Sustainable Hillside Agriculture in Colombia

by Ronnie Vernooy

Colombian hillside farmer participates in conservation research (Photo: Ronnie Vernooy)

On hillsides across Latin America, small-scale farmers face severe problems of land degradation and decreasing yields as a result of deforestation, overgrazing, and overexploitation of the available land base. Experience has shown that a concerted effort is required to deal with the different problems of unsustainable land-use, which range from soil depletion and soil erosion to dwindling water and tree resources.

Several soil-conservation methods have been developed, including planting hedgerows, alley cropping, plowing contour lines and terraces, the use of covercrops, and the tilling of crop residues into the soil. However, the successful adoption of such solutions by hillside farmers ultimately depends on the creation of suitable incentives and a favourable policy environment. Meaningful involvement of the people who are directly or indirectly affected by the degradation of natural resources is essential to any initiative that aims to improve their lives.

These key insights are the basis for the Hillsides Program, an action-oriented initiative coordinated by the International Centre for Tropical Agriculture (CIAT) in Cali, Colombia. Sponsored by IDRC, the program aims to improve the livelihood of poor hillside farmers and the sustainability of the natural resource base upon which they rely.

These twin goals are being pursued through community-based, participatory research and development at research sites in Colombia, Honduras, and Nicaragua. According to Douglas Pachico, CIAT's Director of Strategic Planning, the program's multistakeholder approach and focus on community organization

represents a step beyond both "traditional" crops research and farming systems research.

The Hillsides Program involves a variety of watersheds, including the Ovejas River-Cabuyal Basin, located about 75 kilometres southeast of Cali. This watershed covers some 7,000 hectares of land at altitudes ranging from 1,100 to 2,200 metres above sea-level. Most of the watershed's 6,500 inhabitants tend small farms on steep, degraded slopes. In addition to environmental problems, they face economic hardship, a lack of services such as education, health, and credit, and a lack of agricultural infrastructure.

Ecologically sound technologies

One of the program's objectives is to identify ecologically sound technologies that use resources more efficiently. The program also attempts to design effective strategies for implementing technological solutions that will improve resource management and the livelihoods of local farmers.

Under the program, researchers are examining watersheds from several perspectives including their biophysical, geographical, and socioeconomic characteristics. Most watersheds include a mix of commonly owned and privately owned natural resources that are used by people living both inside and outside the watershed. Case studies are under way in areas that represent a range of watershed types. The analytical methods being developed should, therefore, be relevant over a large geographical level, says Jacqueline Ashby, a rural sociologist and coleader of the Hillsides Program.

Ashby and her colleagues are combining biophysical and socioeconomic research at the field, farm, community, and watershed levels. The Hillsides Program has developed a community resource mapping tool — a three-dimensional physical model of the Cabuyal Watershed — for analytical, awareness-raising, and training purposes. This tool helps community members understand both what a watershed is and how it functions, and can be used to map land-use patterns and problems. It is also useful for setting resource management priorities. Local farmers played a key role in developing the model, which illustrates significant patterns of soil use and degradation resulting from erosion and deforestation.

Basket of technologies

In the village of Pescador, Colombia, researchers are offering local farmers a variety of land-improvement and production-boosting options, which they can adapt to local conditions — for example, different altitudes, soils, and nutrient levels. This "basket of technologies" includes improved varieties of cassava, maize, legumes, fruits, forage crops, and covercrops, as well as upland rice varieties imported from Madagascar by CIAT.

So far, the new plant varieties have been offered to farmers on an informal basis, although a more systematic approach of technology transfer is being planned. The aim is to foster a decentralized, demand-driven approach to research and development activities. To achieve this, the team is scheduling regular meetings with farmers to increase their involvement in designing, monitoring, and evaluating the experiments under way, and is encouraging more visits and interaction with resource-poor farmers, including women.

For its part, the farming community has set up agricultural research committees to select and test the available technologies, and adapt them to their own circumstances. The ultimate goal is to get farmers more involved in setting the agendas of agricultural research and extension agencies. Greater community involvement may ultimately lead to a larger selection of technologies to choose from, increased adoption rates, and higher farming incomes.

Participation and consensus building

To develop a common agenda for the sustainable management of the watershed's natural resource base, the

Hillsides Program is bringing together key stakeholders through CIPASLA, a consortium of 14 government and nongovernment organizations. So far, CIPASLA has financed more than a dozen projects on reforestation, the use of organic fertilizers, biological disease control methods, the establishment of rural agroindustries, and the documentation of local values and culture concerning natural resources.

CIPASLA members strongly believe that the best way to achieve their goals is through the sharing of ideas and resources. To ensure that community members have a stake in the success of CIPASLA projects, local communities are required to match the financial and labour contributions made by the consortium and other institutions. This approach has caught the attention of the Government of Colombia, which has contributed US$50,000 to CIPASLA.

Next Steps

Since its launch in 1993, the Hillsides Program has made considerable progress. "A lot has changed already. We are making some profits right now. Corn and cassava yields have been good," notes one farmer in the Cabuyal Watershed.

The priorities now are to increase the level of face-to-face interaction and information sharing among those involved in research and development activities, outside researchers, policymakers, and community members. For example, the establishment of improved links with government would strengthen the research and agriculture extension base, improve local farmers' access to tools and resources, and create stronger R&D-policy linkages. Similarly, stronger links with Latin American universities would help broaden and diversify the research base and strengthen the national research capacity. This may eventually allow CIAT to withdraw from its role in designing and executing the research agenda.

Once CIPASLA has matured as an organization, the consortium may take on the role of screening, approving or rejecting development projects proposed by government and nongovernment organizations. The ultimate aim is to avoid duplication of efforts and the implementation of conflicting agendas and scenarios.

Ronnie Vernooy is a senior program officer at IDRC.

Resource Persons

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Andean farming for present and future *A farming systems approach and working closely with small farmers in Peru's Andean Highlands offers alternatives for sustainable production and higher family*

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Additional Resources:

"Institutionalizing farmer participation in adaptive technology testing with the "Local Agricultural Research Committees" (CIALs)" Jacqueline Ashby, Teresa Garcia, Maria del Pilar Guerrero, Carlos Arturo Quiroz, José Ignacio Roa and Jorge Alonso Beltran. Cali, Colombia: CIAT, 1995

"Institutionalizing participatory, client-driven research and technology development in agriculture" Jacqueline Ashby and Louise Sperling. Development and Change, Vol. 26, 1995: pp. 753-770

Hillsides Program Annual Report 1993-1994. Cali, Colombia: CIAT, 1995.

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Octubre 2003

Breeding a Better Bean: The Horizontal Resistance Approach

by Douglas Powell

Mexican farmers: sowing seed

Researchers in Mexico and Canada have dramatically boosted the yield of a major Mexican food crop using an unconventional breeding technique that harnesses the power of multiple resistance genes to protect against a range of plant pathogens.

Using horizontal resistance breeding, scientists from the Colegio de Postgraduados in Montecillos, east of Mexico City, — in partnership with the University of Guelph in Canada — have more than tripled the yield of locally grown black beans — without the help of pesticides.

Different Kinds of Resistance

In 1963, J.E. Vanderplank, a South African plant pathologist, coined the terms "horizontal" and "vertical" resistance to describe the different kinds of genetic resistance found in crop plants. Vertical resistance, which involves a single gene, is a temporary form of genetic resistance that breaks down as new pathogens appear on the scene. Horizontal resistance, which involves many genes, is a more durable form of resistance to disease or insects.

To protect crop plants from parasites, most breeders use classic Mendelian breeding techniques to transfer a single gene from a wild plant into a cultivar (cultivated variety), a process that enhances its vertical resistance. This involves crossing a wild plant with a cultivar to generate a hybrid variety, then backcrossing the hybrid offspring with the cultivar parent for several generations until the hybrid is identical to the cultivar but carries the wild parent's resistance gene.

Failed Objectives

> "[Unfortunately], when plants are being bred for vertical resistance, or they are being bred [to improve] yield and crop quality under the protection of insecticides and fungicides, the level of horizontal resistance tends to decline," says Raoul Robinson, a Canadian crop scientist and member of the IDRC-supported plant breeding team. "We have actually been increasing the susceptibility of many of our crops to their parasites. Most of the [vertical] resistance breeding programs of the twentieth century have totally failed to achieve their original objectives."

Since 1991, Dr Robinson has worked with Dr Roberto García Espinosa, the Mexican project manager, to attempt horizontal resistance breeding in black beans — a process in which the best individuals from each generation are selected and bred with each other. After only two breeding cycles, each cycle lasting about a year in duration, the team achieved yields of 1,500 kilograms per hectare **without using pesticides**. For comparison, the average bean yield in the Mixteca region of Mexico is 400 kilograms per hectare **using pesticides**. This is good news for the approximately 200,000 small-scale farmers in the area, who cultivate over 300,000 hectares, of which 40,000 are beans. Moreover, the breeding techniques developed in Mexico can be used almost anywhere and on most kinds of crops.

"Return to Resistance"

Dr Robinson is the author of *Return to Resistance*, which features a how-to guide for amateur plant breeders interested in selecting for horizontal resistance. In addition, he helped to establish the world's first horizontal breeding club at Universidad Autonoma de Chapingo in March 1995. To date, its 76 members have collected more than 3,000 bean varieties from all over Mexico and are considering launching additional clubs for breeding potatoes, wheat, onions, and peanuts.

Douglas Powell is the Science and Society professor at the universities of Guelph and Waterloo.

Resource Persons:

Dr Raoul Robinson, 445 Provost Lane, Fergus, Ontario N1M 2N3, Canada; Tel: (519) 843-2355; Fax: (519) 837-0254; E-mail: raoulrob@sentex.net; Internet Homepage: http://www.mother.com/agaccess/Raoul.html

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> Horizontal Resistance and the Potato Blight Fungus *Horizontal resistance breeding was first used to breed potato varieties that could withstand the most severe epidemics of potato blight.*
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Additional resources:

Breeding for Resistance: Stages

Plant Breeding Clubs

Review of Raoul Robinson's *Return to Resistance*

Cooperative Research Centre for Tropical Pest Management Internet site

IPM (Integrated Pest Management) Net Internet site

National Integrated Pest Management Network Internet site

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Integrated Pest Management for Colombian Small Farmers

by David Mowbray

Integrated Pest Management (IPM) test plot in Colombia

Gerardo Sota farms on some of the most difficult terrain on earth -- the precipitous slopes of the Andes mountains in Colombia. No farm machine can negotiate the steep hillsides and narrow furrows. Every carefully terraced row must be plowed by hand. Every bean pod, ear of corn, or potato that grows is picked or dug by hand. He, his sons, and now his grandsons work year-round to keep their hectare-and-a-half farm productive.

Despite the demanding conditions for farming, Sota loves his land. To him, every square metre is precious and, if treated well, will give something back. "Agriculture is my profession," Sota explains. "My father taught me how to farm the land. Farming is what I most like doing."

Staple Food

Sota grows potatoes, carrots, corn, and -- most importantly -- beans. Beans are a vital food crop in the Andean region of South America. In Colombia, Ecuador, and Peru, beans provide both calories and protein in the diets of the rural poor. Many Andean families eat beans three times a day. By the turn of the century, demand is expected to exceed supply by 30%. Beans have been grown in rotation with corn on the mountain slopes for thousands of years. The stalks left from the harvested corn form climbing poles for the beans. The nodules on the bean roots take nitrogen from the air to fertilize the soil for the next corn crop.

Gerardo Sota had always farmed without using chemical pesticides. More than 20 years ago, his father had warned him of their dangers. For years, he saw no need for them. But 15 years ago, the situation changed. "I started to use them ever since I lost a bean crop," he recalls. "The crop was attacked by a pest. The

beans had already developed pods and suddenly that pest attacked. The pods turned black."

Vicious Cycle

Sota lost his crop and any chance of making ends meet that year. He determined never to let it happen again, deciding that the risk of sickness from the insect spray was worth it. Now Sota and the other bean farmers of the Andean region are caught in a vicious cycle of ever increasing pesticide use.

The indiscriminate use of the sprays killed not only the pests but beneficial insects too. As a result, what had been insignificant pests, such as the leafminer, were left with no natural enemies and began devastating bean crops. So farmers had to spray more. Today, in some bean-growing areas of the Andes farmers spray every week.

> "We farmers have a fault," explains Sota. "If we see that a tablespoonful works to kill the insects, then we say, 'Well let's add another tablespoonful so it will be even more effective!'"

Cause for Alarm

Practices such as these were alarming Dr Cesar Cardona, an entomologist at CIAT, the International Centre for Tropical Agriculture based in Cali, Colombia. "We detected a very serious situation of insecticide abuse among small bean farmers in the Andes of Colombia, Ecuador, and Peru. We found that the levels are extremely high, that the crop is becoming uneconomic because of the excessive use of chemicals," Cardona says.

In the past, Cardona himself had advocated the use of pesticides to improve crop yields. "I was trained to use pesticides 20 or 25 years ago. I did it for a while but I have been convinced that we can produce safer products at lower cost without using so many chemicals."

Participatory Research

Cardona determined that a program of integrated pest management, a strategy that had worked with many other crops to reduce the need for spraying, could work on the tiny mountainside plots if enough farmers could be convinced to use it. The key to his idea was to involve farmers in the research itself.

With funding from IDRC and the cooperation of the national agricultural research systems of Colombia, Ecuador, and Peru, Dr Cardona initiated a program of farmer participatory research to find out which insect management strategies would work.

Implementing IPM

The whole goal of integrated pest management (IPM) is to reduce pesticide use to the minimum necessary by introducing practices such as destroying crop residues that harbour the eggs of next season's pests. The crops are regularly inspected and then sprayed using only the chemical that is appropriate for the particular pest. The various components of the IPM approach had worked well in other situations but this was the first time anyone had tried to use them with small farmers in such difficult terrain and with a crop like beans.

Cardona's research team selected farmers willing to set aside some of their fields for the tests. Each farmer had two similar plots -- one which he or she maintained in the usual way, spraying whenever it was considered necessary. In the adjacent plot, the scientific teams used the more environmentally sound, integrated approach.

If IPM techniques worked, the scientists thought the farmers participating in the tests would see the results

right away. For the most part that was true. But the researchers also learned from the farmers. Not all the ideas tested at the research stations were acceptable to the farmers. For example, the scientists thought that sticky yellow traps coated with fuel oil would reduce the insect population. To trained scientific eyes they did kill millions of bugs. But the scientists had not considered the extra work involved in maintaining the traps on the steep mountain slopes. The extra trips down the mountain to town to get new oil, and the cleaning of the traps demanded too much labour to be worthwhile. Moreover, although the traps were full of dead bugs, the farmers still saw thousands of live insects on their bean plants.

Simple Monitoring Techniques

Another part of the IPM strategy is to monitor the bean plants for signs of insect infestation. But many of the farmers have little formal education. The careful record keeping and arithmetic that served well at the research stations could not succeed with the farmers. So the researchers who were working with farmers on the test plots in Ecuador came up with a straightforward monitoring and counting technique that every farmer could understand and use. It required just a glass jam jar and a pocketful of beans. For every damaged bean pod the farmer spots, a bean goes into the jar. If the jar fills slowly, there is no need to spray.

Cesar Cardona says the results on the test farms throughout the region are impressive. Crop quality has been maintained, pesticide use dramatically reduced and the profitability of the bean crop increased because the farmers spend less on pesticides.

> "If most of them start implementing IPM, insect population levels will gradually decrease in the area," Cardona says. "Now they do see the better economic returns and lower cost. There is no need to use so many chemicals. They can produce the same with at least 60 or 70% less insecticides without losing a penny -- or even make more money."

Everybody Wins

In the towns and on the farms of the Andes, it is an approach by which everybody wins. Consumers get a healthier product, farmers expose themselves and their families to far fewer potentially damaging chemicals, and the land carries a lower toxic burden into the future. Eventually, it appears possible to restore the equilibrium that existed thousands of years ago when the indigenous people of the region first understood the close relationship between beans and corn and never used a drop of insect spray.

The next phase of the project will develop methods of getting the technology from the test farms to everybody's farm. Gerardo Sota does not think this technology transfer will be especially difficult. "It favours farmers and it's less risky for us not to use toxic chemicals. Consumers are in less danger of being harmed by these products. I would recommend it because it gives such good results."

David Mowbray is an Ottawa-based film-maker and writer, reporting from Colombia.

Resource Person:

Dr Cesar Cardona, CIAT, A.A. 6713 , Cali, Colombia; Tel: (57 2) 445-000; E-mail: c.cardona@cgnet.com; Callers from North America: Tel: (415) 833-6625; Fax: (415) 833-6626

The CIAT-Canada Connection

Canada has had strong links with CIAT, the International Centre for Tropical Agriculture based in Cali, Colombia for a quarter of a century. CIAT is one of 16 international research centres in the developing world devoted to improving food security for the world's most impoverished people. It was founded in 1967 and since 1971 both the Canadian International Development Agency and IDRC have been major donors to the operations and the research programs of the renowned Centre.

Robbin Ruggles, a Canadian recently on CIAT's professional staff, points out that Canada was instrumental right from the beginning in getting CIAT's renowned cassava improvement program off the ground. Cassava, a root crop that originated in South America, now serves as a food staple for half a billion people, primarily in South America and Africa.

Canadians Benefit

Canadians farmers have also benefitted directly from work done at CIAT. In addition to its research work to improve beans, cassava and other crops, CIAT holds one of the world's major germplasm collections in its gene bank. A navy bean variety called ExRico 23 was developed by the national research program of Colombia. CIAT introduced it to North American farmers. It is resistant to white mould disease and its use has saved Canadian farmers millions of dollars. Other CIAT bean lines with resistance to potato leaf hoppers will soon find their way onto Canadian farms.

As for the future Ruggles feels there are areas for cooperation between Canada and CIAT that remain to be tapped. He would like to see CIAT linked with more agriculture and environment departments at Canadian universities. "CIAT can act as a bridge for Canadian universities to partner with national organizations in developing countries."

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> IPM Net Internet site *Information for international agricultural interests from the Consortium for International Crop Protection.*
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ANDEAN FARMING FOR PRESENT AND FUTURE

by Neale MacMillan

Beneath a deep blue sky, Peruvian small farmer Isidoro Casas Centellas lifts a wood and plastic roof panel on his low, rustic greenhouse. Although it is a modest structure made of adobe, water, and straw, something exceptional grows in the sheltered soil: onions, radishes, beets, and carrots. Agricultural economist Jorge Reinoso is astonished to see these crops. "Beets at 4,200 metres! People here have never even heard of beets," exclaims Reinoso.

Indeed, Casas is farming at the upper limits of agriculture in the Peruvian Highlands of Lake Titicaca, a region of over one million inhabitants. His community of Apopata lies in the loftiest of agroecological zones near the lake. Farming here is devoted largely to livestock production, alpacas, llamas, and a few sheep.

Below Apopata, closer to the lake and at lower altitudes (3,850 m to 3,900 m) is a second farming zone. The warmer climate permits mixed production of livestock and food and forage crops. Around the lakeshore (3,810 m) is the best farming zone -- soils are better and the warming effect of the lake is strongest.

Up in Apopata, Isidoro Casas never grew potatoes in the fields because they did not survive the frosts. But for 3 years he has been getting three harvests per year from his greenhouses. Casas is testing alternative farming technologies in an IDRC-supported project based in Puno called Sustainable Highland Agriculture or PRODASA (its Spanish acronym).

Project leader Carlos León-Velarde (please see profile in IDRC Reports, January 1995) says the technologies developed through PRODASA are intended "to meet the requirements of the present inhabitants without compromising resources for future generations. Our goal is to raise living standards, to improve well-being, access to education and communication. From the human perspective, this is a long-term goal."

Reaching these goals means adapting to highly complex farming conditions. The major constraint is extreme climatic uncertainty. Frosts or hailstorms can wipe out crops at any time of the growing season. A year of normal rainfall (around 600 mm) can be followed by a year when rain falls in flood proportions, or by drought.

COPING WITH THE WEATHER

Farmers have developed complex systems to cope with the variable weather conditions. Planting several crops in different plots or staggering planting times are among the techniques employed. Watching a woman sow 15 potato varieties in one tiny plot, PRODASA agronomist Roberto Valdivia observes that "this is peasant rationality, a way to protect against climatic risks."

But even these coping strategies fail to overcome low living standards -- seen in inadequate nutrition and high infant mortality. Average annual incomes range between US$800-US$1,300 per family. High population density has led to ever smaller parcels of farmland, in most cases too small to permit even subsistence agriculture. Men often must supplement family income with jobs in cities. Many inhabitants have migrated to opportunities in centres such as Puno, Arequipa, Tacna, Cuzco, and Lima.

As Valdivia points out, the productivity of the different farming zones varies greatly, determining the number of families a given area can sustain. He compares Santa Maria, a community in the middle farming zone, to Apopata, located in the highest and coldest zone. "In Santa Maria you have over 100 families living on 900 ha, whereas in Apopata there are only 67 families but they are living on 13,000 ha," says Valdivia.

The interdisciplinary PRODASA team -- including specialists in agronomy, economics, sociology, and animal sciences -- considers the whole farming system. An important aspect is to analyze the communities and households in relation to the larger region, looking for ways to exploit market opportunities and add value to raw materials through activities such as handicrafts production from alpaca and sheep fibre. The most promising candidates for market development are alpaca fibre and meat, along with quinoa and other cereals.

León-Velarde, a specialist in animal production and farming systems, works out of the International Potato Centre (CIP) in Lima, travelling frequently to the Puno Highlands. CIP and Peru's National Institute of Agricultural Research (INIA) also support PRODASA, the successor to a project funded by the Canadian International Development Agency and executed by IDRC in the mid-1980s. PRODASA is part of the Consortium for Sustainable Andean Development (CONDESAN), initiated by IDRC and CIP, presently coordinated by CIP. It links many institutions in the Andean ecoregion working toward sustainable development. The Consortium is funded by several donors, including IDRC, Swiss Development Cooperation, and the governments of Denmark, Germany and the Netherlands.

PREDICTING IMPACTS

León-Velarde tests alternative farming technologies using simulation models run on computer software. Comparing different scenarios allows PRODASA to identify the best alternatives for application in terms of benefits to families, the environment, and society at large. The models help predict the likely impact of different technologies based on variables such as available land, capital, and labour. They also move the researchers closer to answers to important questions such as whether technologies that prove sustainable at a community level are also sustainable at a regional level. The main concern for sustainability is soil erosion. Cultivation on slopes and the loss of natural vegetation and trees over many years has contributed to extensive soil erosion. Improved soil management practices are essential if the trend is to be reversed.

VALUABLE TRADITIONS

One traditional farming technique the project encourages is the *aynoka*, a word of the native Aymara people. The aynoka is composed of separate family plots managed by common accord. Santa Maria has nine aynokas. As Roberto Valdivia explains, a typical system would have potatoes sown in the first year, quinoa in the second, barley for human consumption in the third, and forage barley for cattle in the fourth. From years five to eight the land could lie fallow or, alternatively, be planted with alfalfa. During this period the land could also be opened for grazing. The aynoka system avoids the irrational overgrazing or overcultivation that has contributed to loss of vegetation and erosion.

Among PRODASA's technical interventions is the rustic greenhouse. "The greenhouse produces very well for our family needs. There is always something to eat and to seed," says farmer Juan Maron Acero of Santa Maria. Maron grows potatoes, lettuce and onions in his greenhouses, producing up to 30% of his family food needs. He also grows alfalfa alongside the companion grass *Dactylis glomerata*. This

combination produces a yield four times greater than it would in the field and feeds rabbits and guinea pigs.

GENETIC DIVERSITY

PRODASA, working with the Andean Roots and Tubers project within CONDESAN, is also recuperating local genetic diversity. "Genetic variety had been lost due to droughts and lack of markets," says Jorge Reinoso. Varieties stored in germplasm banks have allowed the reintroduction of abandoned crops. These include 26 potato varieties and other Andean crops such as *oca* (*Oxalis tuberosa*) , *olluco* (*Ullucus tuberosum*), and isaþo (Tropaeolum tuberosum). "Some varieties are low yield, but they are guaranteed to produce every year, compared to the improved varieties that may be more vulnerable to frosts and drought," says Reinoso. The genetic quality of alpaca and sheep is also being improved through the exchange of animals among local communities to bring new blood into the herds.

Other alternatives include raising trout to produce valuable protein for family consumption and for sale. In Apopata, Isidoro Casas raises trout in small ponds fed by mountain streams. The same streams supply water to wet areas -- called *bofedales* -- where the best pasture grows, and which in the dry season are essential to raising alpaca and other livestock. Encouraged by the PRODASA team, Casas is using rock barriers to divert some of the streamwater to enlarge his *bofedales*.

The project employs agricultural technicians living in the communities who work with farmers to test the best interventions. Enthusiastic farmers such as Casas are invaluable allies for technology transfer between the researchers and the farming community. PRODASA is also disseminating knowledge of viable alternatives through courses at the National University of the Altiplano in Puno. In addition, CONDESAN facilitates the exchange of experiences between PRODASA and projects in Bolivia, Colombia, Ecuador, and Peru.

Despite knowledge of farming alternatives, some are not taken up for a variety of reasons, the prinCIPal one being insufficient cash flow to cover start-up costs. "If the farmer sees that the alternative will not have a short-term return, then he won't invest in it," says León-Velarde. "They recognize utility and they invest in it. But the return has to come within one year." A community revolving fund to provide credit has succeeded in some instances -- such as providing money to buy seed potatoes. But other funds have not run smoothly when farmers have been unable to repay loans within the year owing to a bad farming season.

The lessons learned from PRODASA and other CONDESAN projects show it is unrealistic to expect poor farmers to make all the investments in better soil management and reforestation that are vital to putting highland farming on a sustainable footing. León-Velarde believes that long-term prospects for Andean mountain ecology and its inhabitants will depend to some extent on the willingness of government, private institutions, education programs, and aid programs to help farmers by investing in natural resource management and conservation projects that follow holistic and participatory approaches.

Neale MacMillan, reporting from the Puno Highlands, Peru.

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