parallel Breeding Scheme

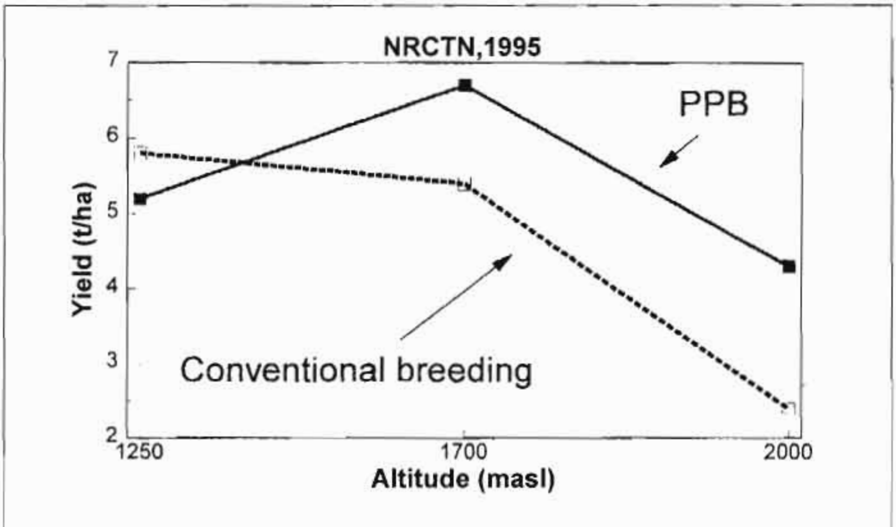

Figure 30.3: Comparison of Conventional and Participatory Plant Breeding in Nepal

This work has shown for the first time that a farmer-selected variety cannot only be farmer acceptable but can also yield well in the formal varietal testing system. This is in part the result of the trials' system having test locations appropriately situated and a trial arrangement that does not differ from farmers' crop management.

PPB will also help to conserve biodiversity as the process leads to the development of different varieties by different farmers. Varietal diversification was achieved within three years, and a dynamic form of Genetic Diversity will persist as farmers select plants for specific niches (Table 30.3). In Chhomrong and Ghandruk villages, two farmers selected two different rice varieties from the same F_5 bulk seed of Machhapuchhre-3 (Fuji 102/Chhomrong) cross (Sthapit *et al.* 1996). They distributed seeds to five more farmers who had selected under their own conditions. These materials might have hidden genetic variation, thus enhancing Genetic Diversity and conserving part of the local gene pool *in situ*. This approach has resulted in a dynamic form of *in situ* genetic conservation of biodiversity by involving farmers and using materials generated from land race x exotic crosses (Witcombe et al. 1996). This system would not necessarily require a formal means of seed supply; seed can be supplied by the same local systems already used by farmers. However, involvement of grassroots' level organizations in the support of a seed supply system would help better dissemination of such varieties.

Table 30.3: **Varietal Diversity Created by PPB in Selected Villages**

	Chhomrong	Ghandruk	Lumle
Before 1993	1	1	4
1995	5	4	6
1996	7	5	6
1997	9	4	6

Farmer participation in varietal evaluation should be adopted because it allows all of the important farmer-relevant traits to be assessed – including taste, cooking quality, market value, good threshing characteristics, and storability, rather than only the limited sets of characteristics measured in plant breeders' trials. Farmers' perception of the programme was assessed in focus group interviews. At the beginning of the programme, farmers were not very enthusiastic. As farmers realised that PPB was beneficial to them, the quality of participation improved. The comments made during field visits reflect the satisfaction of the participating farmers (Table 30.4).

Policy and Institutional Issues

The mandate of institutional breeding is usually to raise national food

Table 30.4: **Farmers' Perceptions of the Participatory Breeding Programme for White-grained Rice in Chhomrong and Ghandruk, 1994**

Location	Date	Gender	Size of interview group	Comments
Chhomrong	7 Oct 94	Male	9	"Any rice variety that grows at this altitude is good. We need a variety that yields more and gives more straw. A white grain colour is a bonus. We will further select the plants to grow in larger plots next year."
Chhomrong	7 Oct 94	Female	5	*"If we can change our local rice into white grain rice it will save a lot of our (women's) time. We spend one to two hours' extra time to dehusk rice to get white grain."* *"Machhapuchhre-3 has both more grain and more straw. It has long panicles and plenty of grains. It matures with local varieties and the plant is taller. If it tastes good I would like to continue this variety."*
Ghandruk	9 Oct 94	Male	1	*"In the beginning I was not interested in involving myself, but when LARC scientists told me that the variety has white grain then I became curious. I first tried it on the worst parts of my land. I saw tall plants producing really good panicles. I selected all the best plants with white grain and maturity similar to our local variety. This year it looks really good and better than last year. Now I am happy to grow it on all my plots. I have no plans to share the seeds until I fulfil my requirements."*

production. It is therefore logical that it concentrates its efforts on the main production areas where higher yields are possible through improved crops. A major challenge in plant breeding is how to address the problems of resource-poor farmers in marginal environments who have often contributed important Genetic Diversity to the institutional system and received little benefit in return (Hardon 1995).

It is extremely important for political leaders and decision-makers at different levels to understand both the problem and the means that exist to solve it, as only with their help can appropriate strategies for on-farm conservation be implemented. This will require some fundamental changes in the institutional systems, considering the generally conservative and technological attitude of most formal institutional set-ups for agricultural development.

The major constraints in institutional systems include:

- lack of incentives for and rewards to plant breeders,
- lack of incentives to use local land races and/or involve local communities,
- over-dependence on the Consultative Group on International Agricultural Research (CGIAR) system,
- centralized variety testing and release systems,
- centralized seed production and distribution systems,
- the attitude of conventional plant breeders and pathologists, and
- competition for resource allocation.

As Ashby and Sperling (1994) anticipated, the institutionalisation of decentralized breeding is the most challenging issue. If the success of these initial efforts is to be sustained, research management should ensure a congenial environment for field staff who work in difficult areas. This is often forgotten by policy-makers and research managers when they try to replicate successful and innovative approaches from elsewhere.

Two levels of decentralization are possible: the first is at an international level from CGIAR centres to the National Agricultural Research System (NARS), and the second from NARS to farmers. This second level should be our focus. Farmers should be involved in the selection process from the early stages. A reform of seed regulatory procedure will be required to accommodate decentralized breeding and variety testing, release, and registration procedures. Current seed certification and quality control procedures often do not serve the needs of farmers in developing countries.

Products from PPB could also be entered into the formal trials and official release system (Sthapit *et al.* 1996). The breeder chooses the material most widely accepted by the farmers and introduces the cultivar(s) into a selection scheme parallel to that of the farmers (Figure 30.2). A cultivar release and seed production system is still a very desirable end product to make the results of the PPB more widely available and gain the benefits of large-scale seed multiplication of the successful released cultivars.

Non-government organizations (NGOs) could play a key role in mobilising community support for agricultural development and on-farm conservation activities. Following successful PPB programmes, experienced and expert farmers with motivation from NGOs may wish to select parents and carry out breeding, and seed multiplication and distribution programmes of their own. This would be a more sustainable way of maintaining genetic conservation *in situ*.

The decentralized selection of segregating material from a few carefully chosen crosses draws on the active participation of expert farmers and presents an attractive prospect for fostering a more sustainable and productive agriculture for diverse risk-prone environments. This new approach could be of considerable significance for managing the on-farm conservation of land races. The prerequisite for the method is that the objectives are clearly identified and the breeders flexible enough to learn from and interact with the farmers. Furthermore, community participation is essential for managing *in situ* genetic conservation of land races.

Institutional building of community-based organizations (CBOs) and NGOs should be a part of the strategy to institutionalise on-farm conservation and to deliver benefits to farmers. Strong support to CBOs/NGOs is required to strengthen the management of on-farm conservation There should be a positive policy to support such activities in the longer term. A working partnership should be developed between the international and national agricultural research systems and CBOs/NGOs to implement successful *in situ* programmes on a wider scale.

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Chapter 31

The Potential for Linking Conservation of Endangered Species with Productive Crop Farming: Case of the Endangered Himalayan Honeybee, *Apis cerana*

U. Partap and L. R. Verma

At present, many species of the true honeybee (*Apis* spp) are found throughout the world, although they are only native to the old world. Of these species only two, *Apis cerana* and *Apis mellifera,* are kept in hives and managed for honey production and crop pollination. The European honeybee, *Apis mellifera,* is native to Europe and Africa. This bee species has been successfully introduced to Australia, America, and many countries of Asia where it has become very popular. The Asian honeybee, *Apis cerana,* is native to Asia. Beekeeping with this species has been a traditional activity among subsistence farmers in many countries. However, the populations of this bee species are decreasing both in terms of the number of colonies and the area in which they are found. The species has almost disappeared from Japan and South Korea and has become threatened in other countries of Asia such as Bangladesh, China, India, Myanmar, and Pakistan. This probably happened as a result of the introduction of the more productive European bee, *Apis mellifera,* which is now becoming more popular with beekeepers in Asian countries. Figure 31.1 shows the present distribution of *Apis cerana* and *Apis mellifera* in the Hindu Kush-Himalayan (HKH) region.

Honeybee Diversity in the Himalayan Region

Five species of honeybee are found in the HKH region. Of these, *Apis dorsata, Apis florea, Apis laboriosa,* and *Apis cerana* are native to the region. During the past few years *Apis mellifera* has been introduced into the region for higher honey production. The first three species are found in the wild and cannot be managed, whereas both *Apis cerana* and *Apis mellifera* are kept in hives and managed largely for honey production. In addition to the true honeybees, the HKH region is

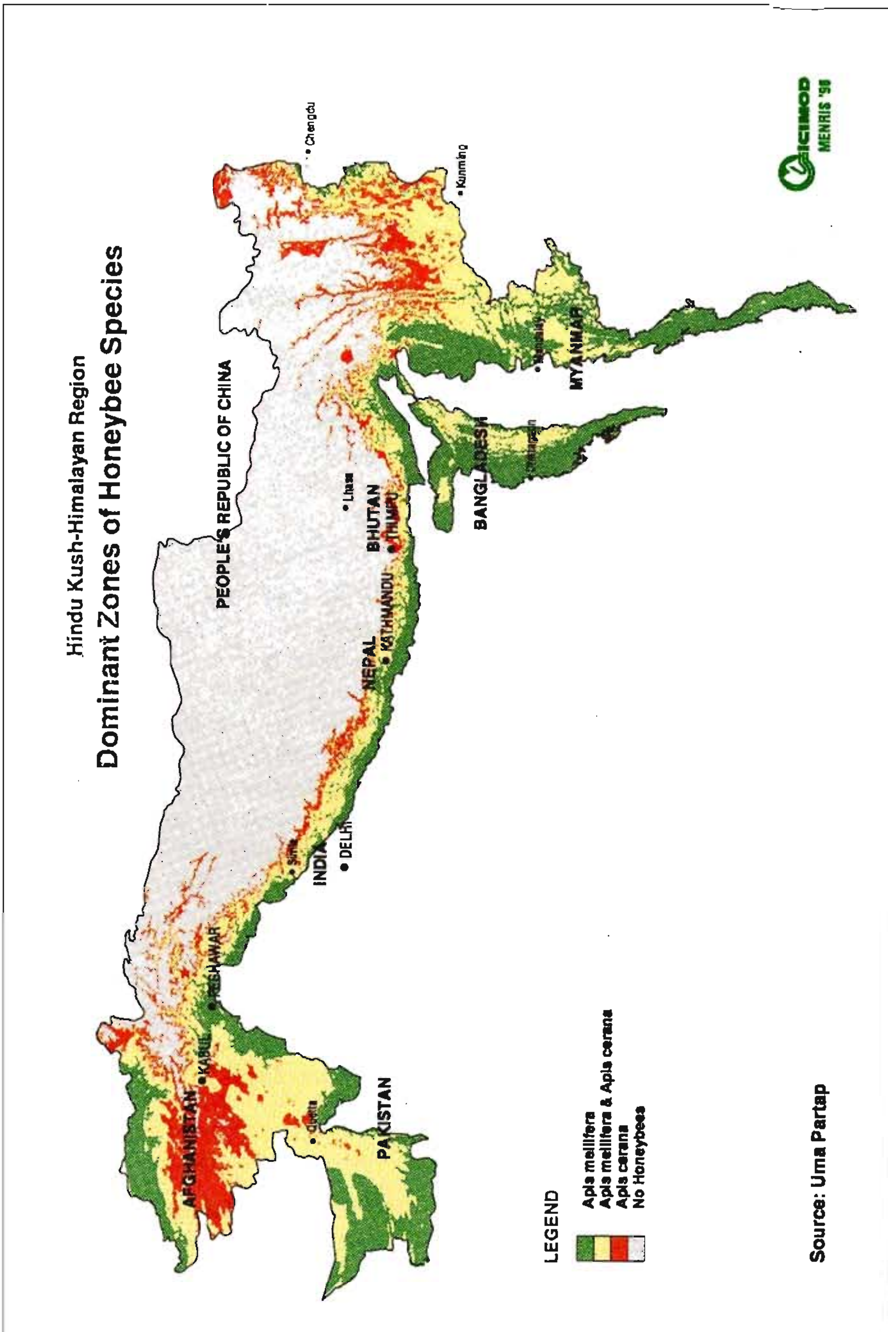

Figure 31.1: Dominant Zones of Honeybee Species

also home to many species of stingless bees (*Melipona* and *Trigona* spp), bumble bees, and solitary bees.

The Genetic Diversity of *Apis cerana* in the HKH Region

The Genetic Diversity of *Apis cerana* in the HKH region was studied in ICIMOD between 1991 and 1994 as part of an attempt to identify commercially valuable sub-species of the bee (ICIMOD 1994). A morphometric analysis was performed of *Apis cerana* collected from 68 localities. The results of this analysis and of preliminary research into the honey production potential of different populations (Verma 1990 1992; ICIMOD 1993), suggested that *Apis cerana* from the Indian and Nepali Himalayas can be classified into three sub-species, namely, *A. cerana cerana*, *A. cerana himalaya*, and *A. cerana indica* (Figs. 31.2 and 31.3). *A. cerana cerana* is found in the high mountain areas of Nepal and northwest India (Himachal Pradesh and Jammu and Kashmir); *Apis cerana himalaya* in the middle hills of Nepal, Uttar Pradesh, and the northeastern Indian Himalayas; and *Apis cerana indica* in the plains of India and Nepal (ICIMOD 1994). Similarly, five sub-species have been identified in China, *A. cerana cerana*, *A. cerana skorikovi*, *A. cerana abaensis*, *A. cerana hainanensis*, and *A. cerana indica* (Zhen-Ming et al. 1992).

Each sub-species has further locally adapted geographic ecotypes which differ from each other in several biological and economic characteristics. Discriminant

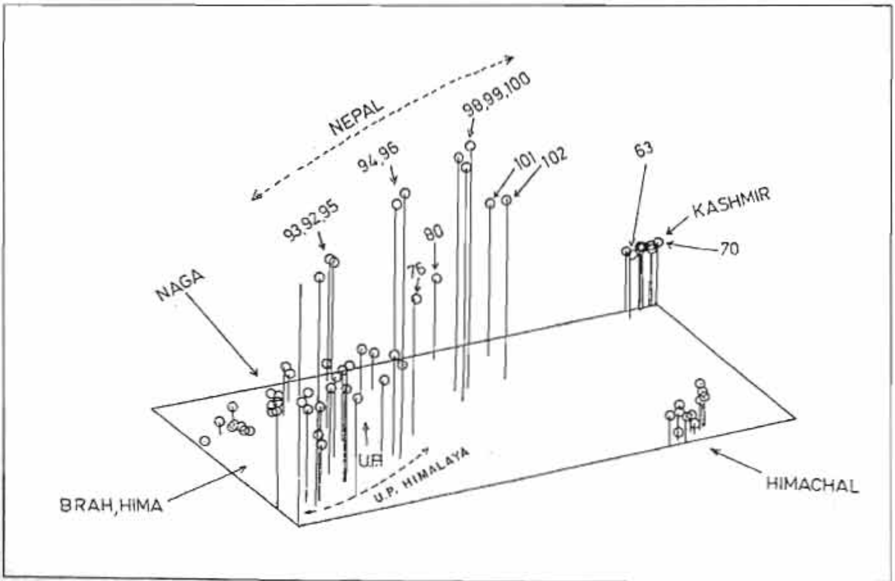

Figure 31.2: Diversity of the Himalayan Honeybee, Apis cerana, from 66 Localities as Shown by Biometric Analysis (Source: ICIMOD 1994)

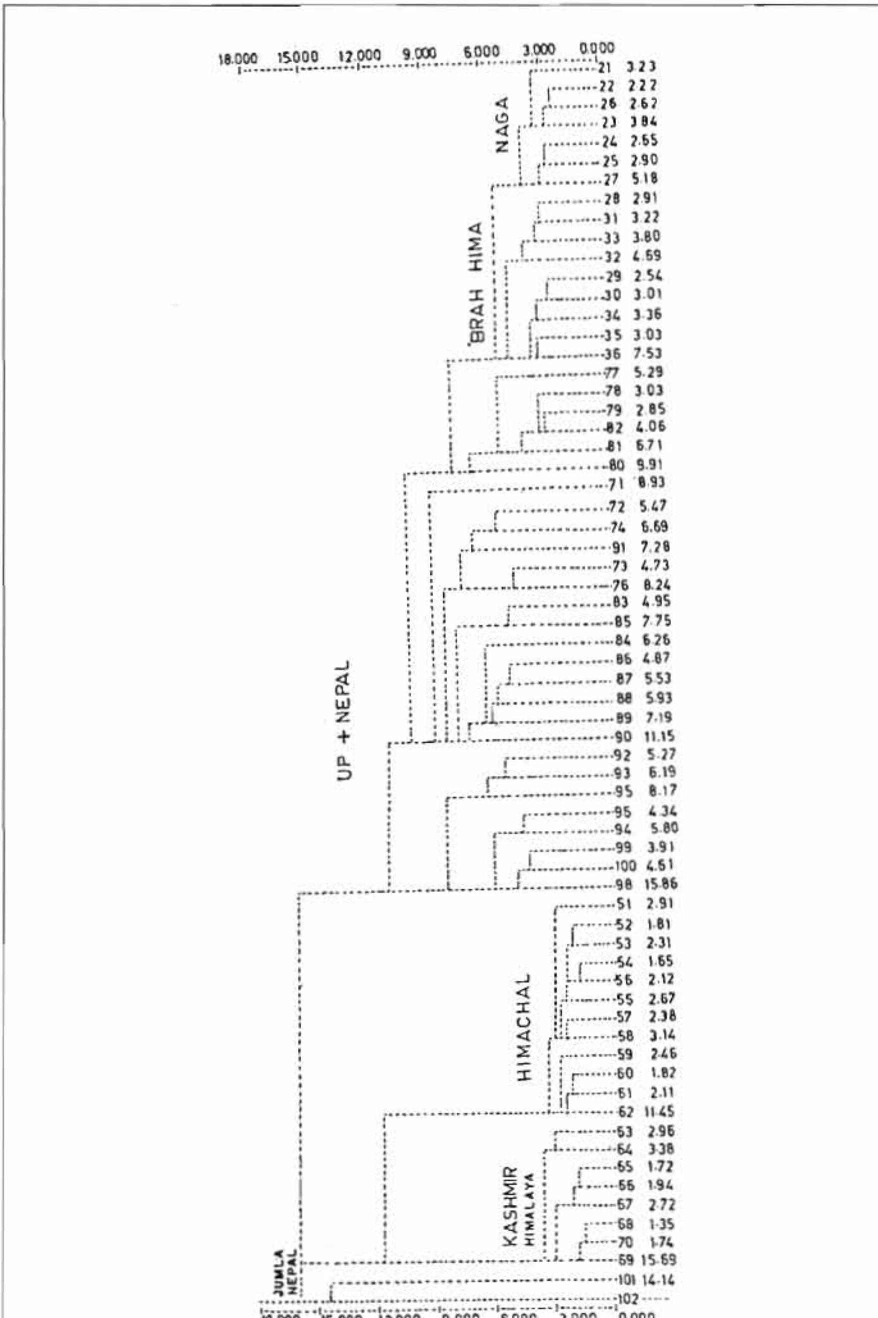

Figure 31.3: Diversity and Relationship of Apis cerana in the Himalayan Region as Shown by Biometric Analysis (Source: ICIMOD 1994)

function analysis and cluster analysis of 55 morphometric characteristics of *Apis cerana cerana* from 20 localities in Himachal Pradesh and Jammu and Kashmir revealed two further distinct groups (Figure 31.4). These groups are linked to the differences in climate in the Himachal and Kashmir region (ICIMOD 1994). The phonetic clustering of samples within each region corresponded to general physiography (Figures 31.5 and 31.6) (ICIMOD 1994).

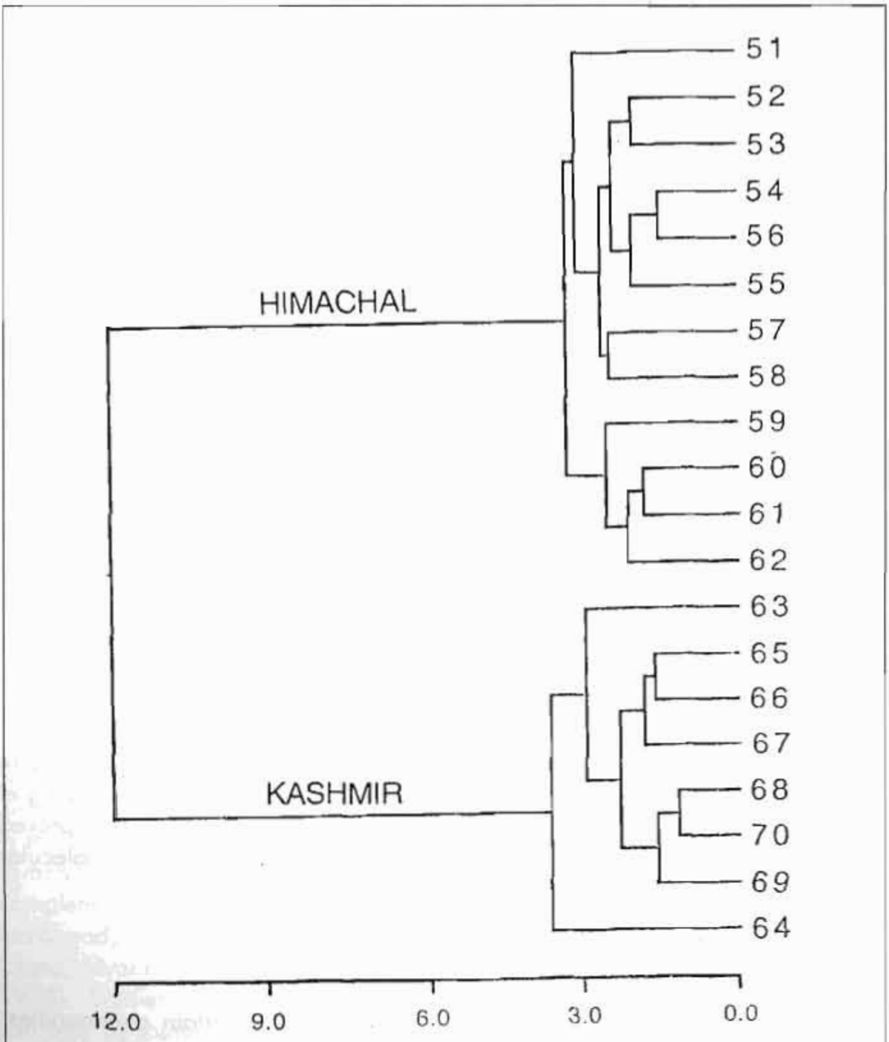

Figure 31.4: Diversity and Relationship of Apis Cerana in Northwest Himalayan Region (Kashmir and Himachal Pradesh) as Shown by Biometric Analysis (Souce: ICIMOD 1994)

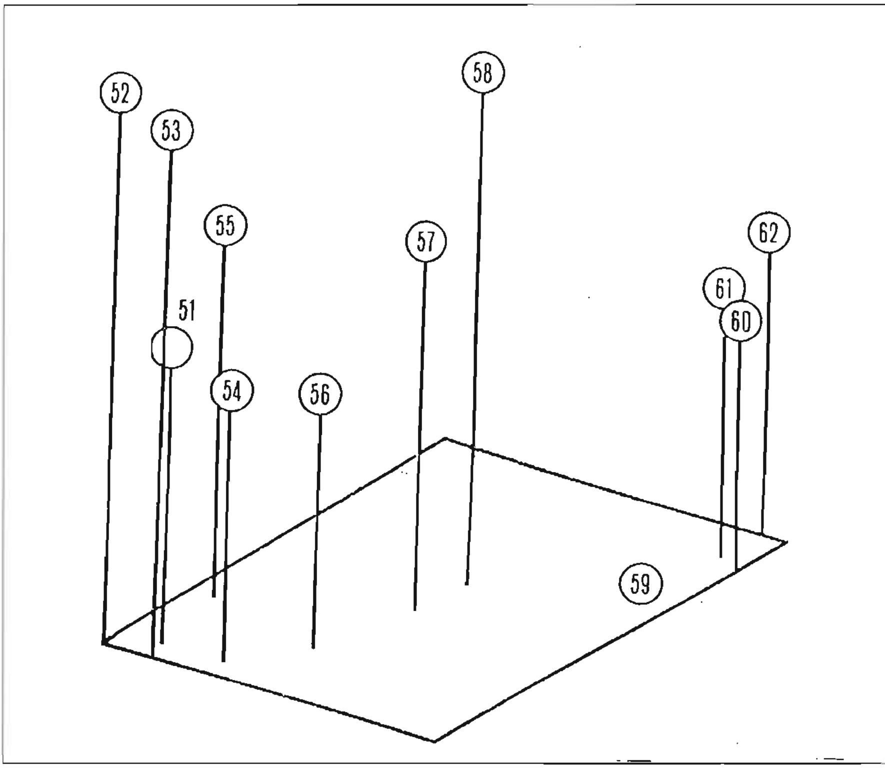

Figure 31.5: Diversity and Relationship of Apis Cerana from12 Locations of Himachal Pradesh Shown by Biometric Analysis (Source: ICIMOD 1994)

These studies on the Genetic Diversity of *Apis cerana* also showed variations in characteristics related to the potential commercial value of the different sub-species. For example, the bees of *A. cerana cerana* found in the high altitude areas of Jumla (Nepal), Himachal Pradesh and Kashmir (India), and northern China are larger in size, more productive, and comparable to *A. mellifera* in terms of honey production and other behavioural characteristics (Zhen-Ming et al. 1992; ICIMOD 1994; Partap and Verma 1997). These bees could be improved further for commercial use by means of further selection, breeding, and molecular research.

The Species and Its Genetic Diversity at Risk

Apis cerana is a part of the natural heritage of mountain communities. Traditionally, farmers have kept this species in log, wall, pitcher, and box hives. Beekeeping with this bee species was a low cost technology, but it produced less honey than the imported *Apis mellifera*. This bee species is being rejected by

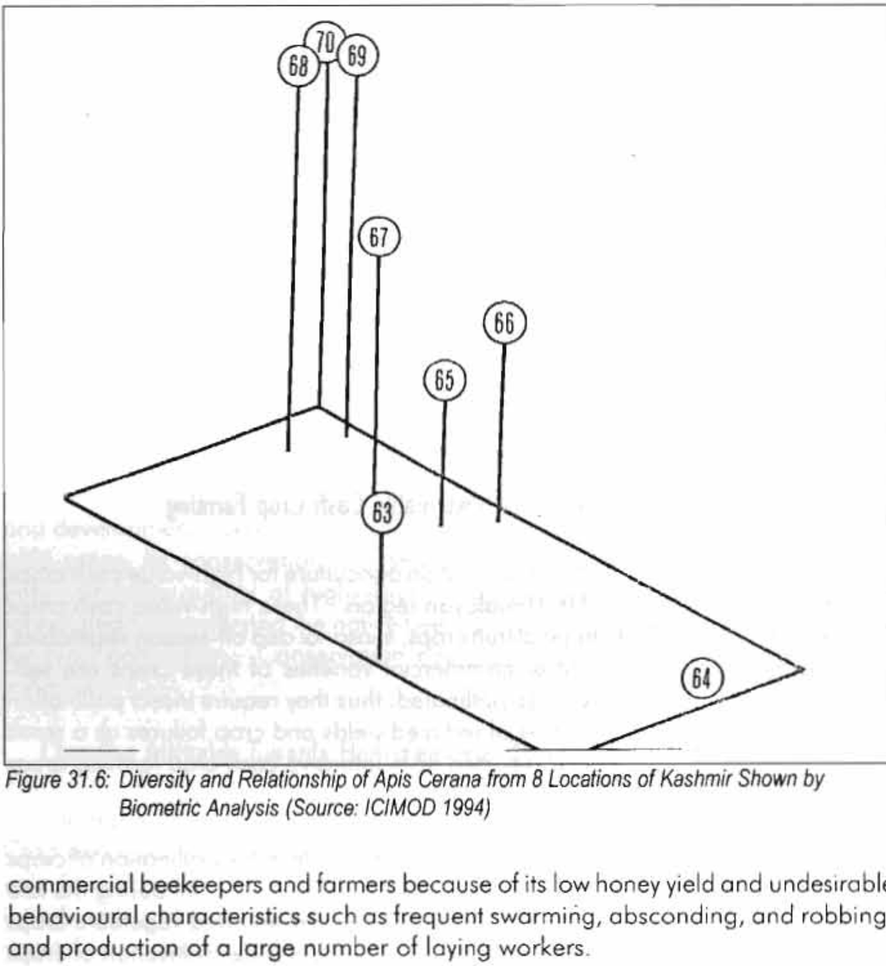

Figure 31.6: Diversity and Relationship of Apis Cerana from 8 Locations of Kashmir Shown by Biometric Analysis (Source: ICIMOD 1994)

commercial beekeepers and farmers because of its low honey yield and undesirable behavioural characteristics such as frequent swarming, absconding, and robbing, and production of a large number of laying workers.

Apis mellifera has been introduced into the region and is popular among commercial beekeepers. As a result, populations of the native, *Apis cerana*, are declining at an alarming rate, threatening its existence in the last gene pool areas in the Himalayan region (Verma 1993). If the process of replacement of *Apis cerana* with *Apis mellifera* continues for another decade, it could lead to the complete extinction of this valuable Himalayan bee. The process of extinction has already been started and the species is endangered in hill areas of Bangladesh, China, Myanmar, Pakistan, and to some extent India (Verma 1993; ICIMOD 1994). Studies carried out by ICIMOD have shown that at present *Apis cerana* can only be found in a few mountain areas in Nepal and India and in Yunnan Province in China (ICIMOD 1994, Bangyu and Tan 1996). In Pakistan, where *Apis mellifera* has been promoted much more vigorously, the last strains of Apis cerana are kept by a few villagers in the Kalash Valley of Chitral.

In the Himalayan region, Nepal was the biggest gene pool of *Apis cerana* until 1990. Before this there was a ban on the importation of *Apis mellifera* and beekeeping with the native bee flourished throughout Nepal. When the ban was lifted in 1990, *Apis mellifera* was brought in on a large scale, and within six to seven years it replaced the native *Apis cerana* throughout the *Terai* region and the Kathmandu Valley. *Apis cerana* is now only kept by subsistence mountain farmers in highly remote areas such as Jumla and Humla. *Apis mellifera* has not reached these places as a result of both their inaccessibility and the fact that farmers cannot afford winter management practices such as keeping the colonies warm, feeding sugar, or relocating to lower areas. Recent information from Pakistan shows that there are a few hundred colonies of *Apis cerana* left in Pakistan, in comparison with over 90,000 colonies of *Apis mellifera* (Muzzaffar 1998). Thus there is clear evidence of a process of extinction of *Apis cerana* in the HKH region.

Potential for Using *Apis Cerana* in Sustainable Cash Crop Farming

The process of diversification of mountain agriculture for high-value cash crops is gaining popularity in the HK-Himalayan region. These high-value cash crops include temperate and sub-tropical fruit crops, seasonal and off-season vegetables, and vegetable seed crops. Most commercial varieties of these crops are self-incompatible and essentially cross-pollinated, thus they require insect pollination to set fruit or seed. Already cases of reduced yields and crop failures as a result of failed pollination have been reported from intensive cash crop farming areas (Partap and Partap 1997).

The natural insect pollinators play an important role in the pollination of crops that bloom during the summer season, but they are mostly absent during the late winter and early spring seasons when apple and other fruit and vegetable crops bloom in the high mountain areas. Moreover, the area under cultivation of crops requiring cross-pollination by insects is also increasing, creating an artificial shortage of pollinators. Other problems are the decline in the population of natural insect pollinators as a result of habitat alteration, which has caused a decline in their nesting habitats and food sources, and the negative impact of modern agricultural inputs. The indiscriminate use of pesticides has killed many useful insects. Thus honeybees and other natural insects should be managed for the pollination of different crops (Partap and Partap 1997).

The information available shows that the value of honeybees in crop pollination is many times more than their value as producers of honey and other bee products (Verma 1992, Verma and Partap 1993, Partap and Partap 1997). The diversity of mountain crops that are dependant on or benefit from bee pollination includes fruit and nuts, vegetables and pulses, cereals, oilseed crops, condiment and spice crops, drugs and beverage plants, forage crops, timber trees, and natural vegetables. Studies carried out in ICIMOD and elsewhere show that *Apis cerana* is an excellent pollinator. It is better than *Apis mellifera* at pollinating mountain crops such as almonds, apples, cherries, pears, plums, and the various seed vegetables that bloom in early spring (Partap and Verma 1992, 1994; Verma and Partap 1993, 1994; Partap and Partap 1997). *Apis mellifera* is also an excellent crop pollinator, but the race of *Apis mellifera* that has been imported to this region is highly susceptible to cold and needs to be migrated to low hill areas during the winter. Thus it cannot be used for pollination of early blooming mountain crops. Since the native *Apis cerana* is cold resistant, there are good prospects for promoting this bee for crop pollination in hill and mountain areas. This would help in the conservation of this valuable bee, as well as benefitting the development of sustainable cash crop farming in hill and mountain areas.

If beekeeping is only done for honey production, there is no match for *Apis mellifera* and no way we can save *Apis cerana*. But mountain farmers, institutions, and development agencies will need *Apis cerana* for pollination of cash crops in cold areas. Its conservation is essential for maintaining the productivity and enhancing the quality of high-value mountain crops. Strategies need to be formulated for conserving the native bee, *Apis cerana*, by promoting its wider use for crop pollination. Conservation could be achieved through the following initiatives.

Changing Attitudes Towards Honeybees and Beekeeping

The traditional way of thinking is that beekeeping is for honey production. Crop pollination has been given only a secondary role. At present, policies are only formulated to favour increased honey production. However, the recently introduced high-value cash crops, such as fruit and seasonal and off-season vegetables, require cold-resistant insects for cross pollination. *Apis cerana* is ideally suited for playing this role. Thus there is a strong need to change the mind-set of planners, policy makers, beekeepers, and farmers about honeybees in order to recognise their role as crop pollinators rather than simply as honey producers. New policies need to be formulated that place more emphasis on the use of bees for pollination.

The Promotion of *Apis Cerana* for Pollination

As discussed earlier, the wild honeybee species native to the region, *Apis dorsata*, *Apis florea*, and *Apis laboriosa*, cannot be managed for pollination. *Apis cerana* is the only species kept in hives that can be transported to fields for pollination of the crops that flower during spring and early winter in hill and mountain areas.

As mentioned above, the sub-species *A. cerana cerana* found in high altitude areas of Nepal, India, and northern China is highly productive, with honey production and behavioural characteristics comparable to those of *A. mellifera*. Research efforts are now needed to multiply the colonies of this sub-species through selection, breeding, and mass rearing of queens. This would require a large-scale selection programme carried out over many years. Those colonies that maintain highly prolific queens and a good number of brood and adult bees are resistant to different diseases and parasites (particularly the dreaded Thai Sac Brood Virus disease), have less swarming and absconding tendencies, and have good honey gathering qualities should be selected and multiplied. Such colonies would be chosen by those farmers and commercial beekeepers who might otherwise prefer *A. mellifera*. To produce such a race of *Apis cerana* would require a lot of research effort and at least five to ten years of selection work. However, the outcome could be a race of *Apis cerana* that is comparable to *Apis mellifera* in honey production and which at the same time has a niche in the Himalayan agricultural systems.

These days, non-government organizations (NGOs) are playing an important role in development. Since the native bee, *Apis cerana,* is more effective as a pollinator of the early blooming mountain crops, NGOs should help promote this bee species for crop pollination as the number of bee colonies at present is much less than required for this purpose. In addition to NGOs, the commercial beekeepers who mainly keep *Apis mellifera* for honey production could be encouraged to keep *Apis cerana* for crop pollination by giving them adequate training in managing honeybees for this purpose; and other incentives such as a support price.

Encouraging Farmers to Keep *Apis cerana* Colonies

Mountain farmers and keepers of orchards clearly need bee colonies for the pollination of their apple and other fruit crops. However, most beekeepers are not interested in renting out their bee colonies for pollination. The awareness among farmers of the importance of beekeeping for fruit crop pollination needs to be raised. In addition, farmers should be encouraged to keep their own bee colonies to ensure adequate pollination of their cash crops.

The population of the native bee species, *Apis cerana,* is declining. Since there is a serious pollination problem in mountain areas leading to very low crop yields, and sometimes even crop failure, there are great prospects for promoting *Apis cerana* for pollination. Once the use of *Apis cerana* for crop pollination becomes popular, the goal of conservation will be achieved automatically.

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Chapter 32

Organizing Mountain Farmers to Carry Out *In Situ* Conservation of Their Agricultural Resources' Diversity

V. Singh

Farmers have managed genetic resources ever since they began cultivating crops and domesticating animals. Farmers' selection, breeding, and continued maintenance of crop variety and livestock breeds have been used to meet environmental conditions and develop diverse farming systems in mountain areas. Systems such as those that exist in the area called Garhwal in Uttar Pradesh, India, are the product of farmers' innovations and informal experimentation. Biodiversity-based mountain farming systems and the central role of farmers in their management must be appreciated and not dismissed as 'traditional'. The 'traditional' can be an important tool for evolving 'modern' approaches to sustainable development.

The main issues facing agrobiodiversity stem from the current mountain transformation process, which is directed by the Green Revolution. In this process the overwhelming emphasis is placed on a small number of cultivars with high commercial value and the heavy use of external inputs. The role of farmers in conserving and using agrobiodiversity has often been undermined. Institutional mechanisms are biased and lack a pragmatic vision. There is such ignorance about the consequences of the loss of agrobiodiversity that many people think that it is simply an extinction of species. Currently the politics related to control of the world's gene pool poses a further potential danger for the regions, nations, and areas rich in agrobiodiversity.

This paper attempts to identify and analyse the diversity in mountain agriculture, the relationships between farmers and agrobiodiversity, and the traditional strategies used by farmers for biodiversity management using the area of Gharwal as an example. These strategies have been, and continue to be, pivotal in developing farming systems, many of which have been sustained for centuries. When the agriculture in Garhwal shows general symptoms of unsustainability, generally as a result of erroneous external development intervention, farmers try to reverse the negative trend. The paper also assesses how the farmers' approach to conserving local biodiversity can help show a path towards sustainable agriculture in the region. The paper describes a situation in one area where a near disaster resulting from the introduction of monocropping was turned into a success story of farmer-led reintroduction of indigenous land races and agricultural practices.

The Area

The northern part of the state of Uttar Pradesh in India, popularly called *Uttarakhand*, lies in the Himalayan mountains. This area has two parts, Garhwal and KumaOn. Garhwal has five districts - Uttarkshi, Chamoli, Auri, Tehri, and Dehradun – covering an area of 29,968 sq. km. The total area of Garhwal and KumaOn is 50,952 sq. km. The present study concerns the Garhwal Himalayas, which account for nearly 59 per cent of the total area of the Central Indian Himalayas. The altitude ranges from 300 to 8,000 masl. The terrain is comprised of steep terraced hillsides traversed by many streams and rivers. The area encompasses four climatic zones: sub-tropical (250-1200m), sub-temperate (1200-1700m), temperate (1700-3500m), and alpine (3500m and above). The average population density is 98/km^2. There are some 8,000 villages, and more than 80 per cent of the population live in rural areas.

Farmers in the Gharwal valleys have developed active networks aimed at improving the ecological, economic, social, and cultural situation. These networks have emerged to confront the negative effects of mainstream development interventions that people have experienced during the last few decades. One farmer is conducting systematic experiments on and demonstrations of traditional cultivars.

After a preliminary reconnaissance, four villages in the Gharwal area were selected for study: Paturi, Palas, Jardhargaon, and Swali. The villages cover a very wide range of agricultural situations.

The evidence presented in the paper is based mainly on the information gained and observations made during intensive field visits to the selected villages. Efforts were made to obtain all the information of interest from men and women farmers of all age groups. The views of resource persons, NGOs, social workers, public departments, and agricultural scientists have also been incorporated. Personal links with the farmers' organizations, and working closely with the Save the Seed Movement and other ecological movements, were of immense help in the collection of information.

Species and Genetic Diversity

One of the most outstanding features of mountain flora is the enormous diversity of both cultivated and wild plants that offer edible products. In the past, people in the Himalayan mountains have enjoyed a very large number of food items, some of forest origin and others cultivated. For example, people in the Henwal Valley of the Garhwal Himalayas have access to at least 127 different food-providing plants and 15 different species of fodder plant (Table 32.1). The food-providing plants include 23 different wild fruits, buds, flowers, and seeds obtainable from the forest ecosystem. Villagers collect 14 different types of wild vegetables and grow 33 different kinds of cultivated vegetables (mostly grown around homesteads); 18 fruit species are cultivated on private land; and nine types of spices and condiments are collected from the wild or cultivated. Other crops include 12 different cereals, millets, and pseudocereals; 10 types of pulses; and eight types of oil seed. The 15 species of fodder (mostly trees and bushes) are fed to domestic animals and, after being converted into milk and milk products, also contribute indirectly to the human diet.

Table 32.1 : **Plant Species Used for Food in the Henwal Valley of the Garhwal Himalayas**

Type of food	No of species
Wild fruits	5
Flowers and buds	18
Cultivated fruits	18
Wild vegetables	14
Cultivated vegetables	33
Cereals and millets	12
Pulses	10
Oilseeds	8
Spices	9
Tree fodder	15

The actual use of the available food resources varied in the valleys. People in Jardhargon, for example, were fond of uncommon food resources, whereas those from Palas and Sawali did not like wild food. The residents of Jardhargon said that the older generation realised the importance of wild food, but these nutritious food products did not attract the attention of the younger generation. The younger people had no time and patience to collect them.

Farmers' Diverse Strategies for Managing Agricultural Diversity

Agro-ecosystems with many different niches occupied by many different species are likely to be more stable than those with only one species (monocropping) and thus give the farmer more security (Reijntjes et al. 1992). Functional diversity, achieved by combining complementary plant and animal species in a synergistic system, provides sustainability in such agro-ecosystems.

Using the central concepts of complementarity and synergy, farmers in the central Indian Himalayas increase the functional diversity through practices such as specific crop rotation or sequences and cropping patterns and associations.

Increasing functional diversity leads to unique crop rotations and fallow practices. The rotations may vary according to altitude, irrigation conditions, moisture regime, soil type, degree and direction of slope, and sometimes farmers' personal choice. More than 90 per cent of the cultivated land in irrigated valleys in Garhwal is managed under rice-wheat rotation. The rice-proso millet-wheat sequence is adopted in only a few villages. In contrast to the uniformity maintained in the major crop rotations on irrigated land, the crop rotations on upland (rainfed) are amazingly diversified. The cropping systems are characterised by a large number of crop species - cereals, pulses, millets, oil seeds, pseudocereals, beans, vegetables, fruits - with a broad genetic base. The crop rotations fulfill diverse local needs and ensure that the health of the agro-ecosystems is maintained. Shallow and deep-rooted plants are sown together so that crops use different soil depths. Land of different quality is used for different crops, for example, irrigated land is generally used for growing wheat and rice, which need more moisture, and more degraded and gravelly land is used for pulses, oil seeds, and pseudocereals. Agro-forestry is common in rainfed areas.

Mixed and intercropping methods are common practices in Garhwal. Finger millet is usually mix cropped with twelve different crops: buckwheat, amaranth, French beans, black gram, rice beans, green gram, horsegram, soybeans, sorghum, foxtail millet, kidney bean, and *jakhia* (*Cleome* spp). This cropping pattern is known as *bharanaja*[1]. Sometimes finger millet is intercropped with three or more crops, a unique example of relay cropping. Amaranth is generally grown together with finger millet. However, at higher altitudes it is also cultivated as a dominant component, usually mixed with beans, most commonly the kidney bean. In upland areas, wheat is generally mix cropped with lentils. Barnyard millet is sown around the rice on many terraces in upland areas. *Jakia* grows naturally but is also raised with finger millet.

Farming is linked to culture and history. The rich experience of farmers, gained from continuous interaction with nature and its rich resources, has from time to time been pivotal in reshaping the agricultural system towards higher biodiversity and sustainability. Farmers have developed a great variety of farming systems, and these have never been static. Farmers have created innovations by consciously

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[1] *Literally means twelve food grains*

and skillfully manipulating the biophysical and socioeconomic resource base and have always kept the system in a dynamic state, setting a positive trend.

In mountain areas every farm tries to use the entire range of diversity available in that area and to cultivate all the native genetic resources of all crops that thrive on a site. Each farm, however small and scattered, is a unique system in itself. The common history, culture, wisdom, experience, and common control over Common Property Resources (CPR) are the integrating factors among farms. Social cohesion is often reflected in sharing or exchanging germplasm, labour, farm agricultural operations, and irrigation.

Most of the agricultural technologies in the Garhwal Himalayas were developed by the farmers, who are the natural specialists, not by formally educated scientists. Research institution, universities, and government departments claim to be a central source of innovation; but in fact they are not and neither are their extension systems. Most innovations have been invented by the farmers themselves. The innovations have been spread throughout the community through the farmers' own informal extension system.

The indigenous knowledge of a farming community, generated from past experience and enriched by new experience, has been, and continues to be, a driving force in farmers' innovations. Indigenous knowledge is not static, it is dynamic like the farming system itself. An understanding of indigenous knowledge is of vital importance for developing and introducing technological changes aimed at biodiversity conservation and management for sustainability in mountain agriculture. Farmers apply the principles of agro-ecology in a holistic fashion in the process of managing the biological-physical resource base and deriving full advantage from the resource characteristics. The strategies evolved by farmers over a long period of trial and error are reflected in the diverse methods used to exploit the resource base for soil fertility management, pest management, weed management, and genetic resource management, and in the diverse economies that have been created.

Conserving the Genetic Wealth: Farmers' Experimentation

Unlike in the Green Revolution areas in the plains, the pace of genetic erosion in the mountains has been relatively slow. However, those irrigated valleys accessible to development agencies display considerable genetic uniformity. Even in the upland rainfed areas, some crop species and varieties have been squeezed out of local agricultural practices. Nevertheless, as a result of the very high degree of inaccessibility, genetic uniformity has not taken over in the mountains. Almost all the local crop cultivars exist in remote and highly inaccessible pockets.

The problems experienced in the Henwal Valley (in which the village of Jardhargaon is situated) and the approach used to solve them, provide a useful lesson in the potential problems associated with external intervention and the importance of indigenous knowledge for the success of agriculture in difficult areas. The Henwal Valley in the Garhwal Himalayas is an area that once witnessed a situation of near genetic wipe-out. Until recently (1988) large areas of irrigated flatland were occupied by only two crops - wheat and rice - and only two varieties of each crop. A considerable proportion of the arable land in the upper rainfed area had come under white-seeded soybean cultivation (an introduced crop). The majority of the farmers had switched over to 'improved' cultivation practices using recommended chemical fertilizers and synthesised pesticides, and heavily reliant on external 'expertise'. The almost completely transformed valley was virtually converted into an experimental ground for an agricultural university and a Watershed Management Project. These agencies conducted their experiments and demonstrations and distributed 'tested' seeds of modern varieties (MVs), chemical inputs, and 'improved' tools and implements to the farmers.

It was only a matter of time until this genetic uniformity displayed its weaknesses. The area was struck by an unprecedented drought in 1986-88 and by pest epidemics in the following two years. The MVs, which had an extremely narrow genetic base, were badly damaged and the farmers saw the worst days in their lives.

To confront the emerging crisis of genetic vulnerability of the narrow genetic base of the MVs, the farmers collected the indigenous seeds that had almost disappeared from the valley. They collected seeds of 10 local rice varieties from remote village areas not affected by transformation technology and re-introduced them into the fields. These varieties showed a remarkable performance, but further pest epidemics still occurred during this crop season.

The next year more farmers in the valley opted for indigenous varieties. The seed produced during the first year was distributed to other farmers in the valley. After strenuous efforts, 35 indigenous varieties or land races were collected during the second year and were all raised on farms. That year nearly 60 per cent of the valley area around Jardhargaon village was covered by indigenous rice land races.

During the third year, a total of 110 local rice varieties were re-introduced, and the Genetic Diversity in rice increased dramatically. Nearly 90 per cent of the area under crops was covered with indigenous varieties. In the fourth year, the total number of rice varieties went up to 126 and the year after to 130.

The yields of different varieties were recorded in the summer season of 1994, at the farm of the farmer who was the leader of the Save the Seed Movement.

Thapachini, a widely cultivated indigenous rice, gave the highest yield (5 t/ha)) of grains. The other indigenous varieties *Jhumkya, Khushboo, Agriya, Lathmar, Kali Makhri, Basmati Nagni, Lalmati, Congressi, Nailchamya, Rekhalaya,* and *Rhikwa,* also gave impressive yields (4.3 to 5.0 t/ha). When the average yields of local rice cultivars were compared with those of MVs cultivated at the nearby demonstration site of the Pantnagar Agricultural University, it was found that the average yield of the land races (4.0 t/ha) was significantly higher than of five MVs (2.8 t/ha), even when the latter were provided with the recommended doses of fertilizers and pesticides. The land races were not provided with any chemical input, but only with organic manure at the rate of about 2.5 t/ha. The manure application rates for seasonal crops do not vary much from farm to farm in the mountains, thus this amount of manure was probably applied on most farms when growing MVs.

The average percentage recovery was also much higher in indigenous rice varieties (72%, ranging from 69% in *Hansnaj* to 75% in *Thapachini*) than in the MVs (60%). In other words MVs had a greater amount of husk, a useless by-product for mountain farmers. The grain husk ratio of the indigenous land races (2.6:1) was higher than that of the MVs (1.5:1), indicating that the land races were superior to the introduced MVs in producing useful biomass (edible rice grains).

Farmers in the mountains do not grow crops for grain only. The straw by-product for livestock feeding is of equal value. The straw-grain ratio of local rice varieties (ranging from 1.4:1 in *Lathmaer* to 2.3:1 in *Congressi* and *Hansraj*) was also higher than that of the MVs (ranging from 1.1:1 in Govind to 1.6:1 in Saket).

The MVs were also said to grow quickly, but the experiment showed that most of the local varieties were ready for harvest earlier than the MVs. Varieties such as *Knaheri, Nyuri,* and *Gorkhpuri* take close to 120 days to mature, whereas MVs sown in the area take at least 150 days.

Under the Save the Seed Movement programme, farmers are also searching for indigenous varieties of all other hill crops. So far, they have successfully collected and re-introduced 50 genetically distinct varieties of kidney beans, nine varieties of rice bean, and about a dozen of amaranth. These varieties, now restored, had earlier disappeared from the cropping systems.

Under the influence of modern agro-techniques, farmers in the valley had given up growing three crops: proso millet, pearl millet, and sorghum. These crops have now been re-introduced into the farming system. Thus, the farmers in this valley in Garhwal are enriching Genetic Diversity at the species' level as an expression of their consciousness of the importance of agrobiodiversity.

The Save the Seed Movement is not just limited to saving traditional seeds and developing diversity. In the words of Vijay Jardhari, the main inspiration behind the movement: *"We have to save and revive the very principles, concepts, and approaches that, working in close cooperation with nature, made traditional agricultural practices sustainable"*. Traditional seeds produced in the village are distributed to the areas from where they have vanished. The community seed exchange system, which was a life-line for mountain agriculture, has been automatically revived. Now farmers do not have to look to development agencies for improved seeds.

Conclusions

For generations, agrobiodiversity in mountain regions has been in the hands of traditional farmers. Traditional systems of management and traditional ecological knowledge have been the vital means by which farming communities have evolved diversity-rich food production and diverse livelihood systems. Traditional knowledge develops from the natural process of adaptation and differs from conventional scientific knowledge in being intuitive, moral, ethical, spiritual, theosophical, and holistic.

One thing that seems to be certain is that, in the historical process of agricultural development, farmers have always sought to enhance the level of biodiversity. The characteristic elements of farmers' strategies for enhancing diversity include managing the different genotypes of all the available species of economic importance, creating ecosystem heterogeneity and complexity, and maintaining intensity of ecosystem use.

Farmers' strategies, driven by indigenous knowledge and enriched by newer experiences based on trial-and-error, are dynamic rather than static. They are not symptomatic of backwardness, but are always innovative and futuristic. If one looks at the vision farmers have developed to manage agrobiodiversity in the mountains, and analyse's their strategies, one cannot help appreciating the efforts they have made and the innovations they have created.

Since agrobiodiversity is the most potential resource for the sustainability of agriculture, and traditional farmers are the best managers of this diversity, any meaningful development exercise in the Himalayan region should incorporate these two as its main ingredients. Agrobiodiversity cannot be isolated from overall biodiversity. The one has a bearing on the other. Therefore, agrobiodiversity conservation should take into consideration the conservation of the whole ecosystem to deliver support and other valuable ecological services.

It is very necessary to identify the main factors and processes responsible for the loss of functional diversity. These include both internal and external factors.

An understanding of these factors would help to address the situation resulting from the loss of agrobiodiversity effectively.

There is an immense need to develop effective institutions for biodiversity conservation in order to provide a more suitable framework for human action, to respond to environmental feedback, to enhance resilience, to identify traditional strategies, and to develop meaningful socioeconomic interrelationships. The thrust of policy should include protection of local rights and elimination of open access in marginal areas. Recognition of the unique role of farmers would help stimulate farmers' own interest in conservation activities. Our projects on sustainability-oriented agrobiodiversity management should encourage farmers to set up their own conservation movements, experiments, demonstrations, and extension services, and should also help them strengthen their creative networks.

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Chapter 33

Involving Farmers in the On Farm Conservation of Crop Genetic Resources: A History of Save the Seeds' Movement in Garhwal, Indian Himalayas

V. Jardhari

Mr. Vijay Jardhari is an activist of *Beej Bachao Andolan* (BBA, Save the Seed Movement) and is working with traditional varieties of rice, beans, and neglected crops such as amaranthus. Mr. Jardhari said that in the face of the massive erosion of crop diversity all over the Indian Himalayas, some farming communities are attempting to conserve and revive their traditional seed systems and traditional cultural practices, which are characterised by the innovative use of a wide range of cropping patterns and wide crop diversity over space and time.

Mr. Vijay Jardhari is part of the group that made such an attempt in the central Indian Himalayas. He explained that agricultural development in the area has caused serious loss of crop diversity and farmer self-sufficiency. He had strong views on agricultural biodiversity and agricultural development. He said that scientists and government policies are the main cause of genetic erosion as improved varieties are replacing traditional varieties. When Mr. Jardhari decided to stop growing hybrid seeds, he was dismayed to find that only two to three indigenous rice varieties were still being cultivated in his area in Tehri Garhwal district. His primary aim became to collect, save, and promote the use of traditional seeds. Beginning with a few varieties from the surrounding villages, the search took Jardhari through a large part of the Central Himalayas. He has now collected 214 land races of rice, 8 of wheat, 40 of finger millet, 6 of barnyard millet, 110 of common beans, 7 of horse gram, 8 of local soybean, 10 of French beans, and many more of neglected crops. Some of the rice land races such as *Thapachini*, have good yields under marginal conditions. The *Chad Dhan* land race has special importance and every local household maintains it.

BBA's search for land races continues. BBA workers have travelled extensively in the Central Himalayas and found several remote areas in which traditional crops are still farmed and farmers continue to barter. 'Save the Seed' is not an institutionalised campaign, but an informal movement. This movement promotes the philosophy that *"the best way to save traditional seeds is to continue to grow them in our fields"*. In the past, farmers' fields were living gene banks.

Table 33. 1: **Comparative Yield Performance of Modern Varieties and Land Races in 1995**			
Variety	**Origin**	**Grain Yield (t/ha)**	**Straw Yield (t/ha)**
Thapachini	Land race	5.3	8.8
Jhumkya	Land race	5.0	8.0
Lalmati	Land race	4.5	4.6
Nagmati	Land race	3.8	8.0
Saket-4	Modern variety	4.9	6.0
Pant Dhan-6	Modern variety	3.6	4.9
Kasturi	Modern variety	2.4	3.4
Govind	Modern variety	1.9	2.1
(Source: Author Results of BBA Experiments)			

The *Baranaja* System of the Central Himalayas

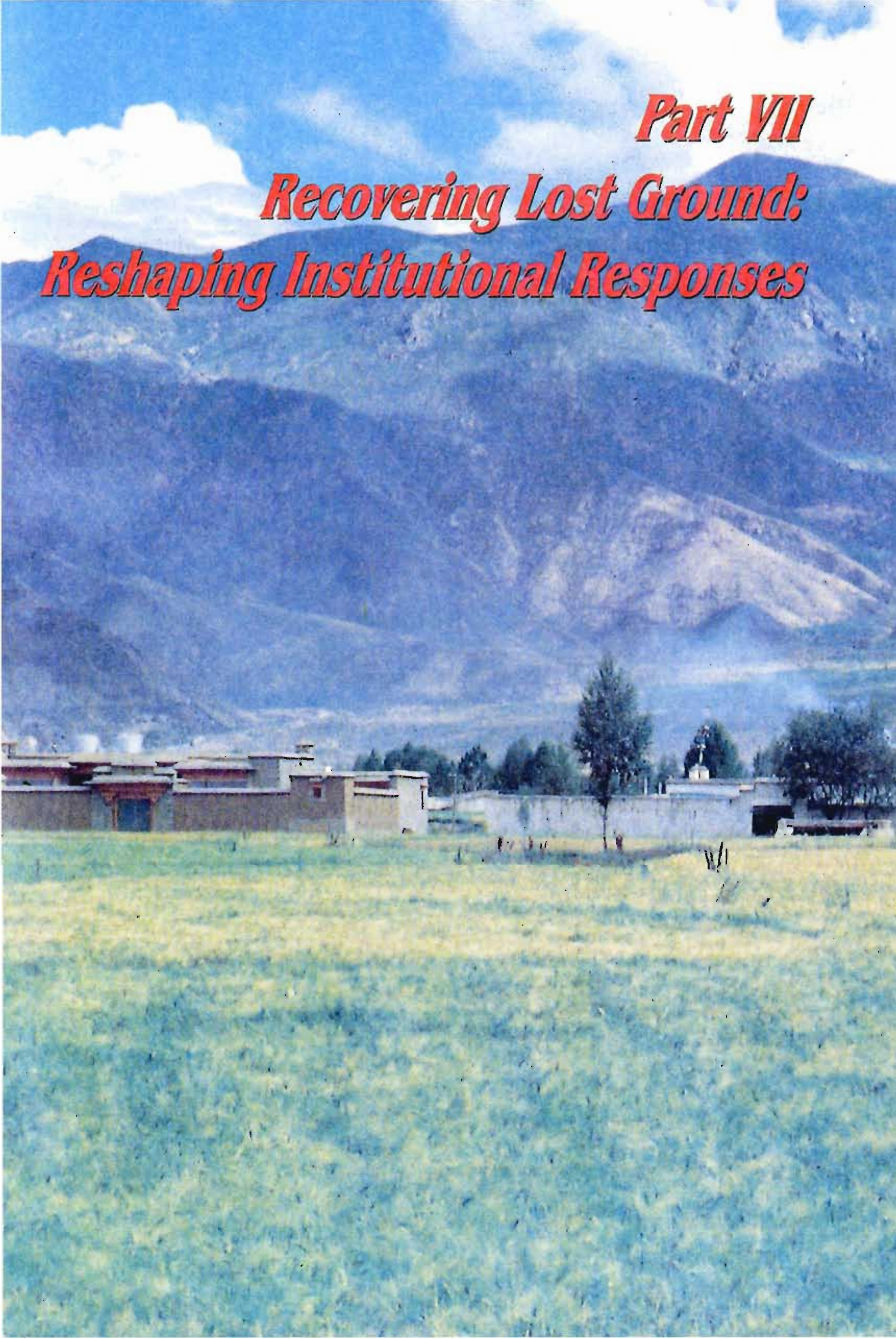
Mr. Jardhari gave some examples that demonstrated the value of indigenous land races and traditional farming systems. He cited the practice of '*bharanaja*' (literally '12 types of seeds') in the Garhwal mountains in which farmers practice mixed cropping with as many as twelve different crop species in the same field. The practice was very common in rainfed fields. The species include *manduwa* (finger millet), *ogal* (buckwheat), *ramdana* (amaranthus), *mash* (black gram), *bhat* (black soybean), *gahat* (horse gram), *masyang* (rice bean), *lobiya* (French bean), *kheera* (cucumber), foxtail millet, *rajma* (kidney bean), and *Jakhia* (cleome). Foxtail millet matures at a time when food grains are starting to run out in farmers' stores. *Baranaja* is geared towards meeting diverse household requirements. In this type of traditional cultivation, farmers have to spend almost nothing on inputs such as seeds, organic fertilizer, and pest control. In the past farmers would start planting when they felt that conditions were suitable, now the first thing they do is head for the seed shops. The traditional system of *bharanaja* is being replaced by commercial farming (soybean and cash crops) to feed the ventures of multinationals. Crop species are disappearing fast with the introduction of monoculture and hybrid crops. Farmers are being brainwashed into believing that traditional crops and systems like *bharanaja* are a sign of 'backwardness'.

"*In traditional agriculture, crops are grown not only for humans but also for our cattle*", said Jardhari. All traditional crops produce more fodder or straw than improved varieties. He is totally against mechanisation. "*Tractors neither eat grass nor produce any manure. What will be the fate of soil fertility and the livelihood of mountain farmers in the long run?*", he warned scientists who advocate mechanisation in farming. The main reason for villagers re-adopting traditional varieties and concepts are the end results, which address the real needs of farmers. He stressed that farmers have to save and revive traditional agriculture and varieties for sustainable mountain life. Up till now, national and international gene banks have taken in land race 'deposits', but 'withdrawals' by the communities that bred them have been much less frequent. Indeed, the banks were not set up to operate in this way. The emergence of community-based conservation initiatives requires new thinking in this area, and gene banks need to have a broader role in supporting farmers' seed security.

The efforts of the Save the Seed Movement in reviving the use of indigenous crops and cropping systems and encouraging the growth of low-input organic farming is noteworthy. The work suggests that it is possible to combine diversity, productivity, and livelihood security in future agricultural policy. For this, the strategies to be followed should emphasise a mix of high productivity, high diversity approaches building on indigenous biodiversity and knowledge, transformation of negative repatriation from genebanks, inter-farmer exchange, appropriate returns for wider use of farmers' knowledge and resources, and the protection of critical agro-ecosystems.

Part VII

Recovering Lost Ground: Reshaping Institutional Responses



Chapter 34

An Inquiry into the Relationship between Agricultural Research, Development, and the Issues Facing Agricultural Biodiversity Management in the Hindu Kush-Himalayan Region

A. Rastogi

Firing the Engine

The Dilemma of Growth Dominated by Science and Technology

Scientific progress has made such an impact on society that technology and human development have become synonymous with each other in popular parlance. However debatable and questionable this growth may have been in certain sectors, scientific developments continue unabated, with knowledge developed in one field being applied to development in another. For example, nuclear technology makes such a useful contribution to developments in the basic life-supporting fields of agriculture and medicine that future technological breakthroughs in this area are not discouraged, despite the well-known hazardous off-shoots of the technology. The faith in scientific and technological development is so strong and deep-rooted that the only way to try and bring about a paradigm shift in this way of thinking is by questioning some of the basic premises of the foundation. Many issues raised by the sustainable development paradigm in the recent past have made an enormous contribution in this direction. Path-breaking work has been done by leading economists and ecologists in the field of agriculture (Jodha et al. 1992, Ramakrishnan 1992, Sachs 1993, Bawa and Gadgil 1997, Rhoades 1997) and eminent doctors in the field of medicine (Bolar 1991, Chopra 1993) that has helped steer the focus in agriculture from crop yields to nutritious food, and the focus in health care from medicines to healthy living.

This process of acculturation of science, though in its infancy, has begun. 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. This paper highlights some of the problems with the rapid advancement of agricultural science that led to the neglect of native cultivators and raises some issues that challenge the incorporation of scientific principles in traditional agricultural practices. It is an attempt to build a case for greater recognition of and participation by the average subsistence mountain farmer in future agricultural research and development.

Hoarding the Growth

Institutional Fueling of Industrialisation

The pace of agricultural developments has been very rapid since the second world war, and the release of hybrid dwarf varieties of rice and wheat during the sixties particularly brought a revolution in the field. The promise of improved crop yields provided new hope of meeting the increasing demands of the burgeoning world population. The Consultative Group on International Agricultural Research (CGIAR) was created in 1971 with a global mission to eradicate hunger from the face of the earth. Armed with the strength of being able to create and transfer new technologies, CGIAR continued to expand and diversify. It now has 18 centres world-wide. These centres, together with other international and regional aid agencies and multilateral and bilateral donors, have dominated the scene of agricultural research in the last three decades. The national research centres and agencies have worked in unison with this international effort bringing about a watershed impact on the overall food production scenario in the world. Such is the international appeal and the pace of development that there is practically no space for incorporation of farmers' knowledge systems. As a result, traditional farming practices have been discarded as an unnecessary burden in formal agricultural research. The impact of the Green Revolution technological package, however, has been fairly uneven between countries and between different regions in a country, depending on the internal capacity to mobilise resources and investments in rural infrastructures such as irrigation, electrification, roads and communication, and research and extension.

Tilting the Balance

Limitations of the Reliance on Industrial Agriculture

The package approach of extension backed by TOT (transfer of technology) has had limited success in the context of the complex, fragile, and diverse marginal environments of mountain regions (Sen 1993). The reasons for the incompatibility can be traced to the inherent biases in the technological package: the chemical bias of the high response varieties, which need artificial fertilizer and pesticides to deliver the promised yields; the crop bias towards a few staples of international relevance; the big farmer bias of trickle down development doctrine; the monoculture bias against indigenous farming systems; and the political bias against the farmer and third world authorities (GRAIN 1994). Besides worries about the associated environmental problems, which are often put to rest by the offer of friendlier technological solutions in future, the economic feasibility of the package has become a big question mark. The increased dependence of governments of the southern countries, many of them in heavy debt and facing severe crises in their balance of payments situation (Bhalla 1992), on international organizations, northern donor countries, and multinational corporations has provoked discussions on the basic issue of the sustainability of this approach. Shiva (1991) suggests that the Green Revolution has not only benefitted rich farmers, but has also contributed to the impoverishment of smaller farmers. Rhoades (1997) has described the adverse impacts on marginal mountain farmers. As an example, note the undercurrent of frustration with the process of the development of technology in the following excerpts from a response to the Quinquennial Review Committee of the Indian Council of Agricultural Research (ICAR) by the Secretary of the Department of Agriculture of a northeastern hill state in India about the selection of a site for a research station.

"From the beginning (mid 1960s) there has been some misunderstanding between the Agriculture Department of the State and the ICAR. The points of contention are as follows. Firstly, the ICAR felt that the selected site was on hilly terrain with virtually no flat land and was therefore not suitable for conducting research; whereas the Agriculture Department felt that if any research work was needed then it should be for hilly terrain, and that the area represented the average climatic and topographic conditions in the State. Secondly, the ICAR contended that the irrigation facility at the selected site was too limited; whereas the Agriculture Department felt that there was a need for research into cultivation under rainfed conditions and that the priority should lie here. There are 1,200 villages in the State. Out of a total geographical area of 16,579 sq.km., the estimated ultimate irrigation potential is only 1,790 sq.km. About 75 per cent of this potential belongs to only 25 per cent of the villages, and only about seven per cent of the land is under the control of the government. To add to this complexity, the altitude of the land that can be irrigated varies from 200 to 1,800 metres. Redistribution of land cannot be done under the current framework of customary and statutory laws and the State government has no programme for land reforms in this direction."

The response letter (Kevichusa 1996) goes on to add that *"the Agriculture Department feels strongly that the problem does not lie in the ideally suited areas having relatively flat lands and irrigation facilities. If such suitable lands were available, then the problems would be much less. If the desire of the ICAR is to produce research findings under ideal conditions like warm climate, good soils, and vast flat lands having irrigation potential, then the research results from the neighbouring State of Assam or any other part of the country could be largely* *applied in the foothills and valleys of the State, and therefore the priority should lie somewhere else."*

Completing the Circle

The Challenge of Farmer-centred Research

The professional challenge of both international and national public agricultural research is to acknowledge the mismatch between the TOT model and the priorities of the poor farmers cultivating marginal lands (Pimbert 1994). Referring to the failure of alternative models for shifting agriculture proposed by the ICAR, Ramakrishnan (1993) emphasises the fact that a drastic departure from traditional land-use practices cannot work because it requires a sudden disruption in society. Development interventions and alternatives should complement farmers' technical knowledge and resources, which are in a state of dynamic evolution as a result of innovative responses to changing socioeconomic and ecological conditions. Though there is a certain level of scientific interest in acquiring greater understanding of traditional practices, there are many daunting challenges to carrying out this participatory learning process.

The fundamental issue is that of the different world views being shared by scientists and native cultivators. Dirk and Box (1993) have said that scientific knowledge systems assume that people have the potential to understand the process of nature, to express underlying causalities in theory, and to harness theory to manipulate the environment. In contrast to this voluntaristic world view of scientists, the cultivators have an adaptive world view of supernatural control. For example, when crops belonging to the *Padam-Minyong Adi* community in the eastern Himalayan State of Arunachal Pradesh, India, are attacked by pests and diseases, farmers resort to many traditional techniques. In one of the methods an altar is erected in one corner of the field. It is made of small branches of some selected trees such as *kow*, leaves of the *talo* (*Bauhinia* sp)creeper, and a bamboo tumbler, and is decorated with different types of bamboo festoons. Ten to 15 big containers of *apong* (a fermented local beverage), a small quantity of rice, small pieces of ginger, and a red coloured fowl are placed near the altar. Small amounts of rice, *apong*, meat, and ginger are placed at the base of the altar, a fire is lit, and the priests start chanting verses to the glory of Kiine-Naane, the goddess of crops. The scientific recommendation would be for the farmer to use DDT to control the pest infestation.

The farmers' practices were rejected outright by orthodox scientists. When the toxic side effects of DDT became known, however, the insecticide was also rejected, but only after it had had a disastrous impact on soils and human health. Thus both the responses might be considered, inappropriate. Even so, scientists could have taken a more analytical view of the farmers' actions because they do actually lead to effective pest control. Kohli (1993) in a pioneering attempt said: "*the chanting of mantras by the priests at different times in the agricultural cycle has different effects. It is believed that the sound frequency produced during the chanting of the mantras by a priest may be instrumental in preventing the mating of certain insects and pests, stopping further multiplication. Specific odours produced in sequence and in various combinations by burning the ingredients placed at the base of the altar drive the insects away. The ash too has certain insecticidal properties.*"

As a result of the basic difference in their world views, farmers and scientists develop different value systems. In the above example the farmer offers favoured food resources (wine, meat, and spices) for the intervention of supernatural powers to save the crops, whereas the scientific recommendation is to spray poisonous chemicals! The development of knowledge is based on the values of a society. The thinking of a farmer is more integrated and holistic, whereas the specialists in particular subjects in scientific circles help develop knowledge in specific directions. To illustrate this point further, take the example of Apatani farmers (in Arunachal Pradesh, India) who maintain a carefully designed irrigation network. Each large stream rising on the wooded heights that ring the Apatani country is tapped soon after it emerges from the forest and reaches a gully wide enough to accommodate a series of narrow terraces. A short distance from the terraces, the first diversion is made from the stream, but usually only a little water is deflected here; the stream continues on its course, while the feeder channel branching off at an angle leads water along the side of the series of terraces so that any field can be flooded or drained as required by blocking or opening the connecting ducts. The sharing of water is such a delicate issue among neighbouring farmers that no farmer who is a part of this water sharing network may use pesticides. The use of pesticides by one farmer adversely effects the fish growing in the paddy fields of other farmers.

From the above two examples it is apparent that the knowledge of the farmer is locally restricted and conditioned, while the appeal of scientific knowledge is more universal. Limited by this vision, the farmers strive to establish linkages between the various land-use units in the rural landscape. For example, in the case of shifting agriculture, an indigenous system of agroforestry, farmers have linked their households to the forest ecosystems and effectively incorporated animal husbandry, thereby establishing ecological and socioeconomic linkages (Ramakrishnan 1992). Effective management of a diverse set of resources enhances livelihood security. This factor determines the risk perceptions of a farmer, which in turn influences decisions on the acceptability of new elements from the scientific knowledge system. According to Dirk and Box (1993), a farmer's assessment of risk may include supernatural sanctions, a holistic view of the environment, an awareness of the consequences of particular interventions for the household and the community, and, in the context of economic insecurity, an aversion to taking risks that can endanger the existence of the household. Therefore traditional practices not only promote the maintenance and integration of a diversity of land-use units (wet rice cultivation fields, shifting agriculture areas, terraced fields, home gardens, forest gardens, multiple use forest areas, and hunting reserves) but also of more species and varietal diversity in each of these units.

Serving the Future

The complexities of conserving agrobiodiversity

If scientists recognise one indisputably positive aspect of traditional agriculture, it is the fact that these practices harbour a tremendous range of biodiversity. However, there is even a difference in perception of the value of this: while farmers have considered and promoted Genetic Diversity over the generations as a dynamic resource, scientists think of it in more extractive terms as a static reservoir of desirable characters. This is reflected in statements like the following: *"The Indian subcontinent is an important centre of origin and diversity for more than 20 major agri-horticultural crop species and their wild relatives - rice, beans, sugarcane, cotton, pigeon pea, citrus, mango, banana, yams, several vegetables, spices, condiments (turmeric and ginger), and a variety of medicinal and aromatic plants. Nearly 160 domesticated species of economic importance, more than 350 species of their wild relatives, and above 800 species of ethnobotanical interest are native to this region. They constitute an invaluable reservoir of genes needed by plant breeders for the development of superior crop varieties."* (ICAR 1995).

This is a true reflection of the international mind-set whereby Herculean efforts have been made to put more and more seeds in deep freeze. According to the FAO there are a total of 6.1 million accessions under *ex situ* conditions, of which 90 per cent are kept under cold storage (FAO 1994, 1996). The problems have been far too many. Besides the fact that many of these gene banks suffer from technical problems, the safety of the collections is questionable because of the lack of regeneration to keep the seeds alive. Almost half (48%) of all seeds lying in gene banks now need to be regenerated; and many may have lost their viability or genetic integrity. It is being recommended to start re-collections of many of these collections, and that indicates the heavy reliance of this system on the native cultivator to whom the system has contributed almost nothing. In fact, this conservation system that leaves out farmers, peasants, pastoralists, and their knowledge, but expropriates their materials — making them available as raw materials to breeders and biotechnologists who may claim intellectual property rights over their creations — is doubly perverse. Not only do farmers lose control over their heritage - the seeds - but they also lose the possibility of continuing with their sustainable and highly productive agricultural practices which build upon biodiversity (GRAIN 1996). So, while the value of gene banks should not be underestimated, the unavoidable erosion of Genetic Diversity in gene banks in the long-term, even under the best storage conditions, questions the appropriateness of this technology as a primary conservation tool for agricultural biodiversity.

The need for greater understanding of farmers' knowledge has surfaced again and again as a result of the limitations that science poses on itself in the process of growth. The dynamism of *in situ* conservation lies in 'niche' based farming practices. Mountain farmers depend on a range of ecosystems that can be ordered approximately according to the intensity of their management. According to Swift et al. (1996) a generalised gradient might move from unmanaged vegetation with restricted use, through 'casual' management (including such things as shifting cultivation, home gardens, and multiple use commons.), to low-intensity management (including traditional compound farms and rotational fallow), middle-intensity management (including horticulture, pasture mixed farming, and alley farming), and high intensity management (including crop rotation, multi-cropping, alley cropping, and intercropping), and finally to modernism (plantation, orchards, and intensive cereal and vegetable production). It is generally acknowledged that diversity decreases as a habitat changes from forest to traditional agriculture to modern agriculture. However, the initial stages of management have only a minor impact on total biodiversity, and further loss is gradual until some critical stage of management intensity is reached. If this relationship holds, then it would follow that planning activities for biodiversity conservation should be focussed on maintaining management intensities below that critical point; rather than aiming at a zero management strategy. Therefore it is imperative to develop a deeper understanding of the dynamics of the traditional practices that enhance biodiversity through selective utilisation of resources, so that they can serve as a complementary approach for long-term conservation needs.

Changing the Course

The New Paradigm of Sustainable Development

The evidence that indigenous knowledge systems can provide positive interventions in the growth of science and technology is on the rise. Greater integration of the two streams of knowledge has been recommended as a major instrument for developing technologies for sustainable agriculture . Practices and recommendations emanating from the two streams could be reviewed through the attributes of sustainability. Jodha and Partap (1993) have summarised the major limitation of traditional systems as being the reduced feasibility and effectiveness in the face of rising pressure on land, weakening of local collective arrangements, changed technological and institutional environments, and unfavourable terms of exchange for local products. Equally the limitations of modern interventions include the side effects of massive interference with fragile resources (waterlogging, landslides), indifference to resource limitations and totality of farming systems, distortion in local demand patterns and resource use, and increasing heavy extraction of niches as a result of external demand. Integration of the two approaches to maximise benefits and minimise the limitations should shape the future research agenda.

At a more fundamental level of cultural integration, the research agenda would have to overcome the 'efficiency revolution' mind-set that came about as an answer to the 'limits to growth' factor. This response is largely limited to a focus on reducing the throughput of energy and materials in the economic system by means of new technology and planning. Twenty years of trying to 'overcome' the problem using the support of an improved industrial base has proven the futility of using a restricted imagination to revise only the means and not the goal. Acculturation calls for a conceptual shift to an attitude of limiting efficiency with sufficiency. This paradigm shift integrates food production with nourishment of body and soul, and health care with healthy living.

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Chapter 35

Can On-Farm Conservation be Compatible with Agricultural Development? Some Policies and Issues

A. K. Vaidya

It is quite often assumed that the diversity of Nepal symbolises a challenge for development and a cost associated with the rugged terrain. But the rich biodiversity in the hills of Nepal reflects the needs of the people and represents a strategy for survival, it is the result of the cultural, socioeconomic, and biophysical diversity. Crop genetic resources are concentrated in some of the world's poorest farming systems (Brush 1995). The general hypothesis that crop diversity is associated with closed and subsistence farming systems, because of the diverse needs of the people, and declines with the increase in developmental opportunities and interventions, needs to be examined in a wider economic, sociocultural, and environmental contexts.

With the introduction of new high-yielding varieties and over-exploitation of natural resources, genetic erosion is taking place in Nepal. Genetic erosion is reported to be high in crops, fruits, and medicinal plants at both variety and species' levels. It is believed to be caused by social factors such as technology diffusion, commercialisation, changing preferences, over-exploitation, and government policy. In the late 1970s the international community became aware that the seemingly abundant Genetic Diversity of food and agriculture was eroding, just as our technical capacity to use and transform germplasm was increasing. Germplasm conservationists have not considered *in situ* conservation of germplasm justifiable. In their view, displacement of traditional land races is a necessary result of development programmes that promote improved varieties and/or different crops as a means of increasing agricultural production (Benz 1988). It is widely believed that the rate of genetic erosion increases with the introduction of improved seed and market incentives. The question whether *in situ* conservation of germplasm is incompatible with development programmes could be resolved if we can find a way of producing more without destroying the natural habitats of potentially useful germplasms. Brush (1995) has demonstrated that on-farm conservation of land races can be decoupled from national farming systems using three cases, one in Peru (potatoes), one in Mexico (maize), and one in Turkey (wheat), as examples. The three case studies demonstrated that farmers in regions of crop diversity maintain Genetic Diversity while adopting modern agricultural technology. The aim was to test the hypothesis of whether conservation can continue under conditions of agricultural modernisation or not. It is important to convince researchers that *in situ* conservation does not necessarily imply denial of opportunities to the farming community that is directly or indirectly responsible for creating and managing the system under which crop land races survive.

In the closed systems of the hills, the farming systems are traditional, characterised by land races, and deep-rooted economic and sociocultural specific preferences that influence genotypes and crop evolution in a given environment. Crop diversity is promoted by physical and economic isolation, dependence on local inputs, production for local consumption rather than for market, and the persistence of local knowledge systems (Friis-Hansen in Brush 1995). One may wonder whether biodiversity should serve as an indicator of backwardness. The rapid replacement of local cultivars by improved ones in North America and Northern Europe may not be relevant, considering the different and heterogeneous sociocultural and environmental settings in third world countries. Land races form the main basis of food security in the hills. The maintenance of a number of cultivars and types is commensurate with socio-economic status, land types, fertility status, and the needs of farmers in specific conditions. Inter and intraspecies' diversification is also a vital strategy in risk prone farming systems to safeguard against unfavourable factors and unforeseen breakdown of varieties as a result of diseases and pests. As a result, yield is by no means the most important criterion.

The hills have climatic, ethnic, cultural, and physiographic diversity, resulting in highly integrated farming systems that depend on livestock, forest, and crops to survive. Hill farming is characterised by a scarcity of arable land, diversified farming, few employment opportunities, marketing problems, weak institutional support, and poor financial ability to modernise agriculture. As a result, wide Genetic Diversity can be seen in food crops, vegetables, fruits, medicinal and ornamental plants, and forest. More than 7,000 species of flowering plants are estimated to grow in Nepal, 79 per cent of which have been collected, identified, and preserved in the National Herbarium and Plant Laboratories, Godawari (NAA 1995). Although no scientific studies on genetic erosion have been carried out in Nepal (Upadhyay and Sthapit 1995), there is a clear feeling that agricultural development processes, on the part of both agencies and clients, lack awareness of the importance and role of biodiversity. Abundant Genetic Diversity exists, for example, in rice, finger millet, barley, grain legumes, wild vegetables, and citrus.

The state of development in the hills of Nepal and the level of infrastructure present are strongly associated with road heads. The Research Impact Study done by LARC has shown that the level of adoption of improved varieties fades with distance from the intervention points or markets (Masdar and Oda 1995). This study also has showed the compatibility of on-form conservation with the process of agricultural development and associated factors in the hills of Nepal.

Land-use Change

At least three distinct land types exist in the hills and this, together with the nature of kinship and inheritance, has resulted in considerable land fragmentation. This fragmentation poses a major obstacle to agricultural development in Nepal but is probably a blessing for Genetic Diversity. Hill farmers whose households possess land of *khet* (irrigated lowland rice field), *bari* (non-irrigated upland), and *tar* (non-irrigated river fan) types have to deal with diverse growing conditions that influence the types of crops grown and interact with household resource entitlements. The diversity in production results from the role of the different land types in the farming systems.

Generally, in the hills, a larger number of crop species is grown on dry land, often in mixed form. More than ten crops may be grown on the same terrace under rainfed conditions when it is near to a homestead. These terraces provide a variety of subsistence foods such as yam and colocasia; a range of local fruits and vegetables including potatoes; cereals such as maize, wheat, upland rice, finger millet barley, naked barley, and buckwheat; a variety of legumes; oil seeds; and some spices and condiments. More than 30 different crops can be seen growing on *bari* in the hill districts of the Western Development Region (WDR), but only some 16 crops on *khet* and 11 on *tar*.

Shifts in land use can be caused by macro-economic or market forces which lead to changes in the choice of crops, displacement of traditional crops, or use of land for non-agricultural purposes. Micro-irrigation projects in the hills have changed *bari* into *khet*, shifting the focus to rice-based cropping and threatening traditional diversity. *Yampaphant in Tanahun experienced a similar situation.*

Varietal Erosion

The adoption level of rice in the mid hills where most of the land races prevail has been very low (below 15%). Rice is grown as a normal (*Barkhe*), early season (*Chaite*), upland (*Ghaiya*), or high altitude crop. Research into these different types of rice culture has been limited, rice cultivation has complicated adoption criteria. On average, households in the hills maintain four cultivars, and sometimes as many as 20, each with a specific use and for a given condition (McNeely 1989). The number of cultivars reflects the diverse and complex environment, the different cultivars are used to maximise production in given micro-production environments.

Rice is grown widely in the *Terai* and river valleys and on hill slopes up to 1,500m, and the Genetic Diversity is evident. Not all types of aromatic rice are market oriented, but with the arrival of market forces the displacement of low-yielding varieties has been reported. *Jetho Budho* replaced other land races in Pokhara as a result of increasing demand, 47 local rice varieties have already disappeared from Pokhara Valley, 14 more are on the verge of extinction, and land races such as *Nathini, Khalte Kholo,* and *Biramphool* are believed to be under threat (Joshi *et al.* 1995).

Land races have evolved over generations to suit the local conditions of farms, they also closely reflect sociocultural preferences. In the case of rice, land races include varieties for different seasons, with different fertility, and for different conditions of water availability, aspect, and land type. There are different varieties for fertile soils and marginal soils. Fine type aromatic rice, noted for its low yield, is kept for festivals and guests. High-yielding but short varieties are rejected as they do not produce sufficient livestock feed. Varieties such as *Anadi* have medicinal use. The normal and staple varieties are well-adapted, giving stable yields under low input conditions with no fertilizer and very little or no manure. The filling content, swelling, and type of grain are important and desired characteristics that depend on socioeconomic conditions. These complex characteristics demanded by the social and biophysical environments promote on-farm conservation and often obstruct easy adoption of modern varieties. Even so, a recent study in the hills of Myagdi, Kaski, and Parbat indicated over 68 per cent of farmers grow improved varieties and the remaining local varieties are only conserved in the *bari* system (Vaidya and Gurung 1995a).

Genetic erosion of local varieties in wheat has also been strong as a result of the yield factor in a largely food deficit region. Anyway, hill people have no strong preference in wheat. But the low-yielding land races are believed to contain many useful traits that are desirable in modern agriculture, for example, *Paundur,* a local land race from Kaski district, showed a significant heritable trait against spike sterility (Joshi and Sthapit 1995). After research intervention at Reesing Patan, an off-station LARC research site for low altitude areas in Tanahun district, the number of improved varieties within the site increased from three to four to 10. Even so, the varietal diversity within households has dropped considerably, as a result of changing needs, and the fact that wheat is a relatively new food in the hills and is only used in a limited number of food dishes (Joshi *et al.* 1996).

The citrus decline in Pokhara Valley wiped out many land races of citrus, the disease was believed to be imported from outside during the process of development. Bacterial wilt (*Pseudomonas solanacearum*) disease has caused severe problems in the Western hills and was also believed to be introduced with 'improved' germplasms. This suggests that introduction of germplasm can be equally dangerous to land races.

Extent of Crop Diversity and Erosion in the Western Hills

A survey was carried out by LARC in nine hill districts of the WDR in 1995 (Vaidya 1996) to assess crop diversity and the extent of genetic erosion. Figure 35.1 shows the varietal diversity across altitude-based domains. Rice varietal diversity was greater in the low hills (600-1,000m), including areas under aromatic rice, followed by river basins (below 600m), mid-hills (1,000-1,700m), and high hills (1,700-2,300m). As many as 17 varieties were reported in river basin and low hill areas, where five varieties of rice are maintained on average by households, and 14 varieties in mid hills. A common pattern was observed for rice, maize, fruit, and vegetables of increasing crop diversity with decreasing altitude. But the reverse was sometimes true for temperate and winter crops, as for crops such as finger millet with specific sociocultural preferences.

Varietal erosion at village level varied with crops (Table 35.1). A greater varietal replacement was observed in the mid-hills for rice, fruit, and millet. There was a decline of wheat varieties in the river basins. Maize varieties had disappeared more from the high hills than from lower domains. Some 140 rice varieties are on the decline, the important ones including *Anga, Manamuri, Phulpata, Gauriya, Chote, Aapjhutte, Bangare, Sobhara* and *Tauli*. Farmers reported stopping using 103 varieties of maize, including *Seto, Pahele* and *Sathiya,* for reasons such as changes in cropping pattern and land-use system, and introduction of high-yielding varieties. *Mudulo* was the only local variety of wheat reported by 2.8 per cent of the respondents.

Ethnicity has some association with varietal maintenance, but this is not evident statistically in Table 35.1. *Brahmin*(s), as the dominant ethnic group in the hills,

Table 35.1: Number of Crops/Cultivars Reported to be in Decline by Different Ethnic Groups

Crop	Brahmin	Chhetri	Occupational castes	Gurung	Magar	Total
Rice	2.31±0.15	2.55±0.33	1.33±0.21	1.87±0.22	2.05±0.21	2.16±0.10
Maize	1.51±0.13	1.61±0.18	1.67±0.21	1.86±0.18	2.0±0.14	1.69±0.07
Fruit	1.67±0.33	2.33±0.88	1.0±0	-	1.5±0.50	1.75±0.28
Vegetables	1.25±0.16	1.25±0.25	1.5±0.50	1.0±0	1.6±0.24	1.32±0.10
Wheat	1.50±0.23	1.0±0	1.0±0	-	1.0±0	1.30±0.15
Millet	1.0±0	2.0±0	-	1.5±0.5	1.0±0	1.13±0.09

generally maintain a higher number of crop varieties. Figures 35.1 and 35.2 show the number of crop varieties or species maintained by the major ethnic groups in the WDR. *Brahmin*(s) maintain more diversity followed by *Chhetri*(s) and occupational castes regardless of crop species. The dominance of the *Gurung*(s), *Magar*(s), and mountain tribes increases with altitude, and crops such as finger millet and wheat varieties are important in their farming systems.

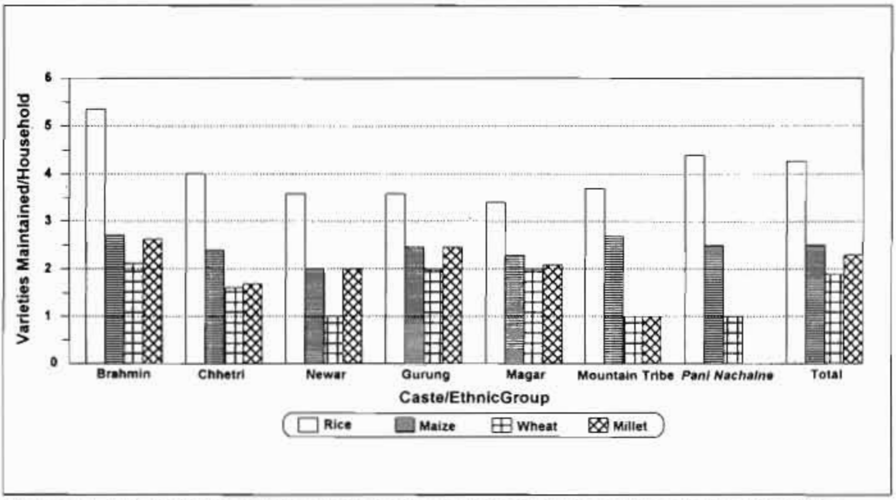

Figure 35.1: Food Crops Varietal Diversity Maintained by Each Household of Different Ethnic Communities in Nepal

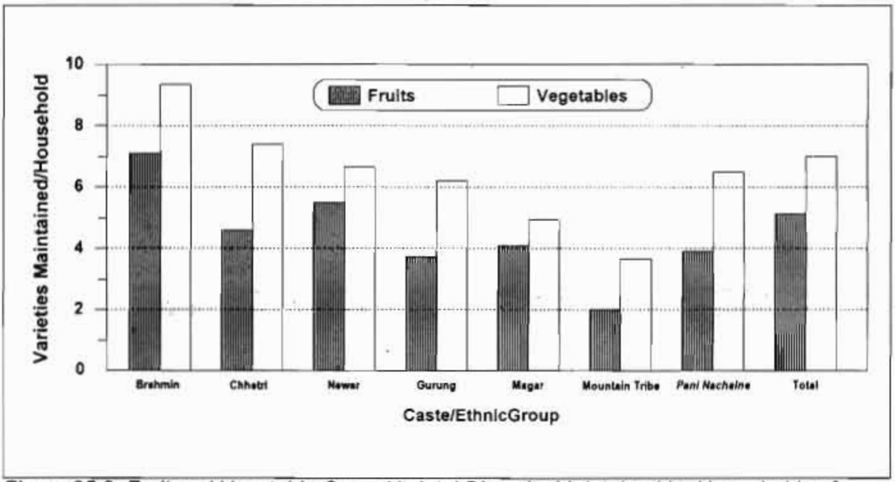

Figure 35.2: Fruit and Vegetable Crops Varietal Diversity Maintained by Households of Different Ethnic Communities in Nepal

The introduction of improved cultivars; market incentives; overexploitation of natural resources; social factors such as technology diffusion, commercialisation, and changing preferences; and government policy are often cited as reasons for genetic erosion. Most of these factors are believed to have a strong association with accessibility. But the study failed to establish any association between genetic erosion and factors such as distance from the road head, input levels, credit facilities, and altitude in the WDR (Table 35.2). Though in some cases diffusion studies in Lumle reported that the level of adoption of improved varieties drops away with distance from the road head.

Table 35.2: **The Correlation between Different Factors and the Genetic Erosion of Crops at Village Level in the WDR**

Crops	Distance	Input	Credit	Altitude
Rice	-0.067	-0.030	-0.070	-0.150
Maize	0.100	0.100	-0.020	0.120
Wheat	-0.180	0.100	0.180	-0.27
Finger Millet	-0.240	0.060	0.15	0.01
Fruit	-0.040	-0.220	-0.08	-0.06
Vegetables	0.140	-0.010	-0.13	0.12
All associations are statistically not significant at $P \leq 0.05$				

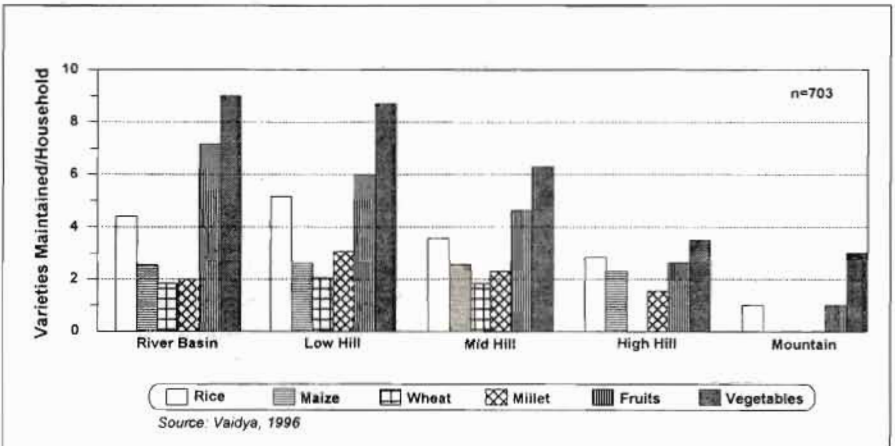

Figure 35.3: Household Crop Diversity Comparisons Among Five Agroclimatic Zones of Nepal

The Production Maximisation Approach

The green revolution in the tropics and subtropics during the mid-1960s helped to achieve incredible production of staple food, outpacing population growth, with the help of input responsive, carefully bred 'modern varieties'. However, it is felt increasingly that the revolution did not serve resource poor farmers, and widened inequality in the farming society. Extra 'entitlements' to food are now felt to be more important than increasing productivity (Sen 1981). The dependence on insecticides and fertilizers often resulted in the disappearance of beneficial insects, development of pest resistance, and deterioration in soil health. The modern varieties with genetic uniformity are designed to exploit productivity traits using external inputs. But now, the negative impact on the mountain environment, its resource poor farmers, and the political economy are being realised. New concepts such as a perspective for farming systems' research, client orientation, farmer participatory research, farmer first and last, and multidisciplinary participatory rural appraisal (PRA) and rapid rural appraisal (RRA) approaches are now being developed to counter the situation.

There has been an increase in adoption of improved varieties, improvements to road networks, input supply, and government extension and verification programmes, concomitant with the increase in population and the arrival of economic forces. However, farmers in the interior still conserve most hill and mountain land races *in situ*. But the block production programme run under the Department of Agriculture in Nepal, in which inputs, credits, and technology are supplied to maximise output, is often undermining on-farm biodiversity. These services involve government subsidies.

Farming Systems' Research Perspective

Agricultural development from the perspective of the existing farming systems has been tried in the western hills of Nepal and by Lumle Agricultural Research Centre (LARC). The aim was to address the problems of subsistence hill farming. The question of conserving biodiversity as a global concern was certainly not in the minds of the multidisciplinary researchers when the programme was conceived in the early eighties. The focus was more on the immediate and basic objectives of increasing the food security and income of hill farmers through the development of appropriate technologies. However, given the diverse and harsh environment the researchers did not take long to realise that use of local genetic resources was the key to addressing the problem. The approach adopted included emphasis on recommendation domains, identification of clients in a heterogeneous environment, and use of farmer participatory on-farm research, all taking socioeconomic diversity into full consideration. The multidisciplinary research teams worked together on prioritised farmers' problems using PRA techniques. They used eco-sites (off-station research (OSR) sites) to carry out farmer participatory on-farm activities and evolve a series of innovative approaches. The experience suggests that working on farmers' priorities with their active participation not only contributes to conserving on-farm diversity but may even enhance it further. The OSR sites' case studies showed that there was a significant increase in interspecies' diversity and no significant disruption to intraspecies' diversity (Vaidya and Gibbon 1991). This resulted in significant changes with higher farm income and increased food security. The cropping pattern achieved at Tapu during 1985-1991 was maintained after the site was closed in 1991, apart from the use of *Sesbania spp* for green manuring of *khet*. The on-farm and participatory approach helped promote the adoption by farmers of *Khari* and *Aule* goats because local selections were evaluated and found to be better than exotic ones at serving local needs and conditions.

Development with Conservation

There are several examples documented that suggest that on-farm conservation and development can proceed together. Some of these are listed below.

1. Maize (Plan Peubla, Mexico) (CIMMYT 1974)
2. Potatoes (Tulumayo and Paucartambo, Peru) (Brush 1995)
3. Wheat (Eskiseher and Kutahaya & Usak, Turkey) (Brush 1995)
4. Maize (Vicente Guerrero, Mexico) (Brush 1995)
5. Staple crops and vegetables (Western Development Region (WDR), Nepal) (Lohar and Rana 1996)
6. Early rice (WDR, Nepal) (Joshi et al. 1995)
7. Green manuring (WDR, Nepal) (Sthapit et al. 1988, 1989)
8. High altitude rice (Kaski, WDR, Nepal) (Sthapit et al.1996).
9. Mid-hill rice (Pokhara Valley, WDR, Nepal) (Sthapit et al. 1996)
10. Summer maize (WDR, Nepal) (Vaidya and Gurung 1995b)
11. Wheat (Tanahun, WDR, Nepal) (Joshi et al. 1995)

Some Issues

While this paper does not intend to draw conclusions, it attempts to raise some of the issues to be considered in local contexts. Attention to these issues should contribute to sustainable development of traditional farming in Nepal, as well as promoting and maintaining genetic resources 'on-farm'.

- The credit and subsidies given by the state favour improved technology to increase productivity, and thus conflict with on-farm conservation of agrobiodiversity and need careful revision. The concept of the Block Production Programme implemented under the Department of Agriculture has forced whole communities to exploit the genetic potential of selected improved varieties. The ambitious Agricultural Perspective Plan aimed at accelerating growth rate through fairly input intensive mechanisms does not consider adequately the impact on on-farm biodiversity; the consequences should be assessed. The activities of most national programmes, if successful, may in fact become the main cause for the loss of agrobiodiversity (Roder 1995).

- How would a farmer know he owns a threatened species and/or valuable gene? Identification of valuable germplasms and creating awareness will result in effective conservation. Awareness about the issue is desirable at all levels of society, from farmers, through grassroots' workers, researchers, and government line agencies, to policy formulators, all of whom play important roles.

- Farmer participatory, multidisciplinary, and on-farm approaches with a farming system perspective are likely to favour on-farm diversity. The formal development approaches lack this perspective.

- Land-use changes in the process of development can pose an important threat to conservation of agrobiodiversity. Land-use systems, such as *bari* in stress environments, conserve more on-farm biodiversity.

- The dilemma between development and biodiversity conservation needs to be analysed in terms of social, cultural, and economical rationales in a given farming system, and this is a dynamic process. Although diversity in species and variety levels in a locality is observed and reported, the understanding of the household dynamics influencing biodiversity needs to be strengthened. Studies should quantify the extent of genetic erosion and efficacy of farmer-based conservation and explore the possibility of community-based gene banking.

- Farmers cannot be persuaded to maintain a species on farm without need, use, or incentive. This may require marketing promotion for land races and elevating species' prestige at fairs and expositions (Brush 1995).

- In the face of the process of development, in whose interest is it to conserve agrobiodiversity? How can farmers be compensated and what are their rights to the germplasm they have preserved for generations? The cost of conservation for a country like Nepal is difficult to imagine in view of its pay-off at the present level of technological knowhow. The issue of resource availability to developing countries for ensuring *in situ* conservation is still unclear.

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Chapter 36

Agrobiodiversity Values and Issues Related to the Domestication and Farming of *Kuth* (*Costus*) by Highland Farmers in Lahul Valley, Himachal Pradesh, Indian Himalayas

K.C. Thakur, S. Bhagwan,
K.K. Raina, and T. Partap

Introduction

The cold and dry valley of Lahul in the high mountains of the Indian Himalayas is now known for its irrigated agriculture, in particular the cultivation of quality seed potatoes, hops, and now vegetables. Traditionally the highland farmers of Tibetan origin were subsistence farmers who cultivated crops such as naked barley, buckwheat, and rape seed, as well as keeping large numbers of livestock. The access to unique bioresources, such as medicinal herbs, was always used to generate cash income to meet the needs of the families. It was this indigenous knowledge of the value of local bioresources that led a few farmers in the area to take the bold initiative in the 1920s of domesticating a valuable wild plant, *Costus sp*, locally called *Kuth*. Natural occurrence of the species in this valley was rare, but the agroclimate for cultivation looked right. *Kuth* was the first ever cash crop domesticated and cultivated by the farmers in the dry temperate region of Lahul Valley, once a most marginalised, inaccessible, and isolated area. *Kuth* initiated the economic transformation of the area, and people in the area have an emotional attachment to it as well. *Kuth* has been used in ethnic-pharmaceutical practices to treat coughs, cholera, bronchitis, and skin allergies. The *Yamchi*(s) (local medical practitioners) use it for various medical therapies. It is also used for colds in animals. Kuth is one of the ingredients in the herbal mixture used in religious ceremonies. The emotional attachment to this crop helps to make it a suitable farm enterprise for the specific climatic/ecological niche in this region.

This paper describes the history of the cultivation process of this important cash crop for Lahul farmers, and the challenges of sustainability it has been facing.

The paper also highlights the fact that, although this folk innovation and practice is most desirable in terms of ecology and agrobiodiversity, marketing controls and overzealous implementation of the national conservation policy is threatening the sustainability of this farmer domesticated cash crop. The paper further highlights the failure to consider the mountain perspective, or take into account local agrobiodiversity when selecting and promoting appropriate niche-based crops for such fragile areas.

Box 36.1
Agroecology of Kuth Crop

Kuth (*Costus*) is a biannual crop. Farmers collect seeds after two years. The seeds are usually broadcast at the time of ploughing. *Kuth* is sown alongside buckwheat soon after harvesting barley in July/August. In addition to organic manuring through inputs of night soil, some inorganic fertilizers are also applied now, for example superphosphate, calcium ammonium nitrate (CAN), and NPK mixture. Irrigation is applied regularly. Sometimes a companion crop of peas is also grown during the first year after sowing *kuth*. Seeds are harvested in the second year, but the roots are collected during the second or third year depending upon the area and crop growth. The fresh roots are cut into pieces, dried, and packed in gunny bags for marketing

Approximately 2-3 kg of *kuth* seed is required to sow a *bigha* (800 sq.m.) of land. This will produce about 8-9 maund (40 kg in a maund) of roots and a further 10-12 kg of seeds.

Ecological Compatibility

Kuth roots are harvested 2-3 years after sowing in the field. Unlike annual crops, *kuth* requires few agronomic operations during its 2-3 year stay in the field. The fertile topsoil experiences minimum disturbance and loss through wind erosion. This minimal soil loss during the growth period of the crop is further indication of the harmony of *kuth* cultivation with the ecological setting of the area. The fields are watered immediately after the roots are dug up to prevent soil loss through wind erosion. *Kuth* cultivation is generally done on flat land in the valley and less on slopes. This results in better root formation and again minimises soil erosion by wind. The cultivation pattern indicates farmers' awareness of environmental conservation. *Kuth* cultivation poses no threat to the environment, rather it helps prevent environmental degradation.

The Domestication of *Kuth*

Folklore says that up to the beginning of the 20th century, *kuth* (*Costus*) was collected from a few locations in the forests of the northwestern Indian Himalayas and it was becoming rare. Around that time, two innovative farmers - Jamga Phunchog of Tholang village and Maya Das Dhoko of Kirting village - took *Kuth* seeds from a folk medicine doctor or *Vaid* in order to try to cultivate it. The idea was to meet the increasing demand of markets outside the valley in the Indian plains. Mr. Jamga Phunchog had a large family of 15 children (out of 25 born) and a wife to support . He first raised *kuth* seedlings and the crop on a small parcel of his family farmland. He was successful in husbanding the new crop and collected more seeds. Following this success he needed more farmland. To encourage him, the local padre of the Morabian Missionary gave him some farmland that the padre had purchased for vegetable farming. When Jamga raised *kuth* seedlings on a large scale in the nursery beds and transplanted these to his 0.25 hectares of new farmland, people laughed at his foolishness for using scarce irrigated farm land to grow a wild plant. Looking at the broad green leaves covering the field in the first year, people mockingly remarked that he was going to feed leaves to the 17 members of his family. Mr. Jamga just smiled. In the second year, tall plants with flowers covered the field like a jungle, but people smiled. In the third year he harvested the roots with his children. He was not really clear of the benefits he was going to earn from this *First Harvest of Kuth* and people were now curious to know what he would do with it. He collected the harvested roots, cut them into pieces, dried them, packed them in bags, and, with a caravan of horses carrying his produce, left for Manali, the nearest market town 100 km outside the valley across the Rorhtang Pass. When Jamga returned to his village, he had four mule loads of silver coins earned from the first harvest of *Kuth*.

The second farmer, Maya Das of Kirting village, had started *kuth* cultivation at the same time. But his idea of *kuth* cultivation was not accepted by most members of his joint family of 150, so he threatened to separate from the family to continue his *kuth* farming experiment. This worked and the family cooperated. Later folk songs were composed about the success of Maya Das in *kuth* cultivation and the economic gains he made. A line in local language says,"*Maya Das a doluru Kia Kia Kia*". It recognises Maya Das's ownership of this valuable crop (we could call it a kind of folk patent system). Both of these farmers perfected the agronomic practices needed to domesticate this plant which originated in the forest. No more laughter, and *kuth* farming took over the whole valley. In those days farmers bartered *kuth* seeds for an equivalent weight in silver coins, such was the high value of the crop. Between 1920 and 1960, *kuth* as a cash crop dominated the farming systems in the valley. The socioeconomic prosperity of the area was essentially a manifestation of *kuth* domestication and marketing as a cash crop. The acreage under *kuth* cultivation increased tremendously. The reasons for its increased cultivation were the increasing need of farming communities for money for education of their children and basic amenities, migration and settlement to the nearby areas of Kullu and Manali, and a greater demand for *kuth* in the international market dominated by the demand from China through Tibet. In addition to China, *kuth* was exported to Taiwan and some western countries, notably France and Germany.

In their first attempt to manage marketing collectively, farmers registered a company. This failed because of the tactics of outside *kuth* traders They then attempted to organize themselves into the *"Lahul Kuth Growers Cooperative Society"* in 1959. This society worked very well until 1962.

Blocked Market as First Challenge

The first blow to *kuth* farming came in 1962 when access to the main *kuth* market in China through Tibet was blocked because China and India were at war. This shook the whole trade and the flourishing farms in Lahul. It was a sudden unforeseen external challenge to the sustainability of farmer-innovated *kuth* farming and to the wild genetic resource that was being conserved through agriculture. Without the support of national institutions in exploring new markets, it was not possible to undo the damage.

Alternative Crop Promotion as the Second Challenge

Although some farmers maintained *kuth* farming even after 1962 hoping that marketing avenues would improve, around 1966 there was a further challenge to *kuth* farming from commercially important potato varieties. National institutions in India faced a serious scarcity of quality seed potatoes, and Lahul was selected as the most promising area for producing disease-free crops. Being free of monsoon, epidemic late blight had no effect in this region. Thus the government made an all out effort to promote potatoes farming in this area as an alternative cash crop. Thus the combined impact of marketing difficulties for *kuth* and the new crop option of potatoes resulted in the near elimination of *kuth* farming from the Lahul Valley. By the late seventies only a few farmers, mostly in remote areas, were cultivating *kuth* hoping for the return of better days. These farmers could not adopt potato farming and crop cultivation because of access problems. They were either storing *kuth* produce or selling in local markets for local use only with less returns.

Export Policy on Endangered Species as the Third Challenge

Kuth cultivation, a farmers initiative, received a further serious setback during 1985-88, from the policy on trade in endangered species. The pro-biodiversity conservation policy announced by the Government of India banned the export of endangered plant species.

In itself the policy was fine, but the improper implementation of the regulations, with respect to the ban on export of *Costus* species, highlighted bureaucratic ignorance reflected in arrogance.

Further, the Botanical Survey of India listed it as an endangered species of wild plant in the Indian Himalayas.

Farmers then petitioned the Government of India, the Botanical Survey of India (BSI), and planning and other government departments to negotiate that *kuth* was cultivated as a crop in their fields, and that they were thus helping its *in situ* conservation. In 1988, after physical verification by the officials from the above departments, the farmers of the valley got permission for its export on the condition that they showed a certificate from the local divisional forest officer (DFO) or the Lahul Potato Growers' Cooperative Society saying it was 'cultivated *kuth*'.

Farmers' efforts indicate their continued interest in conservation of this genetic material.

Conservation of Traditional *Kuth*

The Lahul farmers are protecting through cultivation the same genetic resource that is now endangered in the forests elsewhere in the Western Himalayas. The farmers are maintaining the genetic purity of the species by collecting the seeds every year from the same root stock, or using the root stock to propagate the crop vegetatively. Cultivation of *kuth* is thus ensuring conservation of this endangered medicinal plant.

Abandoning *kuth* cultivation by Lahul farmers would have a direct implication for the genetic erosion of this plant as its populations in the forests of Garhwal hillls in Uttar Pradesh, the forests of Chamba in Himachal Pradesh, and the forest of Srinagar and Jammu and Kashmir have reached near extinction levels.

Economic and Ecological Potentials of *Kuth*

Kuth has played a significant role in the development of sustainable farming systems in the valley through such things as its promise of cash-inflow, ethno-pharmaceutical properties, isolation/confinement to the area, prompt adoption, proven record of economic transformation, place in marginal farming areas, ecological compatibility in terms of less soil disturbance, low labour requirement, low inputs, and negligible insecticide/pesticide use. In fertile and accessible areas, cultivation is supplemented by potatoes, peas, and hops. However, it has also quickly occupied marginal areas where new approaches and technological interventions have failed to show their worth. The advantage of storing or delayed harvesting is an added advantage that further justifies its cultivation in isolated inaccessible areas with marginal lands and scarce labour resources.

As a result of price fluctuations, lack of marketing avenues, lack of research and development initiatives, and lack of government patronage it is difficult to maintain the high value of the crop. There are vagaries in prices, for example it

Table 36.1: **Comparative Cost/Benefit Figures for Cash Crops Grown in Lahul Valley (values are in Indian rupees per Bigha: one Bigha = 800 sq.m., and 1US$ = 35 rupees in 1995)**

Cost per bigha	Costs/benefits per (ICRs bigha)			
Inputs (Labour & Materials)	*Kuth*	Potatoes	Peas	Hops
1. Seed	100	600	150	100
2. Ploughing field	200	200	200	200
3. Cow dung	375	375	125	375
4. Chemical fertilizers	550	500	250	280
5. Sowing/planting cuttings	100	300	100	50
6. Irrigation	300	400	200	250
7. Weeding/hoeing	50	50	50	50
8. Micronutrients	-	100	-	100
9. Fungicides	-	90	300	-
10. Harvesting	250	250	800	800
11. Post-harvest handling (cutting, drying, sieving, grading)	200	100	-	-
12. Packaging (labour & materials)	80	250	250	20
13. Road head carriage	40	250	70	50
14. Total cost of produce	2,245	3465	2495	2375
15. Income from companion crops	1,500	-	-	-
16. Total production in kg per bigha	320	2,000	960	300
17. **Gross income from sales**	11,100	7,500	7,200	9,000
18. **Net Profit**	**8,855**	**4,035**	**4,705**	**6,625**

Net Profit/income (Item 18) is calculated from Item 17 minus Item 14
Source : Compiled by authors (1995) from a survey of *kuth* growers of Lahul

was Rs 2,400 to 3,000 per 40 kg bag in 1995. Bhagwan Singh reported that *kuth* fetched better prices even in 1932-33. It was sold for Rs 20 per kg in Manali. Some farmers, especially those in marginal and inaccessible areas, grow the crop and store it till high prices are projected.

Number of Families Cultivating *Kuth* and Area Under Cultivation

During the 1960s, *kuth* cultivation extended over 400-500 hectares in Lahul. Following the introduction of new cash crops and the problem of marketing *kuth* farming is now restricted to about 80 ha maintained by about 350 farm families. The majority of these farmers belong to Miar Valley in Lahul.

Institutional Support Aspects

Farmers' Initiatives

The domestication and cultivation of *kuth* as a cash crop were achieved purely through farmers' initiatives. Farmers were involved in standardising cultivation practices, post-harvest handling, or marketing of the produce. A *kuth* growers' association was formed during 1930-40. The *kuth* growers' society took some initiatives during 1983-85 to explore domestic markets for selling the produce in Delhi, Amritsar, Madras, Cochin, Bangalore, and Bombay.

Box 36.2

Letter of the Chief Minister of Himachal Pradesh State to the Central Government Agency for Removing Ban on Kuth Crop Produce Export

D. O. NO. TDHP/CM/85
17 April, 1985

Dear

I understand that the foreign export of kuth (Saussurea-Lappa) has been banned as per Import and Export Policy 1984 - 85, Schedule I, Commodities subject to Export Control, Part "A", Item 8 under XII (a) Plants and Derivatives head No. 25. This has caused a lot of hardship to the people of Lahul & Spiti, a border district of Himachal Pradesh. It may be recalled that while Lahul & Spiti was in Punjab, the Government of Punjab had declared kuth as "Agricultural Produce' vide Section 6 of the Punjab General Sales Tax Act, 1948, Item No. 39, Schedule 'B'. In 1982, Himachal Pradesh Government had withdrawn royalty on kuth and other impositions permissible under H. P. Forest Produce Transit Rules, 1978, keeping in view its position as agricultural produce, and it cannot be termed an "Endangered Species" of forest produce.

Kuth is a very remunerative crop and has a lot of demand in international markets. The economy of this border and tribal district of Himachal Pradesh will receive a boost if the restrictions mentioned above are removed. I shall, therefore, request you to consider this matter favourably in the interest of the economy of this tribal district of Himachal Pradesh.

With regards,

Yours sincerely,
(Virbhadra Singh)

[sic]

During the harsh days of the legal embargo on *kuth* export, farmers approached different ministries and politicians to get the ban revoked.

Conclusions

Farmers' initiatives to domesticate and cultivate *kuth* as a cash crop are praiseworthy. But the government's failure to provide support and patronage to

Box 36.3

To : The Additional Inspector General of Forest
Room No. 247-A, Krishi Bhawan
Dept. of Forestry, Government of India
New Delhi

Subject: Appeal to Lift the Ban Imposed on Export of '*Saussurea-lappa*' (costus root/*kuth*) in Schedule I: Commodities Subject to Export Control Part 'A' Items Export of Which is not Normally Allowed Item No:-8 (xii) - 25 - *saussurea-lappa-* (cb. *clastaraceae*)

Sir,

It is respectfully submitted as follows:

1. That ours is a Society working under the name and style of "The Lahul Kuth Growers Co-op; Society Ltd.," office at Manali, Dist. Kullu H. P., registered under the 'Punjab Co-op. Societies Act' and later 'The Himachal Pradesh Co-op. Societies Act, 1968, No.-3-1969. This society is constituted of 591 small and marginal kuth (Sassurea-Lappa) growing farmers of the Dist. Kangra then in Punjab and tribal Dist. Lahoul & Spitti., now in Himachal Pradesh, situated in a very far remote corner in the extreme north of H. P. near the Indo-China border, the area of which remains cut off from rest of world for nearly seven months a year, due to heavy snow fall in the region. These marginal farmers used to cultivate Kuth (Sassurea-Lappa) on their farms since 1920s and since then the produce used to be exported through private traders and later on through State Trading Corporation after the formation of this society in the year 1959. The plantation of the "Sassurea-Lappa' is done entirely on the farms only and under agricultural style. This plant does not exist in the jungles of Dist. Lahoul & Spitti. The yearly production figure varies from 300 mt to 800 mt. The production can further be enhanced in case there is liberal Export Policy to this item. It fetches good price at domestic market from Rs. 30/ - to Rs. 45/- per kg.

2. That the Chief Controller of Import & Export has imposed a ban on the export of this item Sassurea-lappa (Costus root/Kuth) in schedule - I commodities subject to Export Control Part 'A' items export of which is not normally allowed in item O. 8 (xn) 25. under Import & Export Policy April, 1985 to March, 1988 volume Ii Export Licensing Govt. of India Ministry of Commerce, due to the reasons that it comes under the endangered species.

3. That this imposition of ban on exports has not only affected the trade and cultivation of Saussurea-Lappa, but also has affected the economy of the poor growers who entirely depend upon this cash crop for their livelihood. A large quantity of this root is still lying unsold with the Co-operative Society and farmers and the fresh crop too is ready to harvest. The growers have borrowed loans and advances against stocks and are under debits.

4. That the poor kuth growers had discussed the matter with the Honourable Prime Minister Late Srimati Indira Gandhi during her last visit to the Dist. Lahoul & Spitti at Keylong in a meeting on 5th August 1984, where she clearly had assured to safeguard the interest of the poor growers.

5. That the Saussurea-Lappa as an agriculture item has clearly been justified vide Punjab Govt's Notification No. 4-KM/4288 MAII/RCS dated Jullundar, 24th November., 1961, that kuth (Saussurea-Lappa) is an agriculture produce according to section 6 of the Punjab General Sales Tax Act, 1948, item No. 39 (Schedule B) the sale of kuth is not liable for the payment. A copy of notification is attached in annexure No.-I.

   For its further justification the publication of the Council of Scientific & Industrial research, New Delhi in "THE WEALTH OF INDIA" RAW MATERIALS VOL. TX-RL-So page No.-240-241 clearly justifies the farming, production and status of this item in Lahoul & Spitti Dist. A Photo-stat copy of the same is attached in annexure No. 2.

6. That the costus root/Saussurea-Lappa is generally used for medicines and high perfumes in the foreign countries. There are also a few small oil extracting units of this material in India, whose capacities are very small against the production. M/s. A. T. Banon & Co., near Kullu also is among one of those. It has been reliably learnt that this Company has approached the Govt. of India to stop the export of the Saussurea-Lappa for its personal gains at the cost of the poor farmers who are still suffering with the unsold accumulated stocks of two years and one more harvesting season is ready in the near future. It is requested that while making any change in its export policy, the growers only Co-operative Society along with the local Forest Dept. and Himachal Govt. should also be consulted because any change in its policy directly effects the interest of the poor cultivators who do not have any say in the policy making.

Thus keeping in view, the above facts the worthy Additional Inspector General of Forests is requested to kindly recommend the case to the worthy Chief Controller of Import and Exports, Govt. of India to lift the ban imposed on the export of the "Saussurea-Lappa' as soon as possible so that the poor tribal kuth growers be saved from its worst effect in time.

Thanking you,

Yours faithfully,
for the Lahoul Potato Growers Co-operative,
Marketing-cum-Processing Society Lahul

kuth cultivation has discouraged its further expansion. *Kuth* has been mistakenly listed as an endangered species by the Botanical Survey of India. An export ban was introduced because it was feared it would become extinct as a result of intense collection from the forests. But the farmers in the valley have been growing *kuth* since the 1920s, and are actually conserving this plant species *in situ* through cultivation in their fields.

Though *kuth* is a high-value cash crop, the prices received by farmers over the years have fluctuated greatly. This is frustrating for the growers. The quality of Indian *kuth* is considered best amongst that from other countries such as China. There may be greater marketing potential in terms of produce diversification in international markets such as those of Japan and Germany and other European countries. But, in the absence of proper marketing interventions, this potential remains untapped. There is ample scope even within the country to increase the value of the crop by promoting use by pharmaceutical and cosmetics' companies. Government intervention is needed to develop better marketing opportunities and promote cultivation as a cash crop by the farmers in the valley.

Despite the high potential for economic gain, the crop has not received any R&D support from the government. There have been only negligible attempts by the government to explore marketing avenues; or to invest in research to make the product more valuable. In place of *kuth*, the government has tried to promote other crops. Although these crops can provide quick monetary gains, they can never harness the niche occupied by *kuth*, since the valley offers the specific climatic conditions required for *kuth* cultivation. Cultivation of high quality *kuth* is only possible in mountain areas with arid and temperate conditions, and this valley has the most favourable conditions in the Himalayas.

Studies are needed on development, crop improvement, post-harvest handling, marketing, and related aspects. A rich export potential could be developed through value addition and development of by-products. This requires analysis of its chemical properties, which would lead to industrial research on its use. Product diversification should also be investigated, *kuth* might compete with Korean *Ginseng*. Research efforts are needed to help in the standardisation of cultivation practices to boost its productivity and reduce the crop period to one year from the present two to three years. Biotechnology (tissue culture techniques) could be used to shorten the vegetative growth period and enable setting in of early root formation.

Marketing is the major constraint to *kuth* cultivation and expansion as a low input/high economic return cash crop. Government interventions are needed to explore new marketing avenues. A research focus on value addition, coupled with the standardisation of cultivation technologies and the exploration of marketing opportunities, could benefit the economy not only of the Lahul Valley but also of all the dry temperate areas in the Hindu Kush-Himalayan region. Several areas in Himachal Pradesh are suitable for *kuth* cultivation, and they include the Spiti Valley, Kinnaur, and the higher reaches of Kullu, Mandi, Shimla, Pangi, Bharmaur, and Bara Bangal. Export rules need to be relaxed.

Kuth cultivation is definitely a sustainable cash farming enterprise in the Lahul Valley, unlike other cash crops such as potatoes. This is because the specific agroclimatic conditions required for *kuth* are confined to this region only, whereas crops such as potatoes can be grown anywhere in the country. Crops such as potatoes offer immediate economic returns, but other areas might produce them more successfully, or cheaper, leading to a collapse in the market from this area. Good quality *kuth*, however, cannot be grown anywhere else. As long as there is a market, the region will be able to exploit *kuth* as cash crop.

Kuth harnesses the advantages of the specific agroclimatic niche in this valley better than other cash crops that can also be grown in other parts of the country. The crop represents a unique example of a farmers' initiative to domesticate and cultivate a wild crop for cash farming. Development of this crop is compatible with the perspective of mountain areas and with the sustainable development of traditional farming systems.

Chapter 37

Use Value of Rice and Wheat Land Races in the Public Sector Breeding Programmes in Nepal

R. P. Devkota and R. P. Shah

Genetic resources are valuable assets for any country. Land races, in particular, are the patrimony for breeders involved in crop improvement. The evolution and existence of land races within a country depend largely on its variation in altitude, topography, climate, and ecosystems. The wider the variation in these factors, the greater the Genetic Diversity.

Wheat Land Races and Breeding Use

The mid- and high-hill (MHH) zone of Nepal, is generally considered to be the traditional wheat belt in which a number of land races is still under cultivation. On average there is more diversity in the western part of Nepal than in the eastern part. Different areas have been explored in the past by several national and international agencies and concerned individuals. During 1979, a total of 85 *Triticum aestivum* accessions were collected from the western and mid-western hills by an IBPGR/FAO mission (Erksine and Bourgois 1979). At present, the Plant Genetic Resource Unit (PGRU) of the National Agricultural Resource Councils (NARC) has a total of 381 wheat accessions (Adhikari et al. 1994).

Nepalese wheat land races have been evaluated for both general and specific traits by several workers. In general, these land races have been reported to be relatively resistant to hail damage, drought stress, and storage weevils (Erksine and Bourgois 1979). Other important attributes of these land races have been identified, for example, prolonged dormancy (Rajbhandary 1976), high protein content (Haldore et al. 1982), wider range of variability (Gilani 1985; Damania and Jackson 1986), cytogenetic implications for improvement in bread-making qualities (Damania 1985), tolerance to stripe rust (Mudwari 1988), and spikelet sterility (Joshi and Sthapit 1995). Some of the outstanding land races have the ability to outyield the old standard reference varieties such as RR 21 under stress conditions (Chand 1985).

Some of the land races were used in crossing programmes during the late seventies and early eighties. A total of 219 simple crosses (Local x Improved) were attempted at the National Wheat Research Programme (NWRP), Bhairahawa, in 1979/80 to 1982/83. However, as a result of their extreme susceptibility to leaf rust (*Puccinia recondita*) and lack of acceptable phenotypes, almost all the progenies resulting from these crosses had to be discarded by the time they reached multilocation screening nurseries and yield trials (Devkota 1985). As a result, the approach of using land races in crossing programmes has changed over time from simple crosses to triple or multiple crosses (Local x Improved x Improved) in order to incorporate disease resistance and acceptable phenotypes. Some popular land races have been used in this crossing programme: *Dabdi* local from the far western hills; *Lumle (Paundur)* local from the western hills; and *Balangkha local, Change local*, *Masino Gahun*, *Sano Gahun*, and *Pangdure Gahun* from the eastern hills (Table 37.1). Unlike the earlier progenies from single crosses, progenies from these triple and multiple crosses have progressed towards production of succeeding generations. Land races such as *Hansi, Hande, Dolakha, Darmaili, Dabdi local*, and *Lumle local* have been used widely in a similar programme at Khumaltar using top/multiple crosses for breeding hill varieties (Mudwari 1988).

Table 37.1: **Wheat Land Races in the Breeding Programme at the NWRP, Bhairahawa, 1995/96**

SN	Cross	Pedigree	No.
1	Dabdi Local/NL 297/3/NL 539/Siddhartha//NL 297/4/BL 1022.	NC 2119-	27
2	Lumle Local/NL 297/3/NL 251/Fan#1//NL 297/4/NL 539	NC 2120-	7
3	Balangkha Local/NL 297/3/NL 297/Ning 8319//BL 1022/4/NL 539	NC 2121-	13
4	Change Local/NL 297/3/NL 297/Ning 8201//BL 1022/4/NL 539	NC 2122-	9
5	Masino wheat/NL297/3/Siddhartha/Ning 8319//NL 297/4/NL 539	NC 2123-	13
6	Sano wheat/NL297/3/YMI#6/NL 539//NL297/4/BL 1135	NC 2124-	7
7	Pangdure wheat/NL297/3/NL251/G 162//NL 297/4/NL 539	NC 2125-	6

Rice Land Races and Their Use

The tremendous Genetic Diversity in the rice crop in Nepal is evident from the existence of more than 2,000 land races of cultivated rice, four wild *Oryza* species (*O. nivara, O. ruffipogon, O. officinalis,* and *O. granulata*) and two wild relatives (*Leersia hexandra* and *Hygrorrhiza aristata*) in different places (Gupta et al. 1996). Different agencies have been involved in the exploration of rice land races in Nepal. Several missions have collected many land races from different parts of the country, and, as a result, the NARC has a collection at present of 2,387 rice accessions (Adhikari et al. 1994). Recent evaluation of 115 accessions has shown a wide range of variability for different characteristics such as early heading, dwarf height, tall height, higher culm number, sturdy plant, large panicles, and scented type (Gupta et al. 1996).

So far, of 680 accessions evaluated at the National Rice Research Programme (NRRP), Parwanipur and Khumaltar, Kathmandu, 24 were identified as important sources for blast resistance and four for cold tolerance.

Some of the outstanding land races of rice, such as *Jumli Marshi, Chhote Marshi, Raksali, Pokhareli Masino, Jarneli, Chhomrong, Darmali,* and *Dhunge Dhan,* have been used in the breeding programme. Some cultivars such as Khumal-2, Khumal-4, Khumal-5, Palung-2 resulting from local x improved crosses have already been released for general cultivation, and many others are in the pipeline (Table 37.2).

Table 37.2: Use of Rice Land Races in the Breeding Programme of the NRRP

SN	Genotypes	Cross and pedigree	Remarks
1	Khumal-2	Jarneli/Kn-16-361-BLK-2-8	Fine grain, released in 1987
2	Khumal-4	IR28/Pokhareli Masino	Fine grain, released in 1987
3	Palung-2	BG 94-2/Pokhareli Masino	Fine grain, released in 1987
4	Khumal-5	Pokhareli Masino/Kn-1B-361-BLR-2-6	Fine grain, released in 1990
5	Chhomrong Dhan	Local selection	Cold tolerant, released in 1991
6	NR 10157-2B-7-1-1	Jumli/IR 9129/Kn-1b-361	Promising line
7	Machhapuchre-3	Fuji 102/Chhomrong Dhan	Cold tolerant, released in 1996
8	NR 10293	Fuji 102/Jumli Marshi	Advanced line
9	NR 10250	Fuji 102/Chhommro	Advanced line
10	NR 10258	Akiyudaka/Jumli Marshi	Advanced line
11	NR 10260	Akiyudaka/Chhote Marshi	Advanced line
12	NR 10296	Stejaree 45/Jumli Marshi	Advanced line

Sthapit (1991) identified a highly cold-tolerant rice land race, and it was released by the NARC for high altitude villages. Land races can also be improved in those areas where farmers do not have access to other varieties. The variety, *Chhomrong Dhan,* has resistance to bacterial sheath brown rot diseases (*Pseudomonas fuscovaginae*) and blast, besides being cold tolerant (Sthapit et al. 1995, 1996). These valuable genes from a local land race were successfully exploited to develop the new Machhappuchre-3 and 9 varieties (Fuji 102/ Chhomrong Dhan) with better quality.

Issue

With increasing efforts placed on popularising the improved genotypes, and considering the way modern high yielding varieties (HYVs) are replacing traditional cultivars, it seems that the valuable land races of both wheat and rice are likely to become extinct. This may seriously limit the scope for crop breeding to develop ecological niche-based varieties. The situation is worse for wheat than for rice, as at present the rate of replacement of traditional varieties by improved ones is much faster.

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Chapter 38

The Shifting Perspectives of Biodiversity/Agrobiodiversity Related to Land Use in the Himalayas and Its Implications

V. Sharma

Mountain Biodiversity

Mountains make up one-fifth of the world's landscape and are home to at least one-tenth of the world's people. In addition, two billion people depend on mountains for much of their food, hydroelectricity, timber, and mineral resources. Mountain areas in general, and the Himalayas in particular, are considered to be a storehouse with a wealth of economically important and endangered species. Now that the lowlands have been hugely altered by agriculture, industry, and urban settlement, the last stronghold of nature is in the mountains (Denninston 1995).

The Himalayas have not received sufficient attention in the context of global biodiversity compared to the tropical rain forests. This lack of attention may be because species' diversity generally declines with increasing elevation, and there are far more species per unit area and in total in the tropics than in temperate mountain regions. The Himalayan region, however, has considerable biodiversity and agrobiodiversity, particularly at levels of biological organization higher than species, i.e., genera, families, phyla, habitats, and ecosystems and agroecosystems. Perhaps no other life zone contains so great a variation in habitats and ecosystems (beta diversity) as the mountains. Mountains also rank high in another indicator of biodiversity - endemism, the occurrence of species only within narrow ranges, typically after a century or more of isolation. The eastern ranges of the Himalayas are richer in both species and endemism than the western ranges, although similar habitats are rich in some taxa and poor in others. The Himalayas, which are about 3,000 kilometres in length and only 80-200 kilometres in width, have a striking vertical zonation in natural vegetation. Furthermore, the changes in plant and animal communities are very abrupt, and smaller areas may contain a variety of habitat types as a result of changes in aspect, slope, and altitude. The micro variations in climate, soil, and vegetation over very short distances lead to the occurrence of species within narrow ranges. The ecological changes in the Himalayas occur along three principal axes.

- A vertical axis, with variations in temperature and moisture determined by the increasing altitude

- A transverse axis cutting across the main ranges, with a decrease in annual precipitation and extreme temperature fluctuations between the front and interior ranges along the axis resulting from the topography

- A longitudinal axis parallel to the ranges, with a decrease in monsoonal precipitation and winter snowfall along the axis from southeast to northwest.

Since the interaction of these three axes determines the climate and biodiversity-agrobiodiversity at any place in the Himalayas, our perception of biodiversity in the area has to go beyond the conventional measures of biodiversity based on species' diversity and species' abundance, since the absolute number of species is generally smaller than in lowland and tropical forests (Gaston 1981). The Himalayan region is also characterised by diverse ethnic groups. These have developed their own cultural practices based on the available natural resources, giving rise to a high level of cultural diversity on par with that of the biodiversity found in the region. The interaction of mountain people with the natural ecosystem has helped people to maintain the richness of species, communities, and genetic material, both in farming systems and in the wildlife of the mountain environment (Gurung 1994). This has led to a depth and diversity of indigenous knowledge about the management of biodiversity and agrobiodiversity, examplified by the diverse farming systems, use of minor forest products, and richness of cultivars and land races of mountain crops.

Monitoring of Agrobiodiversity

Post independence land-use changes have not remained limited to forests, grazing lands, and minor settlements, but have also involved large-scale use of land for mining, horticulture, road building, hydroelectric projects, construction, urbanisation, commercial tourism, and industry resulting in water pollution, severe landslides, pressure on forests, and shrinkage of wildlife habitats. The front ranges and low altitude areas of the mountains are more prone to these environmental disturbances, though the interior areas experience a seasonal burden in summer.

Summing up the chronological events of land-use changes in Himachal Pradesh, it seems that the period from early 1800 to 1870 was a phase of harnessing unused forests. from 1870 to 1900 saw the exclusion of locals from forest use and management. From 1900 to 1947 was the so-called 'conventional conservation phase' with changes to stricter regulations further restricting the use of forest land and resources by people, and increasing conflicts over land use with local farmers. Post 1950 saw moves changing forest composition for commercial requirements, and the development of chir pine plantations in the mid hill grasslands and rangelands. The conservation phase started only in the 1980s. The degradation in biodiversity had already started in the early 1800s, in the form of deforestation and hunting. The history of land-use changes provides a chronology of processes relating to structural changes in the dimensions of biodiversity.

Thus, during the past century and a half there have been considerable losses in the area of habitats for natural biodiversity, but equal gains in the area of agrobiodiversity habitats. Has this increased agrobiodiversity? The addition of cash crops may be a gain, but the loss of native land races and farming cultures are a net loss for which we do not have actual accounts. The moves towards commercial forestry for timber and resin, and to restricting the use and management of forests by people, have added to the risk of loss of several wild species. The biological degradation of grassland ecosystems through chir pine plantations and lantana invasion represents an added threat to the diversity of animals and plants associated with these systems. The now endangered pheasant species is one example of this. Government policies and institutions are at the helm of the factors directing change, particularly the forestry department. The other key influence is the increase in the population working to sustain their livelihoods.

Monitoring of Agrobiodiversity

Agrobiodiversity and human needs have been in a state of continuous adjustment since historical times. There is much talk today of environmental degradation in the Himalayas, but most of this is literary and sentimental, asserting the impression that the Himalayas are facing destruction by people, and unable to distinguish between natural changes and changes caused by anthropogenic activities and improper institutional interventions.

The pace and characteristics of change within mountain zones over the past 50 to 100 years need to be evaluated. But data on the natural rates of regeneration may not be available, so that it might be difficult to compare the human-induced rates of degradation with natural changes. Loss and gain accounting for biodiversity and agrobiodiversity might help.

We need sound monitoring and management of environmental changes, along a network of on-farm sites to detect the range of changes, particularly those resulting from continual anthropogenic changes in land-use patterns and the use of natural resources and human influences. Biological monitoring programmes can evaluate trends in the status of species, communities, and ecological systems over time. The conservation of biodiversity could be enhanced by monitoring programmes, providing a feedback loop that signals to managers and policy-makers the need to make appropriate changes.

Monitoring programmes should be on a scale relevant to the ecological processes being monitored and the conservation and management questions being asked. Surveys and monitoring should be aimed at identification of areas with rich diversity; of trends in species and habitat loss; of loss in agrobiodiversity resulting from factors such as population, resources, consumption, and trading systems; and conservation measures needed, including such things as monitoring species to audit the changes in diversity, custodial management, and buffer zone eco-development.

There are some simple and cost-effective biodiversity monitoring methods aimed at identifying trends in species and habitat loss. Some of these are listed below.

Comparative Historical Data

Historical data related to natural history observations have been collected for a century or so and are available in museums and libraries for comparison with recent records. Local changes in diversity should be analysed in the historical setting.

Revisiting of Sites

Sites for which historical accounts are available should be revisited to enable a fresh assessment of changes in species and habitats. This could form a basis for evaluating the status of agrobiodiversity components and also for future prediction of the processes. Spatial data on the distribution and abundance of people-crop-livestock-forest species are of great value in assessing diversity.

Biodiversity can also be monitored using such tools as photographs and maps, repeat photography, ethnosciences, and wildlife studies.

Agrobiodiversity conservation will also require assessment of the economic, social, and ecological effects of land-use policies. The socioeconomic data at household level needed for this may be acquired from various sources.

The Options and Imperatives

The dichotomy of conservation and development policies needs to be addressed through a holistic approach to agrobiodiversity in the mountains. This would require an institutional change, as the present institutional mechanisms are oriented towards sectoral approaches at both policy and field levels. A variety of approaches and strategies has to be worked out for this purpose. These would include incentives and disincentives to agencies directly or indirectly affecting the conservation of agrobiodiversity in the Himalayas.

Participatory Monitoring Protocol

Simple and participatory methods need to be developed for the assessment of agrobiodiversity. Our perception of the full dimension of mountain agrobiodiversity remains very vague, but we may expect species' estimates to be made with increasing confidence and precision. Standard sampling methods and protocols that allow reliable comparison between sites without a complete inventory being taken need to be developed.

Study of both formal documented records and non-formal indigenous knowledge can provide vital information about indigenous resource management systems and present day agricultural management methods.

Outstanding Individuals and Communities

The process of change always results in the emergence of a set of individuals or communities who are outstanding in terms of local innovation and set the trend among the people in how to deal with changed circumstances. Recognition should be given to innovative farmers, indigenous communities, and institutions who have a stake in conservation of biodiversity for their own survival.

Benefit Sharing Mechanisms

An effective conservation policy based on the better understanding of biological resources and the human uses of agrobiodiversity would require new mechanisms of cooperation among local communities, government agencies, and non-government organizations. Economic values need to be assigned to each component of agrobiodiversity, in particular, those elements that have been considered as the free gifts of nature. New benefit sharing mechanisms need to be evolved so that resource use is minimised.

Policy Awareness

An informed public is the most effective custodian of agrobiodiversity. This would require the publication and dissemination through modern and traditional methods of field guides and educational materials on components and values of agrobiodiversity. To make the conservation of agrobiodiversity a goal, we need a fundamental shift in our policies. Agrobiodiversity conservation should be looked at from all levels, from subsistence farmlands with a 100 old varieties, to rapidly developing modern agriculture.

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Chapter 39

Addressing Broader Issues of Biodiversity/Agrobiodiversity Conservation within the Framework of National Policy: A Case from Nepal

R. Pant

"Affirming that the conservation of biological diversity is a common concern of humankind, Reaffirming also that States have sovereign right over their own biological resources, Reaffirming also that States are responsible for conserving their biological diversity and for using their biological resources in a sustained manner,..... ......"

The Preamble to the Convention on Biological Diversity, 1992, has brought about a major shift in the international perception of claims over biological resources. Where earlier these resources were referred to as 'the common heritage of mankind', the Convention on Biological Diversity has brought these resources back under national sovereignty. The former implied that anyone had the right to collect bioresources from anywhere in the world and process them. The industrialised world, with a poor genetic resources base, had easy access to the rich genetic resources and indigenous knowledge systems of their colonies. This contributed largely to profiteering of companies from the North. A UNDP study has found that if agriculture in the North paid royalties on the plant varieties and knowledge it has used to developing countries and indigenous people, then these royalties would amount to $5.4 billion a year. Some of the products and technologies that are results of common knowledge of the people in a region, such as the Hindu Kush-Himalayas, are sold back to the region at higher prices. Patenting of such products by industrialised countries is often a violation of the intellectual property rights of the people of culturally and resource-rich nations. Hitherto, there was no obligation for industrialised nations to share the technologies developed by them from resources collected from resource-rich but economically underdeveloped nations. Nor were the research scientists required to pay anything for their access to genetic resources.

The Convention on Biological Diversity, which came into force on 29 December 1993, intends to put an end to this free flow of resources and knowledge. Article 15 of the Convention on Biological Diversity provides specific clauses with regard to access to genetic resources that must be subject to the prior informed consent of the contracting party and on mutually agreed terms. It further places a duty upon the contracting parties to take appropriate legislative and policy measures aimed at sharing in a fair and equitable way the results of research and development and the benefits arising from the commercial and other use of genetic resources with the contracting party providing such resources.

Biodiversity is essential to the world's ability to maintain its current level of food supplies, and, according to the FAO, a 60 per cent increase in food output will be necessary in the next 25 years. Crops need to be made more productive – able to yield more, to resist pests and disease, to tolerate difficult environments, and to cope with climatic changes. These characteristics might be found in the range of existing varieties of plants, both cultivated and wild. Research shows that plant biodiversity is primarily the resource of the South – over 90 per cent of plant species are located in Africa, Asia, and Latin America (Panos Briefing, 1995).

The notion of Trade Related Intellectual Property Rights (TRIPs), introduced in the Uruguay Round of GATT negotiations, is an attempt to direct the developing countries to introduce patents on plant varieties by either passing their own legislation or by joining one of the existing Union for the Protection of New Varieties of Plants (UPOV) conventions. TRIPs has conveniently excluded patenting of diagnostic, therapeutic, and surgical methods for the treatment of humans and animals; and plants and animals other than micro-organisms (essentially biological processes for the production of plants or animals other than non-biological and microbiological processes).

Most of the countries of the Hindu Kush-Himalayan (HKH) region do not allow patenting of plant varieties. For example, the Indian Patents' Act 1970, does not allow patents for inventions relating to agricultural processes. The Indian Parliament recently rejected an amendment to the act on the grounds that it sought to curtail farmers' traditional rights to innovate and adapt their own varieties and could have wiped out centuries of biodiversity material and skill (Panos Media Briefing, 1995). Exemption to agriculture under patents has to a great extent helped the public sector research infrastructure to develop and release more than 2,000 improved varieties in India itself. (The share of the private sector in this field in India is less than one per cent.) This has aided the increase of food grain production since breeders have been able to develop high-yielding and disease-resistant varieties without any hindrance through payments of royalties, and seed could be made available to farmers at low prices. Times are changing and multinational corporations have entered the markets of the developing nations seeking stringent laws to do away with exemptions granted to farmers as breeders (FAO meeting 1985) and subsidies in this sector (IMF Structural Adjustments' Programme).

Patent laws vary from country to country. US law, for example, allows patenting of plants. Many multinational companies involved in drug research and biotechnological projects have sought patents to monopolise entire varieties. For example, in 1992 Agracetus Inc, a subsidiary of W.R. Grace, received a European patent on all transgenic soybean varieties. Instead of receiving patents for the characteristics of genetically improved genes, they have been granted exclusive rights over the varieties. Similar patents have been sought by biotechnology companies for rice, coffee, cabbage, cauliflower, melon, peas, and cotton. The number of such industrial patents being issued in the US and in European countries has risen over the years. Numerous other examples of bio-piracy in the form of germplasm being taken from developing countries, especially from the HKH region, and patented in the west have been documented (Bija - The Seed, Issues No. 19 & 20).

Efforts are now going on to have these patents revoked. *"The long list of biopiracy cases is an indication that the US patent system has its own weaknesses which allows biopiracy to be practised as a rule. The withdrawal of the turmeric patent is only a first step in reversing biopiracy"* (Shiva 1997).

Nepal: A Case Study

It is imperative to look at policy developments in the countries of the South against the backdrop of the broad international canvas of biodiversity conservation. Nepal, although a gene rich country, is far behind in understanding the ramifications of the international league it seeks to join. The country owes its Genetic Diversity to the varied agroclimatic environments existing there. In order to fulfill its international obligations towards the conservation of this rich Genetic Diversity, Nepal has become a party to several international agreements and conventions and has been actively involved in the discussions leading to them in various preparatory meetings. The agreements and conventions include the following.

- Plant Protection Agreement for the South-East Asia and Pacific Region, Rome, 1956
- International Union for the Protection of New Varieties of Plants, 1961 (UPOV)
- Convention on Wetlands of Importance Especially as Waterfowl Habitat, Ramsar, 1971

- Convention Concerning the Protection of the World's Cultural and Natural Heritage, Paris, 1972
- Convention on International Trade in Endangered Species of Wild Fauna and Flora, Washington D.C., 1973
- Convention on Biological Diversity, Rio De Janeiro, 1992
- International Technical Conference on Plant Genetic Resources' Global Action Plan on Plant Genetic Resources, Leipzig, June 1996.
- World Food Summit, Rome, November 1996
- General Agreements on Trade and Tariffs - Observer status
- World Trade Organization - Observer status

The World Trade Organization was created under the GATT and came into existence in 1995. This agreement has far-reaching implications for developing countries. Although Nepal is not yet a member of the WTO, it has expressed its desire to become a member and is in the process of filing its draft memorandum on the foreign trade regime. WTO extends beyond the purview of the GATT, which was restricted to trade in goods only. WTO deals with the trade in services, trade related intellectual property rights, trade related investment measures, agriculture, and textiles. The provisions of the WTO are not in favour of farmers of the developing countries. The implications are discussed later in this paper.

Policy Developments

A cursory glance at these conventions shows that the thrust of most of the agreements is towards biological diversity. This fact is further evident following perusal of the (Nepal) national laws and policies on the conservation of genetic resources. The concept of protectionism followed by the developing nations is one that has been thrust upon them by the North. The entire notion of formal *in situ* conservation, which ignores people and their wisdom, is alien to the developing nations. Fortunately, Nepal realised this at an early stage and made the relevant amendments and additions to the prevailing laws. The Forest Act, 1993, and the Buffer Zone Regulations, 1996, drafted under the National Parks and Wildlife Conservation Act, 1973, have recognised the role of people and communities in conservation.

The objective of the National Conservation Strategy (NCS) 1988, is to preserve biological diversity and maintain essential ecological and life support systems.

The NCS also states that the single sector approach of government departments to resource conservation is not conducive to maintaining biodiversity, which requires a comprehensive approach that integrates the management of all resource sectors. The NCS indicates that Nepal lacks both a comprehensive programme for the collection of inventory data related to ecosystems and a scientific catalogue of flora and fauna occurring within the Kingdom.

The National Environment Policy and Action Plan (NEPAP), 1993, chapter on biodiversity conservation recommends, among other things, (i) to identify and take action to protect wetlands significant to biodiversity conservation; (ii) to develop management plans to conserve biodiversity; (iii) to mount a study to assess the status of biodiversity of endemic plants and animals, both terrestrial and aquatic, occurring outside of protected areas; and (iv) to establish a national biodiversity database and identify and strengthen institutions responsible for research, education, and training in biological resource management.

His Majesty's Government (HMG)/Nepal has not yet formulated a policy relating to agricultural biodiversity and its conservation. The country is in no hurry to take the necessary steps and is taking its time to come up with a policy on the matter. Nepal expects to take advantage of its status as a Least Developed Country, as a result of which it has been accorded certain exemptions until 2005 A.D. The feeling in the administration is that there is no institutional pillar to support and follow up such an effort. Hence the first step should be the creation of the infrastructure and an institution, policy-making shall follow.

The Constitution of the Kingdom of Nepal, 1990, requires ratification by the members of Parliament of all International Agreements entered into by the country.

According to Article 126,

"(1) The ratification, accession, acceptance and approval of treaties or agreements to which the Kingdom of Nepal or His Majesty's Government, is a party shall be done in the manner specified by law.

1. *The making of law under Clause (1) shall, among other things, contain a condition that ratification, accession, acceptance and approval of the following treaties or agreements be done by a two-thirds majority of the members present in the Joint Session of the Parliament:*

    a. *Peace and Friendship*
    b. *Defence and Strategic Alliance*
    c. *Boundaries of Nepal, and*
    d. *Natural Resources and Distribution in their Utilisation.*

Among the treaties or agreements relating to the matters mentioned in Sub-clauses (a) and (d), treaties or agreements which have no wide, grave, or long-term effect on the country may be ratified, acceded to, accepted or approved by the House of Representatives by a simple majority vote of the members present.

"Nepal Treaties Act, 1990" [sic]

The Nepal Treaties Act, 1990, prescribes the procedure for the implementation of International Conventions. Reading Section 9 of this Act, we can gauge that it is not imperative for HMG/Nepal to enact a new law or to amend an existing law for the implementation of the provisions of all International Agreements. Once a treaty has been ratified by Parliament, it becomes legally binding upon the nation unless the treaty creates an additional obligation upon the state to enact legislation.

Article 9 (1): If a treaty in which the Kingdom of Nepal or HMG is a state party and which was ratified, acceded, accepted or approved by Parliament is inconsistent with the existing law, the law shall be declared void to that extent and the provisions of the treaty will be implemented as the law of the land.

Article 9(2): A treaty which is not required to be ratified, acceded, accepted or approved by the Parliament but that the Kingdom of Nepal or HMG is a state party to it and if it creates additional obligation or burden and if it requires the enactment of a legislation for its enforcement then HMG must take appropriate measures for the enactment of such implementing legislation at the earliest. [sic]

The following provision of the Constitution of the Kingdom of Nepal, 1990, directs the laws and policies of His Majesty's Government of Nepal in conservation of its natural resources.

"The state will adopt the policy to utilise the natural resources in a beneficial way in favour of the national welfare. The state will give priority to protect the environment from the adverse effects of physical development activities by providing public awareness of conservation. The state will also provide special care for the conservation of scarce wildlife, forest and plants." [sic]

To fulfill these objectives set in the Constitution, the Parliament of Nepal has enacted the following laws.

1. Plant Protection Act, 2029 B.S. (1972 A.D.) This Act was legislated with the objective of preventing exported and imported plants and plant products

from spreading epidemic diseases. So far the government has not enacted any specific law on safeguarding the international transfer of plant genetic material, but the provisions of this law can be applied. The act authorises the government to prohibit the importation of any plant, plant material, soil attached to plant or plant product, or soil only, or any other medium on which a plant can grow from any country. The government can specify necessary prohibitions or restrictions regarding the transport from one district to another of any plant or plant product. Entry points for the import and export of plant products are to be specified.

2. Seed Act, 2045 B.S. (1988 A.D.) This deals with the quality of seed production and its distribution to help maintain crop diversity.

3. National Park and Wildlife Conservation Act, 2030 B.S. (1973 A.D.) This act provides for the *in situ* protection of wild animals and their habitats. Besides *in situ* protection, it also provides protection to all species of animals mentioned in the schedule. Habitat protection takes care of protection of all plant species existing in the protected area. The National Park and Wildlife Conservation Act in its amendment in 1996 has incorporated the concept of a buffer zone to facilitate public participation in conservation, design, and management of any area in and around national parks and protected areas. The Buffer Zone Regulations promulgated in April 1996 empower wardens to constitute a users' committee in coordination with local agencies for the protection of wildlife, natural environment, biodiversity, and forest; development work; community development; and balanced use of forest products.

4. King Mahendra Trust for Nature Conservation, 2039 B.S. (1982 A.D.)

5. Forest Act, 2049 B.S. (1993 A.D.) This act relates to community forest user groups. The user group is entitled to develop, conserve, use, and manage the forest; and sell and distribute forest products by fixing their prices. The user group is also responsible for reafforestation or rehabilitation of its community forest. Extraction activities, such as harvesting of timber and collection of fuelwood, fodder, and other non-timber forest products, from the forest is done in accordance with a work plan. The act accords sufficient incentive to the people to conserve the forest resources. The forest act also incorporates a major disincentive to unsustained use of forest resources. The community forest can be taken back by the government.

Rules gazetted under the Forest Act and notified on Manseer 10, 2053 B.S. (25th November 1996 A.D.) These rules regulate the extraction of and trade in different species of plants. The notification prohibits the international transfer of the species mentioned below unless they are processed in Nepal and have obtained a certificate to that effect.

Jatamasi, *Nardostachys grandiflora*
Sarpa gandha, *Rauwolfia serpentina*
Sugandha kokila, *Cinnamomum glaucescens*
Sugandha bal, *Valeriana wallichii*
Jhyau, Lichens
Shilajeet, rock extract
Taalis Patra, *Abies spectabilis*
Laudh Salla, *Taxus baccata*

The collection of *Cordyceps* (a fungus variety), known as *Yersagumba* in Tibetan and used as an aphrodasiac, and of *Panch angula* (*Gymnadaenia orchidis*) is completely prohibited.

The Convention on International Trade in Endangered Species of Fauna and Wild Flora (CITES) imposes restrictions on trade for several species. *Taxus baccata* and the wild species of orchids fall into this category. Nepal allows export of cultivated orchids, but the Department of Plant Resources of HMG/Nepal, which acts as the management authority for CITES in Nepal, has to certify the origin of the cultivated orchids. Nepal, in order to protect its plant resources, is trying to promote the concept of export of plants in processed form only. This will serve as an economic incentive to people to cultivate certain species that have a commercial value, and the people of the country can also benefit from the value-addition through processing.

At this point it is important to note that countries should adopt long-term policies. I would like to highlight the example of a poor and short-sighted policy followed by the Government of India. A farmer, on recognising the value of (wild) *kuth* (*Saussuria costus*) in the world market, started to cultivate it on his farm. The crop brought good returns, and cultivation ensured the species was maintained. When the Indian Government put this plant on the list of endangered plants under the Wildlife Protection Act, 1972 (following the prohibitions imposed by CITES), it was the end of a good on-farm conservation effort. This could be the same as the case of *Yersagumba* in the high mountains of Nepal. This deprived the local community from their initiative of managing conservation with development..

The Export Policy of Nepal stipulates the need for licences for the export of products banned or qualitatively restricted as listed in Annexure 1 of the Trade Policy. This list includes protected wildlife and related articles such as wild animals, bile and any part of wild animals, musk, snake skin, and leopard skin (as per the provisions of the National Park and Wildlife Conservation Act). The list also includes plant species such as marijuana, opium, and hashish (as defined in the Single Convention on Narcotics 1961).

Nepal has not made any significant progress in the field of biotechnology. Yet the Department obtained a patent on two aromatic plant species ten years ago. The Patent provisions in Nepal are found under the primitive Patents, Design and Trademarks Act,1965. This act does not distinguish between a product and a process patent. In India, the patent act offers two kinds of patent - process and product. The Indian Patent Act allows only process patents and not product patent in the fields of agriculture, pharmaceuticals, and biotechnology. But, in Nepal, the law is not clear on the subject and no distinction is made between the two types of patent. *Sugandha kokila*, a plant species found in Western Nepal, was patented here 10 years ago for its aromatic properties which can be used in perfumes. The species, *Osmanthus*, was patented for the same property around the same time.

One important aspect that so far remains untouched by legislation in Nepal is Intellectual Property Rights and Farmers' Rights. With the creation of the WTO, it has become imperative for countries to protect their rights over intellectual property. The issue of Farmers' Rights also falls within the arena of Intellectual Property Rights. Farmers' Rights have been defined as *"rights arising from past, present, and future contributions of farmers to conserving, improving, and making available plant genetic resources"* (Swaminathan 1995). Supporters of Farmers' Rights contend that it is *"immoral to allow Plant Breeders' Rights over commercial crop varieties unless the international community also accepts Farmers' Rights over the crop varieties they have bred for their own fields"* (IDRC 1994). Breeders' Rights in the West are referred to as Plant Breeders' Rights as plant breeding is mostly done by the private sector. The position and rights of farmers as breeders are ignored. In the West big corporations are involved in plant breeding. This is precisely the reason for the actions and voices in developing countries against the notion of Breeders' Rights, as promoted by the UPOV provisions. The provisions of UPOV 1991 pose a threat to the farmers' right to save seed from one harvest to plant for the next one. Many farmers and NGOs fear that Plant Breeders' Rights granted to crop breeders under UPOV 1991 give a boost to Breeders' Rights at the expense of small and marginal farmers. Plant Breeders' Rights are property rights granted to crop breeders to give them exclusive rights over plant varieties they develop.

Nepal seems to be in no hurry to enact any legislation or formulate any policy regarding protection of Plant Breeders' Rights as HMG/Nepal is of the opinion that there is no threat of competition in the near future from any foreign multinational seed company to the breeders of Nepal; the farmers. The attitude is that the market isn't big enough yet to attract seed giants. However, TRIPs allows governments to legislate their own plant protection laws to provide the necessary protection to commercial varieties and to safeguard the interests of farmers and indigenous communities.

It is critical that the countries in the HKH region formulate suitable laws and regulations to protect the rights of traditional communities and provide for sharing of benefits with the rural and tribal farming communities. It is also necessary that the neighbouring countries in the region should have uniform laws in this regard – weaker laws in one country or lax enforcement could be detrimental to the conservation of genetic resources in the region.

This examination of Nepal's policies in the field of genetic biodiversity shows that the focus of the country's policies and strategies is on *in situ* wildlife conservation. The country still has to go a long way to frame laws and policies to conserve all its genetic material.

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Chapter 40

Incorporating the Intellectual Property Rights of Mountain Farmers over Native Crop Resources in the Agenda for Management of Mountain Agrobiodiversity

S. Sahai

The subject of Intellectual Property Rights (IPRs) over biological materials has become important in all kinds of bilateral and multilateral negotiations. The central issue is the fact that biotechnology will be the most dominant technology in the next twenty to thirty years. Bioresources, which are the raw material of biotechnology, are mostly located in developing countries. The industrial countries, which are strong on technology, have few bioresources. Forcing a harmonised IPR regime on developing countries through international negotiations is their way of gaining access to the bioresources they need in order to flourish in the field of biotechnology.

If companies with a stake in biotechnology procure the right to patent their products, whether plant-based medicines, neem-based pesticides, or wound-healing products derived from turmeric, in India, Nepal or Bhutan, then they will actually have acquired guaranteed access to certain medicinal plants, such as neem and turmeric, in these countries for the duration of the patent. In this way, the multinational patent holder will be able to control bioresources in developing countries. This will be facilitated by the requirement that all signatories to conventions such as the General Agreement on Trade and Tariffs (GATT)/World Trade Organization (WTO) and the Convention on Biological Diversity (CBD) must accept the patent/IPR laws determined by the industrial nations as the standard for these conventions.

Countries owning germplasm must be cautious about what kind of IPR regimes they accept. For these nations, genetic resources are not only the raw material of potential biotechnological applications, they are first and foremost the socioeconomic foundation of tribal and rural populations. Hill populations in countries like Nepal, India, and Bhutan that are the custodians of valuable knowledge about their biological resources must not be hindered in their potential to commercialise this knowledge in the expanding era of biotechnology. The opportunities that tribal and rural people have to engage in self-reliant growth based on their own skills must not be jeopardised by the overwhelming financial capacity of multinational companies.

In this context it is of utmost importance that the Hindu Kush-Himalayan countries – India, Nepal, Myanmar, Bangladesh, Pakistan, Bhutan, and China – work together to formulate a regional policy. This will strengthen the position of the Hindu Kush-Himalayan region as a germplasm rich centre, and no one country will be able to undermine the greater interests of the region. Genetic resources do not recognise political boundaries and the countries of the Hindu Kush-Himalayas have a similar distribution of bioresources. It should not be possible for one country to grant access to a particular germplasm if another country in the region has refused access to the same germplasm.

What needs to be done now is to understand the requirements of the GATT Trade Related Intellectual Property Rights' treaty (TRIPs) and the Convention of Biological Diversity (CBD). These are currently the two most important treaties dealing with the treatment of genetic resources and intellectual property regimes connected to them. Germplasm rich countries should formulate national legislation that will protect their interests to the maximum extent. This will be possible if nations demonstrate political will in taking firm positions on what is their most valuable natural resource. It is possible to draft strong national laws without actually contravening the internationally accepted conditions in the two treaties.

The Requirements of GATT/TRIPS

The Trade Related Intellectual Property Rights' (TRIPs) regime of GATT requires member nations to provide patent protection for micro-organisms and a *sui generis* system for plant varieties.

Our region should refuse to accept patents on micro-organisms. We should offer to accept patents on the products derived from the micro-organisms but not on the organisms themselves. In order to do this, we can call upon the clause of 'odre public' and morality. GATT/TRIPs has a provision that nations can refuse to bring under the purview of patents any products or processes that offend the sense of morality of their societies or goes against the public order ordained in these societies. We can claim that accepting the ownership of any agency other than God over living organisms offends the religious sensibility and sense of morality of our people (mountain communities in particular). The Europeans have successfully invoked these ethics clauses in the European Parliament and succeeded in getting the right to patent life forms struck down.

We should agree to the institution of a *sui generis* system for protecting new plant varieties. However, our *sui generis* system should not be modelled on Union for the Protection of New Varieties of Plants (UPOV), which is the European organization whose name, originally in French, translates into Union for the Protection of New Plant Varieties. The UPOV model has been developed for industrial countries, not agricultural nations such as those in our region.

UPOV recognises the rights of the breeder and rewards it with the Plant Breeders' Right (PBR). It does not recognise that the farmer has any rights, and it has no provision for acknowledging or, therefore, rewarding any contribution that the farmer makes to the development of new plant varieties.

UPOV in its 1978 version grants two exemptions to the Breeders' right over a new variety. One is the Farmers' Exemption which allowed farmers to save seed out of the harvest of the PBR protected seed for his next sowing. The second exemption, known as the Breeders' Exemption, allows other breeders the right to use the PBR protected variety as breeding material for the development of other varieties. The revised version of the UPOV treaty, which came into force in 1991, does away with both exemptions so that it is only the breeder who retains almost monopoly rights over a new variety, although other parties have contributed to its development in a major way.

It needs to be remembered that women and men in the mountains have not only created several thousand races of food and cash crops, they have also identified valuable genes and traits in these crops and maintained them over generations through a highly sophisticated system of crossing and selection. Mountain farming communities have not only developed complex systems of pest management and biological control, they have identified and managed a series of genes conferring valuable traits for commercial and domestic needs. So it is that genes for traits as diverse as disease resistance, high salt tolerance, resistance to water logging, and drought tolerance have been maintained in the repertoire of communities. Along with these commercial traits, characteristics such as cooking time, taste, digestibility, milling, and husking characteristics are recognised and maintained. Women, who have been the traditional custodians of seeds and are responsible for seed selection, are the repositories of this knowledge and, in the true sense, the owners of this complex seed technology and knowhow.

The farmers' work of genetic selection, maintenance, and crossbreeding is the result of innovative and creative scientific experimentation in the field. The work is in no way less than the scientific experimentation conducted by scientists on the experimental plots of agricultural research stations. We need to overcome the bias that most of us suffer from, that of acknowledging the research conducted by scientists in white coats working in laboratories of universities as 'science' and dismissing the complex knowledge systems contained in rustic, rural communities as something infinitely less and not worthy of acknowledgement.

The fact is that there would be no plant breeders in long white coats working on experimental farms if it were not for the prior knowledge gained from rural communities. Indigenous knowledge is not only the foundation of modern science in this and many other fields, it is also what could be described as the reference and referral centre for modern plant breeding. Today, faced with the threat of global warming and climate changes across agricultural zones, scientists are on the look out for crop varieties that are more heat tolerant. The scientists do not acquire information about the location of heat resistant wheat or millet varieties by sitting in their expensively appointed laboratories and meditating for guidance. They acquire this information by going to deserts and hot regions and asking local farming communities about the varieties that grow in that region that can withstand extreme heat. Armed with the benefits of indigenous knowledge, these scientists return to there labs and their experimental farms and engage in a breeding and selection programme that will result in the combination of traits that they seek to achieve in the new variety that is to be designed for post global warming agriculture.

If credit had to be apportioned for the breeding of a new crop variety, then it should be shared perhaps 70:30 or at the least 60:40 between the farming and scientific communities. One can say quite easily that, if the breeding of a crop variety entails 100 steps, then indigenous knowledge will have contributed the first 60 or 70 steps and laboratory science the next 30 or 40. It stands to reason, therefore, that credit, reward, and recognition for a new variety should be similarly shared. That is the reason why the claim to place Farmers' Rights on a par with Breeders' Rights is so natural. Farmers have a greater and more innovative share in the creation of new plant varieties than scientists. Their contributions must be recognised with at least the same degree of enthusiasm as, if not more than, that accorded to scientists.

In Europe and the USA where UPOV operates, farmers constitute no more than two to seven per cent of the population. In our countries, they constitute more than 70 per cent of the population. In UPOV nations, farmers are rich and receive huge subsidies to keep their fields fallow in order to keep down the volume of surplus food produced. In our countries, a large percentage of the farming community has small land holdings and practices subsistence agriculture.

UPOV nations have ensured their food security over time. Our region still has to struggle to achieve food security. In the countries of the west, not only is the agricultural profile different, the research to develop new varieties and production of seed is also conducted very differently. In India and its neighbouring countries, agricultural research is conducted by scientists in universities and public institutions. This research is financed by taxpayers' money and public grants. Research exists in the public domain. In UPOV nations, on the other hand, most of the research needed to produce new varieties is conducted by private companies. This privately-funded research belongs to the company and is not in the public domain.

Similarly, seed production in UPOV nations is the exclusive domain of the company that has developed the new variety. It is the only agency that can produce and market the seeds of the new variety. That is precisely the right conferred by the Plant Breeders' Rights granted to individual breeders or the company under the UPOV system. In India, seed production and sale are largely in the hands of farmers. Although the National and State Seed Corporations had been envisioned for this task, it is performed much more efficiently by the farmers themselves. Today, farmers provide over 82 per cent of the total annual requirement of more than 6,000,000 tons of seed in India.

Clearly, the compulsions and needs of UPOV nations are vastly different to the needs of the nations in our region. Having established this, we need to specify the components that should go into the *sui generis* system that we give ourselves.

Our system should place Farmers' Rights on a par with Breeders' Rights. Our regional policy should clearly make the grant of Breeders' Rights reciprocal to the grant of Farmers' Rights.

We should affix a fee for the use of germplasm from the region. If disease resistant genes are used for vegetables or drought resistant genes used for cereals, then breeders and seed companies should pay for the use of these genes. No distinction should be made between foreign and local seed companies. Anyone using germplasm that has been maintained by communities (and this includes the germplasm collected from farmers' fields and now banked in the CGIAR system) should pay into a Community Gene Fund. Money obtained from Farmers' Rights, from the fee for gene use, or for the use of indigenous knowledge about certain kinds of germplasm, such as medicinal plants, should be paid into a Regional Gene Fund for the community. This money could be used for the conservation of the region's genetic resources as well as for other needs that the community may have, such as a primary school or health care centre.

It is often said that it is difficult to compute the fee that can be charged for gene use. This is not true. There are several indices that can serve as the baseline from which to compute the values of genes. For instance, the US Department of Agriculture once put out a figure that germplasm import had benefitted American agriculture to the tune of 70 billion dollars. Since the genes and their countries of origin are documented in such cases, it should not be difficult to calculate what was owed to which country for the use of its genes. Similarly, some years ago, the California musk melon crop was threatened by a fungal rot. Scientists brought in disease resistant genes from India and saved the California musk melon industry worth millions of dollars. Some percentage of the profits made by California from the import of the resistant musk melon genes could be the fee payable for the use of the resistant genes.

Requirements of CBD

The Convention on Biological Diversity rectifies a historical wrong. It reverses the principles of Common Heritage of Mankind according to which the genetic resources of the world belonged to everyone and not particularly to the nations in which they were found. Now CBD has acknowledged the principle of ownership according to which genetic resources are recognised to be the property of those nations in whose sovereign territories they are located. In addition, CBD lays down two other conditions of great importance to germplasm owning countries. These are the ones on Prior Informed Consent and Material and Information Transfer Agreements with respect to the transfer of genetic resources from owner countries to countries/companies/individuals that want to use these resources.

The clause of Prior Informed Consent states that parties wanting to use genetic resources must first take the permission of the relevant authority in the owner country. Material and Information Transfer Agreements are to govern the conditions under which these resources will be transferred to the user party. These conditions could, for instance, lay down such things as the fee that will be levied for bioprospecting whether or not a product is developed, the basis of profit sharing from products developed, whether such products can be brought under the purview of IPRs or not, and the royalties payable to individuals or communities for the use of indigenous knowledge.

Although the Biodiversity Convention was ratified in December 1993, our countries have yet to formulate laws that will allow the conditions of the CBD to come into force. We must pass these laws immediately in the form of domestic legislation that will allow us to protect our biodiversity and indigenous knowledge from marauding corporate giants who, at present, can take advantage of the legal limbo and transfer our genetic material without proper agreements. Today even when foreign nationals are apprehended at airports carrying genetic material such as seeds, oil samples carrying micro-organisms, or butterflies and insects in their suitcases, it is difficult to proceed against them if the samples are not on the endangered or prohibited list. Unless ownership rights are established over genetic resources, they remain the Common Heritage of Mankind and their transfer cannot be considered illegal.

Three new laws have to be formulated for the CBD. These are (i) to establish ownership rights over the biological resources found in the sovereign territories of each of the countries of the region; (ii) to formulate the guidelines and structures for Prior Informed Consent according to which user parties will have to seek the permission of some kind of National Authority authorised to grant or refuse access to genetic resources; (representatives of the communities that have been responsible for maintaining genetic resources over generations and are the repositories of indigenous knowledge should be members of such a National Authority); and (iii) To lay down the conditions for Material and Information Transfer Agreements so that the use of biological resources is just, equitable, and sustainable. This law would seek to ensure that indigenous communities are not denied their share of the profits that accrue from the commercial exploitation of the genetic resources that they have conserved.

The question of Intellectual Property Rights will have to be addressed in the CBD, although indirectly. Our position should be that India will not grant IPR protection over products and processes derived from indigenous knowledge. The rationale for this is that knowledge that belongs to communities should not be privatised. Whereas this knowledge can and should be used for commercial exploitation and the betterment of communities, it should not be monopolised.

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Participating Countries of the Hindu Kush-Himalayan Region

- Afghanistan
- Bangladesh
- Bhutan
- China
- India
- Myanmar
- Nepal
- Pakistan

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