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mountain biodiversity at risk

threats to knowledge from high places

BY JEAN-MARC FLEURY

A farmer lived in the mountains, another on the plain. The plainsman, in the forefront of all that was modern, swapped all his seeds for ones they said were better. The mountain man kept planting his same old seeds. How backward can you get!

And then one day, the crops in the plain just died. And so, to the mountain man, the valley dweller a-begging went. For treasures lay hidden in that rustic's seeds: treasures to give everyone a better life.

(A modern fable)

Twenty-some plants supply 80 per cent of humanity's food. Six of them, maize, potatoes, barley, sorghum, apples and tomatoes, originated in mountain areas. Seven others, wheat, rice, beans, oats, grapes, oranges and rye found new homes in the mountains and evolved into many different varieties. Diversification continues to thrive in the mountains of Africa, Latin America and the Himalayas, where farmers cultivate a multitude of traditional forms of these plants. This is fortunate for us all.

Down on the plains, the many "varieties of the land," which were the source of such pride for entire villages are only souvenirs. The diminishing number of agricultural varieties grown on the Earth's plains is worrisome. There, farmers now grow mostly the same few identical types of wheat, rice and potatoes. Every time a virus or a fungus finds a weak spot, there is a literal killing field of crops. Modern, high-yield varieties constantly need to be reinforced with genes resistant to some new fungal or viral disease. Often, the genes that provide resistance to these new diseases can be found among traditional, mountain-growing species.

"Two hundred years ago, plant diversity in plains and mountains was much more comparable," says Joachim Voss, Research Manager at IDRC. "But there were probably always more varieties in mountains than in plains since conditions are more uniform in plains. One of the reasons for so much diversity high up is because there are so many different micro-environments."

Differences in altitude, sun exposure, rainfall and soils make a unique environment of each valley, slope and plateau. And different varieties adapt to these different environments.

Today, 10,000 years after the invention of agriculture, much of agricultural plant biodiversity no longer exists in the plains. Instead, it has found refuge in the mountains. The question is: *How long can it continue to hold out?*

In Central Africa, farmers grow up to 30 different varieties of beans in the same field. (Photo Joachim Voss)

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The potato first appeared in the Peruvian Andes, corn in the sierras of Mexico, and coffee and sorghum in the high Ethiopian plateaus. For millennia, our ancestors who farmed the plains or the mountains grew, selected, transported and traded plants. They shaped them to meet their needs and the demands of the environments in which they lived. The most useful plants were propagated across other continents, where they became even more diversified.

It is estimated that it takes only three to five centuries for a new centre of diversification to come into being. The Himalayas, where corn and potatoes were introduced at about the same time as in Europe, have become a secondary centre of diversity for these crops. This means maize and potato varieties can be found there that do not exist in Europe or in the Americas.

For example, the Hindu Kush-Himalayan region has become a secondary centre of diversity, or has been the centre of origin, of some 50 species of vegetables, and 30 species of spices and condiments. Agri-cultural diversity and cultural diversity go hand-in-hand. Each of the region's many ethnic groups grows its own particular assortment of varieties. In some areas, domestication of wild plants continues to add to agricultural biodiversity. For example, the Lepcha people of Sikkim share, with their Nepalese and Bhutanese neighbors, giant cardamom fruit they pick from among the wild varieties that grow in their mountains. These brand-new domesticated varieties of this popular spice require no fertilizer and sell for a good price.

Diversity is the building block of agricultural systems in marginal environments.

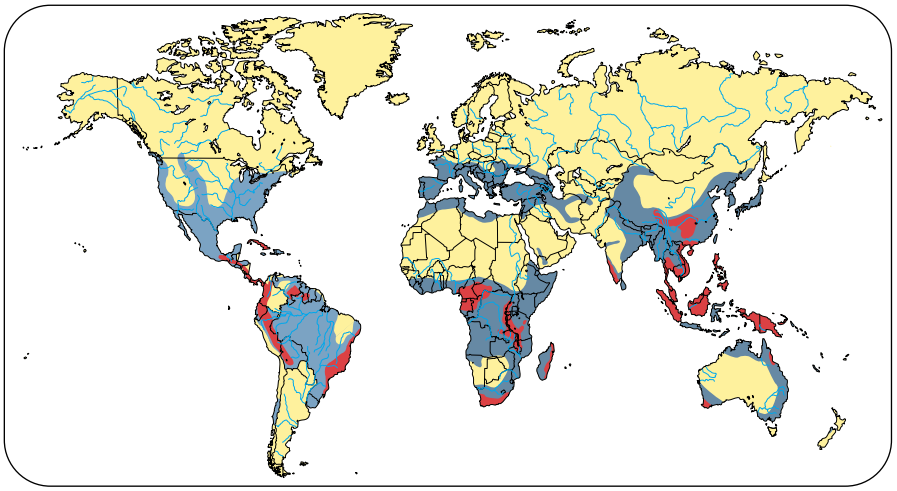
The inhabitants of temperate countries owe an enormous debt to farmers in tropical mountain areas. The tropics teem with biodiversity, but it is their mountain plants that have proved most successful in adapting to the plains of temperate Western countries.

Christopher Columbus learned this first-hand. As a result of his second voyage in 1493, he became the first person to introduce maize to Europe. The transplantation of that corn from the low-lying Caribbean Islands was unsuccessful. But two decades later, corn taken from the high plateaus of Mexico and Guatemala produced the first good harvests in Europe.

In the Andes, farmers grow up to 50 different kinds of potatoes to take advantage of subtle differences in the climatic and soil conditions of mountain ecosystems.

"In the mountains of Rwanda, Burundi and Kivu (Congo-Kimshasa)," says Voss, "farmers nearly always cultivate beans as populations of several varieties, between six and up to 30 varieties in the same field."

"The widespread cultivation strategy of growing whole populations of varieties in mountain areas is not only a result of the variety of environments, but is also demanded by climatic conditions. It reduces the climatic risk. Farmers say: 'At least, there will be a few varieties that will survive if the season is drier or wetter than normal.'"



Mountain ecoregions are exceptionally rich in biodiversity

Number of species per 10.000 km²

< 1 - 1000 | < 1000 - 3000 | < 3000 - 5000

Map of Mountain Biodiversity adapted from Mountains of the World, pp. 18 and 19

Voss, an anthropologist who worked for many years among the farmers of Central Africa, continues. "Such a strategy also protects crops from a range of pathogens. Farmers there don't use pesticides or fungicides and you hardly see any fields badly damaged by disease."

Miguel Altieri of the University of California (Berkeley) and Camila Montecinos of the Centro de Educacion y Tecnologia de Santiago (Chile) have established that, throughout Latin America, biodiversity increases with altitude. In Peru's Mantaro Valley, 87 per cent of lowland farmers plant modern, high-yield potato varieties, whereas in the upper Mantaro, farmers hold onto their numerous traditional varieties; a mere two per cent of farmers have adopted the modern varieties. In Nepal, farmers in villages at higher elevations also rely exclusively on their many traditional species.

Throughout the world, marginal environments, like semi-arid areas and mountains, are conducive to greater biodiversity. In return, "diversity is the building block of agricultural systems in marginal environments," says Daniel Buckles, Program Officer with IDRC. "People use this diversity to create integrated and robust ways of producing food."

Refuges of last resort for agrobiodiversity, mountains also continue creating new biodiversity. The precursors of today's potatoes and corn still exist in a wild state in the South American high altitude plateaus and mountains. Andean farmers often tolerate these undomesticated ancestral plants even in their own fields. They encourage cross-fertilization between domesticated and wild varieties resulting in new varieties and increased biodiversity.

The same cross-fertilization between wild and domesticated varieties is observed in Ethiopia for sorghum. And, in the beans fields of Central Africa, the rate of cross-fertilization among the numerous different varieties sharing the same plot of land is approximately four percent. "Beans with new characteristics appear and farmers plant them separately to document their characteristics," observes Voss.

Of these 75 traditional varieties inventoried in the Pokhara Valley, 17 have been lost.

In the Himalayas, domestic and wild varieties of lemon, orange and mango trees often grow side-by-side. Wild and domestic trees fertilize each other, blending their genes and supporting increased biodiversity.

Since the 19th century, the world's seeds have been systematically collected. They represent a kind of 'still life' of the world's agrobiodiversity, refrigerated and dehydrated in gene banks, mostly located in the plains. On the other hand, the agricultural biodiversity found in the mountains lives, evolves and continues to diversify.

Now, *in situ* conservation (the conservation of varieties in farmers' fields) is threatened by modern agriculture practices," says Anil Subedi, Director of LI-BIRD, a Nepalese NGO dedicated to the preservation of agrobiodiversity. "All the efforts are focused on modern varieties. Even the research system has not given due consideration to the utilization of local genetic materials.

The genetic resources vital to the improvement of modern varieties are mostly found in human-altered ecosystems, rather than in untouched natural ecosystems.

"On one hand, there is a continuing selection by the environment; on the other, sociocultural and socioeconomic factors are also affecting the selection process," says Subedi.

Nepal, a quintessential mountain environment, has more than 2,000 indigenous varieties of rice alone, including many of the famous aromatic basmati type.

"Of these 75 traditional varieties inventoried in the Pokhara Valley, 17 have been lost, that the peasants can recall," says Subedi. "There are another 47 whose areas of cultivation have shrunk so much that they are in the process of being lost." Some of these are unique to Nepal. Japanese tourists know how valuable they are; they carry them back home in their luggage.

PLANTS ORIGINATING IN MOUNTAIN AREAS

region	centre of origin	secondary centre of origin
Andes	potatoes, maize, teosinte, tomatoes, amaranth, quinoa, peanuts, cocoa, lupin, beans, cotton	bananas
Central Africa		beans, bananas, sweet potato
Ethiopia	sorghum, coffee, teff, sesame, castor oil, chick peas, ensete, niger	barley, durum wheat, flax, lentils
Hindu Kush-Himalaya	carrots, mustard, gooseberries, apples, pears, apricots, oranges, lemons, cardamom	barley, rice, rye, wheat

Nepal is also home to many indigenous species of mustards, gourds, pumpkins, cucumbers, tomatoes, peppers, garlics and cowpeas. But as a result of a burgeoning commercial seed distribution network in Nepal, the native vegetable gene pool is being drained. In the Pokhara region, despite a very strong farming tradition, LI-BIRD has noted the disappearance of types of cucumbers, pumpkins, gourds and peppers while varieties of tomatoes, mustards and radishes are quickly vanishing, as well.

In Mexico and Guatemala, teosinte, a distant ancestor of corn, overlaps the mountainous regions where corn originated. Traditional and wild varieties of teosinte have been disappearing at an alarming rate. In 1991, Garrison Wilkes of the University of Massachusetts, returning to areas he had visited

vox populi

"We have been testing the new varieties (which resulted from cross-fertilization with M-3) for three years. Out of many varieties tested, there were some good ones, there were some bad ones. But we have faced a problem. Last year, there were hailstones which made the grains fall. So we want a crop variety which does not lose its grains before the harvest. We obtained those new varieties. And this year it was hard to separate the grains from the stalks."

The Srijanshil Mothers' Group, Marangche (Nepal). (Photo JM Fleury)

30 years earlier, noted the disappearance of 75-90 per cent of the ancestors of today's corn.

"In the eastern Himalayas," says Barun Gurung, an anthropologist with the NGO Resources Nepal in Kathmandu, "I guarantee you, the most distinct division of labor is in terms of management of genetic resources. You can go and ask any man detailed questions about how genetic resources are managed. They will tell you: 'Go ask the women.'"

While researching agrobiodiversity, ethnicity and gender interrelations, Gurung met farmers who, even though they were also school teachers (as commonly occurs in those regions) admitted sheepishly that it is their wives who know all about seeds. Among most mountain communities, the women are guardians of the seeds.

Timothy Reeves, Director-General of the International Maize and Wheat Improvement Centre (CIMMYT) in Mexico, explains that when specialists ask Mexican farmers to choose the best maizes, men look for those with the highest yields. The women, on the other hand, use several criteria, one of which is yield.

Both men and women are knowledgeable about the numerous characteristics of the plants they grow: How much work is needed to protect them from weeds, how susceptible they are to disease and insects, how easy they are to harvest, thresh, store, mill and cook (not to mention how they taste). As it is, the women who have the greatest responsibilities for these tasks have the most to gain or lose. They are the guardians of agrobiodiversity.

While the urgency of conserving handfuls of seeds in the controlled environments of gene banks, or *ex situ* conservation, is generally accepted, some experts strongly support the maintenance of genetic diversity *in situ*.

"Conservation for the sake of conservation does not make sense," says Subedi. "When it comes down to agriculture, it is the community which has been experimenting for a long time with different crops, trying to find a suitable crop or variety, that does best in that particular environment.

Among most mountain communities, the women are guardians of the seeds.

Our participatory approach to improvement consists in using one of the indigenous varieties as a parent (crossed with a high-yield variety) and testing it (the resulting crossbred) in their own fields. We are thereby retaining the good characteristics of the existing indigenous plants while introducing good genetic characteristics from exotic parents."

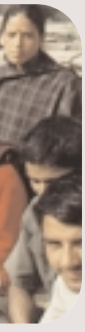
In the early 1990s, Nepalese farmers began to use the first varieties from participatory improvement of a native rice crossed with a high-yield rice from Japan. One of these varieties bears the name of the most spectacular Himalayan summit visible from Pokhara – the Machhapuchhare (Tail of the Fish).

This best variety, Machhapuchhare-3, was even distributed by the government, something unprecedented in participatory crop improvement. However, the farmers from around Pokhara found that M-3 rice lost its grains too easily when it ripened. In collaboration with LI-BIRD, they decided to improve it.

"We have kept some varieties that were hard to thresh and we will watch to see what happens."

"It would be easier for us just to plant only the recommended seeds. Although we have not yet seen the final results, we think it will work."

— Radhika Paudel, president of the Srijanshil Mothers' Group, in the village of Marangche (north-west of Pokhara)



"We have experimented with some of the new varieties. The experience so far is that our varieties are good. Although the new varieties produce more, they are not good in taste, not good in straw. They need chemical fertilizers which we cannot afford."

"We do worry about any possible loss of local crop varieties. And there have been some cases where there have been already some losses. We realize that we must conserve not only the seeds, but also the social aspects. Even if we grow new seeds, we hold on to the local ones. If we lose our varieties, we will regret that they are lost. If they are all lost, we will be even more regretful."

Ms. Sumitra Tiwari (fifth from left) and colleagues, near Begnas (Nepal). (Photo JM Fleury)

"In the past, we used to have maize crops that provided us with good harvests. The plants were tall and strong. Our parents would leash animals to the stalks. Now, these new varieties do not produce well. We are confused."

— Sumitra Tiwari, near Begnas (east of Pokhara)

"I am specifically in charge of the seed nursery, transplanting, weeding, harvesting, drying, storage, seeds selection, milling and cooking."

— Yog Maya Paudel, a woman farmer in the village of Leknath

what IDRC is doing

IDRC supports many initiatives designed to maintain the exceptional agrobiodiversity of the mountain regions. For example, it has funded some of the LI-BIRD work described above. In the same vein, IDRC supports the Community Biodiversity Development and Conservation Network, created in 1994, and which has, among its many activities, funded work by Miguel Altieri and Camila Montecinos. The Centre also supports the research of Barung Gurung in the Himalayan region. And it is a partner with CIMMYT to discover which criteria farmers use to base their selection of crop varieties.

All IDRC-supported activities aimed at preserving agrobiodiversity in the mountains are part of a coherent research strategy: Finding how to reconcile the improvement of crop yields of poor farmers with the conservation of biodiversity.

IDRC focuses its support on the complex farming systems of the small farmers living in marginal areas – hills, mountains, high plateaus (and coastal zones). These marginal areas are a priority for the Centre as they include a relatively high proportion of the world's poor. They are also rather fragile environments, even though they can be made quite productive. And their biodiversity is precious.

Many researchers, with IDRC support, are looking for the best means to help marginal farmers and their families who are continuing to preserve agricultural biodiversity. One approach developed by Salvatorre Ceccarelli, of the International Centre for Agriculture Research on the Dry Areas (ICARDA) in Aleppo (Syria), seems promising. Instead of looking at marginal zones as problem areas, this approach establishes synergy between a highly diversified environment and the increased biodiversity. It promises to turn mountains into even greater engines of agricultural biodiversity.

According to Ceccarelli, if an area is characterized by great environmental variability, it is better to provide it with many different varieties (of potatoes, for example).

Mr. Tiwari's 30-year old mandarin tree is still thriving while new trees are dying.
(Photo JM Fleury)

Each micro-environment will eventually adopt the variety best-suited for its specific conditions. Instead of investing their energy on trying to find THE best variety, plant breeders should facilitate the farmers' access to whole series of varieties. The farmers themselves will then select the varieties that match their unique conditions.

"This is a very sensible approach for scientists who wish to answer the needs of farmers living in marginal areas while preserving biodiversity," says Voss. "At the end of the 1800s, on its own, Japan managed to obtain rice yields that compare with those now reached in Malaysia thanks to the Green Revolution. Across the country, they put in place a system that encouraged local crop variety improvement. They also set up a mechanism that promoted the exchange of varieties between groups of five families. With this strategy, they doubled their rice yields in 20 years."

key facts

- Six of the 20 plants that supply 80 percent of humanity's food originated in mountains;
- Diversification, the creation of new varieties, continues in mountain areas;
- Mountain food plants from the Tropics have adapted more easily in the plains of temperate Western countries than plants from low-lying tropical areas;
- In the mountains of Central Africa, farmers grow between six and 30 different varieties of beans in the same field;
- Marginal environments, like semi-arid areas and mountains, are conducive to greater biodiversity;
- In many mountain areas, cross-fertilization between domestic and wild varieties of food crops continues to occur and new varieties are produced;
- Nepal farmers cultivate approximately 2,000 different varieties of rice, but in the Pokhara Valley, out of 75 varieties known by farmers, 17 have been lost and 47 are threatened;
- In many mountain areas, the women are the guardians of agricultural biodiversity;
- Diversified marginal environments need and can increase biodiversity;
- The poorest farmers in the world are the ones with the richest agricultural biodiversity.

resources

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IDRC (Biodiversity) http://www.idrc.ca/biodiversity

LI-BIRD (Local Initiatives for Biodiversity, Research and Development) http://www.panasia.org.sg/nepalnet/libird/libirdprofile.htm

ICIMOD (International Centre for Integrated Mountain Development) http://www.south-asia.com/icimod.htm

CIMMYT (International Maize and Wheat Improvement Centre) http://www.cimmyt.cgiar.org/

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Convention on Biological Diversity http://www.biodiv.org/ Claire Thompson (1994)

Mountain Forum Group Discussion http://www.mtnforum.org/mtnforum/survey/survey.htm#top

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