BHUTAN–IRRI PROJECT

Local Tradition Meets Modern Know-How

Writer/Editor
Joyce Gorsuch

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INTERNATIONAL RICE RESEARCH INSTITUTE

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2001

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The International Rice Research Institute (IRRI) was established in 1960 by the Ford and Rockefeller Foundations with the help and approval of the Government of the Philippines. Today IRRI is one of 16 nonprofit international research centers supported by the Consultative Group on International Agricultural Research (CGIAR). The CGIAR is cosponsored by the Food and Agriculture Organization of the United Nations (FAO), the International Bank for Reconstruction and Development (World Bank), the United Nations Development Programme (UNDP), and the United Nations Environment Programme (UNEP). Its membership comprises donor countries, international and regional organizations, and private foundations.

As listed in its most recent Corporate Report, IRRI receives support, through the CGIAR, from a number of donors including UNDP, World Bank, European Union, Asian Development Bank, and Rockefeller Foundation, and the international aid agencies of the following governments: Australia, Belgium, Canada, People's Republic of China, Denmark, France, Germany, India, Indonesia, Islamic Republic of Iran, Japan, Republic of Korea, The Netherlands, Norway, Peru, Philippines, Spain, Sweden, Switzerland, Thailand, United Kingdom, and United States.

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About the cover (clockwise, from left): Bhutan landscape; farmer and cow walk along road; using scythe to harvest rice; researcher presentation at Dompola village; transplanting rice.

ISBN 971-22

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IRRI's mission statement

Our goal

To improve the well-being of present and future generations of rice farmers and consumers, particularly those with low incomes.

Our objectives

To generate and disseminate rice-related knowledge and technology of short- and long-term environmental, social, and economic benefit and to help enhance national rice research systems.

Our strategy

We pursue our goal and objectives through

- interdisciplinary ecosystem-based programs in major rice environments
- scientific strength from discipline-based divisions
- anticipatory research initiatives exploring new scientific opportunities
- conservation and responsible use of natural resources
- sharing of germplasm, technologies, and knowledge
- participation of women in research and development
- partnership with farming communities, research institutions, and other organizations that share our goal

Our values

Our actions are guided by a commitment to

- excellence
- scientific integrity and accountability
- innovation and creativity
- diversity of opinion and approach
- teamwork and partnership
- service to clients
- cultural diversity
- gender consciousness
- indigenous knowledge
- environmental protection

Foreword

IRRI's involvement with national research and extension systems (NARES) varied, depending on the specific country needs and level of development. For the last 16 years, IRRI has been proud of its fruitful partnership with Bhutan, which has led to the development of a functional research and development system in Bhutan. Our collaborative partnership is an excellent example of building a small but effective research system. Bhutan is now widely considered to be a model research system for a small country.

It is worth documenting the history and the many achievements associated with the development of the Bhutan national program. Others can appreciate what has been achieved through partnership with the other stakeholders, particularly the main donors, the International Development Research Centre and lately the Swiss Agency for Development and Cooperation. Through effective collaboration, a strong foundation has been laid for developing a national research program on rice, oilseeds, wheat, and vegetables. In addition, a small farm research station (CARD - Wangduephodrang) has been transformed into an effective national agricultural research center that serves not only the wetland production system but also the national research and development program for field crops. Project efforts have contributed positively to enhancing research-extension linkages and have generated farm-level impact through the adoption of new varieties and production technologies in many parts of the country.

I would like to congratulate our Bhutanese colleagues whose dedication and competence in their work have made all these accomplishments possible. May the stories told in this document inspire them to continue their efforts in pursuing relevant agricultural research and development in Bhutan. Tashi Delek!

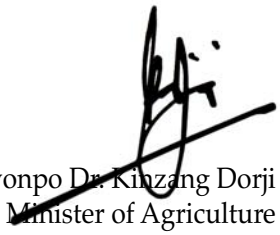
Ronald P. Cantrell
Director General

Foreword

Bhutan's partnership with IRRI, supported by the International Development Research Centre (IDRC) and the Swiss Agency for Development and Cooperation (SDC), has played a key role in laying a strong foundation for our national renewable natural resources (RNR) research system. IRRI's involvement came at a crucial time when Bhutan's effort to initiate national agricultural research began in 1984. While IRRI gave technical support to our rice-based farming systems research, IDRC and SDC provided the much needed funds.

As our population grows, Bhutan must continue researching ways to increase food production. The limited availability of cultivable land is one challenge to this goal. Another challenge is the growing shortage of farm labour as more Bhutanese farmers leave the farm and become urban dwellers. The Ministry of Agriculture has been a very enthusiastic supporter of the partnership to build a strong research programme that is addressing key issues facing Bhutan. Research from the renewable natural resources research centres (RNRRCs) has an important impact on Bhutan's rural population, which is about 79% of the total population.

Bhutan looks forward to future collaborations, as the RNR sector has a crucial role to play in providing a livelihood to our farming communities, through the sustainable management of Bhutan's natural resources. I would like to thank IRRI, IDRC, and SDC for working with Bhutan towards this goal.



Lyonpo Dr Kinzang Dorji
Minister of Agriculture

Introduction

cultivating Bhutan's national agricultural research and development system

Background

Very few people beyond the Himalayas have heard of Bhutan. Those who know of the country could never forget it. A neighbor of China (Tibet) and India, this small landlocked kingdom has a stunningly beautiful terrain of mountains and trees. Very old traditions remain part of everyday Bhutanese life. Bhutan's landscape and Buddhist culture fascinate many visitors and scholars, but the country's natural resource management strategy may be the most compelling feature of all.

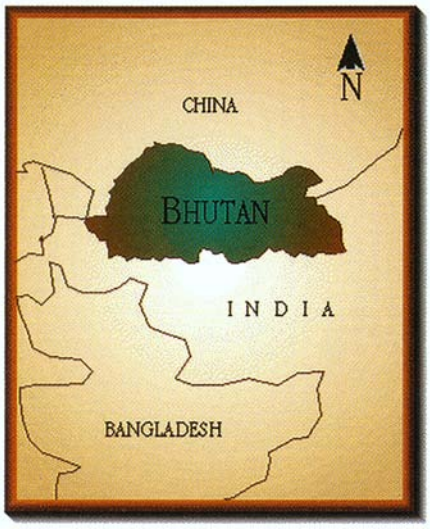
Bhutan's king has ruled for more than a quarter-century. His Majesty's personal interest in his country's environmental issues continually draws government attention to the kingdom's natural resources sector. Agriculture comprises the largest part of Bhutan's economy, providing a livelihood for over 79% of the population and generating about 37% of the national GDP.

RNRRC photo

His Majesty King Jigme Singye Wangchuck of Bhutan inspects a citrus tree at Renewable Natural Resources Research Center-Bajo.

Forest covers more than 70% of the kingdom's total landmass and provides a home to rare animals such as the golden langur, the takin, the blue sheep, and the black-necked crane. It endows villagers with firewood, timber, wood for roof shingles, leaf litter to aerate the soil, and land for cattle grazing. Many villagers also use and sell non-wood forest products such as mushrooms, edible ferns, medicinal plants, and herbs for making tea.

Many Bhutanese, like their ancestors, practice integrated subsistence farming on small pieces of land. Bhutan's extremely mountainous and forested topography remains similar to the landscape of ancient times. To the north, the Himalayas form a steep boundary. Throughout Bhutan are forests, mountains, and rivers separating sparse tracts of farmland. Integrated farming takes resources from one part of the farming system and uses them in another:



J. Gorsuch

Bhutan is a mountainous, forested country bordering the Himalayas.

- Cattle fodder from the field feeds livestock
- Leaf litter from the forest aerates farm soil
- Manure from livestock replenishes soil nutrients

For these reasons, powerful policymakers in the Bhutanese National Assembly place a high priority on the sustainable development of the country's renewable natural resources (RNR) sector of the economy. RNR includes the categories of livestock, forestry, and agriculture. Agriculture encompasses two subcategories: field crops and horticulture.

Bhutan is making rapid progress in developing the sustainable use of its natural resource management sector with support from the King, government policies, the International Development Research Centre (IDRC), the Swiss Agency for Development and Cooperation (SDC), the International Rice Research Institute (IRRI), and the Bhutanese people themselves.

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Since ancient times, the Bhutanese have prepared and eaten puffed rice on special occasions.

Early 1960s: no national agricultural research system in Bhutan — yet

Bhutan began opening its borders in 1961 after many years of self-imposed isolation from the rest of the world. The kingdom realized that it needed to form partnerships with other governments in order to address important food security issues. The Government of India provided early contributions toward the development of agricultural research within Bhutan. Expatriate scientists generated preliminary data on rice varieties by conducting ad hoc research.

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As a result of improved rice farming practices, this woman and her family have access to more rice, as well as a greater variety of foods.

Early 1960s: importance of rice in Bhutan

Rice's role in the Bhutanese diet factored strongly into Bhutan's efforts to build its own agricultural research system. In the 1960s, Bhutan produced as much rice as it consumed. Surprisingly, this self-sufficiency resulted from insufficient supply, not from a reflection of true demand. Domestic production kept pace with demand because, on the surface, demand was much lower than it is today.

This seemingly lower demand was actually the result of limited access to rice. People could not afford rice or even find anyone to sell it to them, so they did not buy it. Bhutanese who had preferred rice all along were making do with other grains. Maize (corn) was the kingdom's largest staple crop, yet rice was the most preferred staple. Demand has continued to rise steadily.

After the kingdom opened up, it increased its trade with nearby countries. Intensified trade meant larger incomes for many Bhutanese. Improved earning capacity allowed more people to buy more rice. These trends suggested that Bhutan would need to rely on other countries and import even more of its most

popular staple unless the Bhutanese made major changes in their approach to food production.

Early 1980s: Bhutan becomes an active member of the world community

A greater understanding of national priorities allowed Bhutan's leaders to initiate successful dialogues with other countries. Prior to the 1980s, centers at Bhur and Yusipang sometimes functioned as research centers and at other times functioned as government farms. Non-Bhutanese staffed them. By the 1980s, the Royal Government of Bhutan (RGoB) placed a high priority on establishing its own agricultural research infrastructure.

In 1984, Bhutan began its collaboration with IRRI to develop Bhutan's national agricultural research infrastructure. IDRC and SDC have funded this collaboration, known as the Bhutan-IRRI Project.

Early 1980s: Bhutan-IRRI Project

At Bhutan's request, IRRI and IDRC jointly submitted their proposal in 1983, titled "Rice Farming Systems Research." The proposal aimed to assist the RGoB in building a knowledge base for conducting its own agricultural research and development. The project would train the Bhutanese people, provide outside technical expertise, and assist in securing buildings, vehicles, field equipment, and other basic research necessities. Bhutan intended to improve the kingdom's food security by increasing domestic rice yields.

A few key individuals had to be convinced before giving their support to this ambitious project. Dr. Glenn Denning, an IRRI scientist during the 1980s, worked vigorously to win the support of IRRI's Board of Trustees for the project. Some trustees initially expressed concern over Bhutan's comparatively small population. Compared with other rice-growing countries, Bhutan had far fewer people than its densely populated neighbors, and a smaller rice-growing area.

In reply, Dr. Denning and other supporters explained the potentially far-reaching benefits of the Bhutan-IRRI Project. Bhutan was starting from scratch. Though daunting, the country's lack of a permanent homegrown research institution actually provided an opportunity. The kingdom could build something without having to adapt it to a preexisting organization or "reinventing the wheel." Research in Bhutan would benefit the Bhutanese, as well as the people of other countries who were facing similar resource management challenges.

Though small, the country of Bhutan sought assistance and IRRI's mission has always supported national agricultural research systems. The Bhutan-IRRI Project's goals of increased food security and sustainable resource development fit well with the resource management and technology transfer goals of most donor and research organizations. Also, IDRC wanted to fund the project. This reasoning convinced the Board of Trustees that IRRI should play a key role in this innovative venture.

Increased cooperation among farmers, extensionists, and researchers came about after years of refining the focus of the Bhutan-IRRI Project. Commodity-based Phase I focused on increasing rice yield. Using improved varieties of rice such as IR64, farmers, extensionists, and researchers significantly increased the yields in several regions of Bhutan. Improved rice can yield 4.17 t ha^{-1}, compared with the local variety yield of 0.83 t ha^{-1}.

At the same time, it became clear that constraints on further increases in yield had complex, interrelated causes which needed further study.

Phase II focused on accelerating the development of rice farming system technologies and strengthening the Ministry of Agriculture's (MoA's) capacity for agricultural research and development. It studied and made recommendations for cropping patterns, varietal improvement, and nutrient and pest management in rice farming systems. Most importantly, it encouraged greater farmer participation in research efforts.

Early 1980s: Renewable Natural Resources Research Centers (RNRRCs)

Thanks to the focus and dedication of many individuals, as well as steady support from the King, the RGoB, and international agencies, Bhutan today has a young and growing agricultural research system in place.

Lyonpo Dr. Kinzang Dorji, Minister of Agriculture, expresses appreciation for IDRC's and SDC's financial contributions toward building Bhutan's agriculture research system: "Research from the centers has an important impact on Bhutan's rural population, about 79% of the total population. We look forward to future collaborations as the RNR sector provides a livelihood to our farming communities through sustainable resource management."

RNRRC photo

Lyonpo Dr. Kinzang Dorji, Minister of Agriculture, is an important supporter of agricultural research in Bhutan.

Bhutan now receives tangible returns on an investment that began in the 1980s. Established in 1982 just prior to the Bhutan-IRRI Project, Bhutan's Center for Agricultural Research and Development (CARD), now known as RNRRC-Bajo, evolved into Bhutan's first dedicated agricultural research center. It is the oldest of Bhutan's four RNR research centers.

RNRRC-Bajo was essential for starting Bhutan's network of RNRRCs. The work begun at Bajo has laid the foundation for Bhutan's expanded research capabilities in more recent years of the Bhutan-IRRI Project. Relative newcomers, the Jakar, Khangma, and Yusipang RNRRCs, were established during the 1990s.

"Many of the staff who are working in other centers, especially in the field crops area, actually were working [at Bajo] earlier. Now they have been transferred to start research on field crops in other research centers," observes Sangay Duba, program director of RNRRC-Bajo. "So I think the national awareness of the importance of research and the national capability to do such research started here."

The organizational support, training, and expertise provided by the Bhutan-IRRI Project were instrumental in the successful establishment of the RNRRCs. In addition, equipment obtained via the project, such as field vehicles, field equipment, laboratory supplies, and computers, have profoundly impacted the centers' daily activities. Fewer staff members must make the 3-hour hike between the RNRRCs and the nearest communities that they serve. More staff now ride to and from villages and research sites in five-seater pickup trucks, bringing along greatly needed (and heavy) research and laboratory supplies.

Research from the centers has an important impact on Bhutan's citizens. It addresses the issues of food security and environmental preservation. These issues present considerable challenges given Bhutan's limited acreage of arable land (about 8% of the country's total land mass), growing human population (3% increase per year), and priceless natural resources.

To increase food production efficiency, the centers have developed high-yielding, locally adapted varieties, incorporated winter cropping and intercropping systems, developed practices that increase dairy production, and implemented improved pest management strategies. Trained scientists and community intermediaries bring to Bhutan's rural communities the best practices for conserving water resources, improving forest health, and using land wisely.

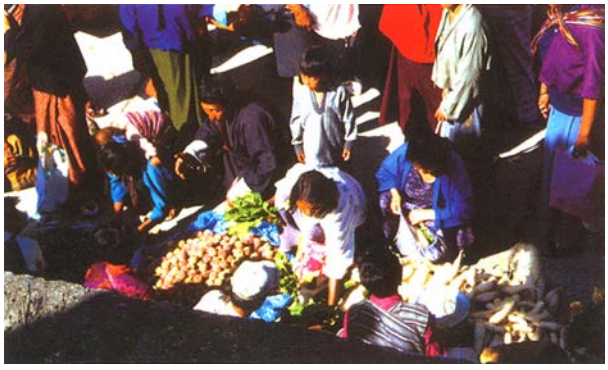
The 1990s: guiding the RNR sector's growth

Mr. Sherub Gyaltshen, director of the Department of Research and Development Services (DRDS), mentions the role of Bhutan's own government in guiding the RNR sector's growth: "The Ministry of Agriculture has been a very enthusiastic supporter of the partnership to build a strong research program that is addressing key issues facing Bhutan. The new research directions have already had significant impact on the farming community."

Ganesh Chettri, joint director for research, DRDS is one of several up-and-coming experts on Bhutan's RNR research centers. Recently promoted within DRDS, he oversees from Thimphu the national dissemination of research information. He also provides strategic thinking and coordination at the national level for the four RNR research centers.

Initially, the budding agricultural research sector consisted of three departments: forestry, livestock, and agriculture. "Our approach used to be a departmental, sectoral approach [in which] three individual departments approached the farmer," Ganesh Chettri explains. The Ministry of Agriculture's recent reorganization combines these departments into one, to provide effective services.

At the regional level, each center studies need and capacity, with a special emphasis on the area's popularly grown staple crop. RNRRC-Khangma, for instance, conducts maize research for the entire country. Where a region popularly grows a crop, that region's center focuses on that crop. Networking and interdependence among centers greatly facilitate the efficient use of precious resources for Bhutan's agricultural research.



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Vendors and customers reap benefits of crop diversification in Bhutan.

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Today's children: tomorrow's rice farmers?

Beyond 2000: the future of agricultural research in Bhutan

"With better practices, income increases and our living standard improves," says farmer Zeko Penjor through an interpreter. Because of research conducted at the RNRRCs, farmers can access better seeds and send their children to school.

The Bhutan-IRRI Project's achievements are many:

- Laid the foundation of a national agricultural research system
- Created a growing base of trained Bhutanese researchers and extensionists
- Increased Bhutanese farmers' access to new technology
- Began screening rice plants for blast resistance
- Diversified the Bhutanese diet
- Intensified cropping to produce higher yields of food
- Established links to governments and organizations around the world
- Generated a growing body of research literature on Bhutan's agriculture

These successes have positioned Bhutan to build upon its traditional integrated farming practices. With continued development of its research infrastructure, the country can increase its self-sufficiency in rice; it also can implement more human resource training and development, establishing a national university system that serves as a resource for the entire geographic region.

As the population grows, Bhutan must continue researching ways to increase food production. The limited availability of cultivable land is a significant challenge to this goal. Also, more Bhutanese are leav-

ing the farm to become city dwellers, creating a farm labor shortage and a need for more human resource development to keep up with the changing job market. Bhutan plans to meet these challenges by continuing its research on water use, agricultural productivity, soil fertility, and forest management within the context of Bhutan's integrated farming system.

By combining the best of traditional knowledge and modern agricultural technology, Bhutan has made an inspiring start. With continued long-term support to build upon the country's knowledge base, Bhutan would surely continue its remarkable transformation into a traditional yet modern kingdom. ■

Human resource development

building upon Bhutan's knowledge base

Many generations of Bhutanese have studied abroad. Bhutan has lacked in-country facilities to train agricultural scientists, but in recent years has overcome numerous obstacles to human resource development. The kingdom's new and growing research system has begun to reap the rewards of this investment in human potential.

"A lot has changed since the mid-90s when we sent large batches of people out for diploma and certificate courses," noted Sangay Duba, program director of RNRRC-Bajo. Until the early 1990s, a shortage of university-trained personnel within the kingdom to teach at the tertiary level meant the absence of a Bhutanese national university or other centralized training facility.

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Kezang Jamtsho from RNRRC-Bajo explains that rice yields remain constant even if villagers use less than the usual amount of water.

In 1999, the Royal Government of Bhutan's (RGoB's) Planning Commission indicated an important change in trend: increased self-reliance for education and training in Bhutan. RGoB's strategy document, *Bhutan 2020: A vision for peace, prosperity and happiness*, stated "we must take steps at the earliest feasible opportunity to establish a National University (p54)." That Bhutan could now consider such a possibility was a sign that Bhutan's capacity building had been successful. Already, Bhutan had begun offering in-country training with Bhutanese instructors.

The RNR sector of Bhutan's economy has three human resource groups: farmers, extension staff, and researchers. With recent help from the Bhutan-IRRI Project, each of these groups has benefited from human resource development in the form of degree and nondegree courses, hands-on demonstrations of new technology, and periodic discussions of how best to harness knowledge to solve farmers' problems.

International Rice Research Institute (IRRI) courses

Sponsored by the International Development Research Centre (IDRC) and the Swiss Agency for Development and Cooperation (SDC), the Bhutan-IRRI Project has built a vital base of modern know-how in Bhutan. Since the project's inception in 1984, Phase I of the project has trained 40 Bhutanese research and extension staff in short-term, nondegree courses at IRRI. Another 200 Bhutanese agriculturists have participated in short-term, nondegree IRRI courses in Bhutan.

In addition to the nondegree IRRI courses, one-time, in-country trainings have taught extension staff to carry out germplasm collection and preservation. Trainees who have attended these courses have brought the latest technical knowledge directly to Bhutanese farmers. At agricultural conferences and workshops outside Bhutan, Bhutanese agriculturists have enhanced their skills and developed international contacts for agricultural research collaborations.

Natural Resource Training Institute (NRTI) courses

Sixty Bhutanese trainees per year earn diplomas at the Ministry of Agriculture's (MoA's) Natural Resource Training Institute (NRTI) in Lobeysa, established in 1992. Through their coursework, vocational apprentices combine theoretical knowledge and hands-on experience. As agricultural extension agents, they will share information with Bhutanese farmers, research scientists, and other extension agents. Today's trainees will form tomorrow's critical mass of in-country expertise.

"In-country training courses have been especially beneficial," says Mr. Tirtha Katwal. A researcher at RNRRC-Yusipang, Tirtha Katwal has directly benefited from the germplasm collection courses offered here in Bhutan. He notes that, while Bhutan is forming its own pool of trained personnel, the most cost-effective arrangement is to send one or two experts here from IRRI rather than sending 20 or more trainees to the Philippines. By conducting the training in Bhutan, instructors allow trainees to learn the material in the context of their own natural environment.

Courses train Bhutanese researchers and extension staff in germplasm collection and preservation, needs assessment, curriculum development, instructional media, and other topics. Many participants bring to these courses 10 or more years of experience in agricultural research, and in turn they will teach other Bhutanese.

Training and information exchange, enhanced by the Bhutan-IRRI Project, develops a pool of farmers and agricultural professionals who understand firsthand the problems and opportunities of their country. Pairing this skill and cultural understanding, and providing resources to tap into it, can only further empower Bhutan to achieve a more sustainable and productive use of its land. ■

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Rice farmers benefit from improved practices (above, transplanting seedlings; below, maneuvering a power tiller onto flooded rice field).

Farmer involvement

learning from farmers' expertise

J. Gorsuch

Logistical challenge: several hours' walk or drive between a Renewable Natural Resources Research Center (RNRRC) and its nearest villages.

Over the past 16 years, the Bhutan-IRRI Project has created a closer partnership between farmers, extension staff, and agricultural researchers in Bhutan.

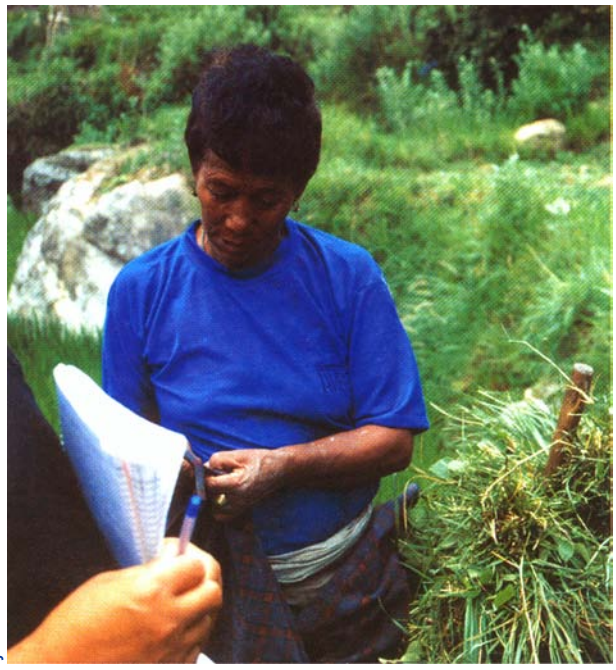
Farmer input has been invaluable to extensionists and researchers. The first Bhutanese researchers were pioneers, says Sangay Duba, program director of RNRRC-Bajo. No one in the world at that time had experience doing exactly what the Bhutanese were setting out to do: establish a research system within Bhutan's unique local conditions. Pirthiman Pradhan (first director of CARD, later known as RNRRC-Bajo) and Ganesh Chettri (joint director for research at the agricultural ministry's Department of Research and Development Services) were two early trailblazers. "[They were] the innovators and could ask nobody. [They] went on and made mistakes. It was a challenge," notes Sangay Duba. Ganesh Chettri began his agricultural research career in Bhutan, right out of college. Right away, he encountered difficulty designing research experiments in the field.

"[Both Pirthiman and Ganesh] had theory but no experience. Field conditions were small plots. [They] had studied experimental designs for flat areas. Here we have small terraces. How to base a trial on such topography is a problem," says Sangay Duba. "[By the time] I came [research] was [more] comfortable because they had learned to tailor their research trials to the local conditions."

The RNRRCs brought farmers, extensionists, and research scientists together in the field on a regular basis. This person-to-person interaction matched the most pressing needs of Bhutan's farmers with the latest farming technology.

The RNRRCs provided regionally based resources for people involved in Bhutan's agricultural research. Nationally, the four centers coordinated among themselves and with the administrative office in Thimphu, to pool resources between farmers, extensionists, and researchers.

Direct contact between farmers and trained agriculture specialists forged a particularly important information link. Most of the country's farmers lacked reading and writing skills, knowledge of the English language, and access to literature that could help them produce more food.



J. Gorsuch

Farming in Bhutan requires strenuous physical labor. This farmer puts down her heavy bundle to describe the crops she grows on this steep slope.

Communicating better with farmers

A group effort, agricultural research in Bhutan closely involves all three players — farmers, extension staff, and researchers. The government's agricultural ministry works to understand and document local farming practices and preferences, allowing for a better fit between farmer needs, extensionist expertise, and research goals. The Bhutanese government also serves as a resource in screening new technologies, helping farmers to adopt practices and inputs best suited to their priorities.

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A cluster of farmers' homes, Lingmuteychu watershed.

Farmers, extension agents, and researchers exchange knowledge during presentations and discussions at the farmers' villages and at the RNRRCs. Farmers give feedback about practices that are the most effective in solving their day-to-day problems on the farm. Extensionists use conflict resolution skills to resolve disputes over the use of water or other resources in the farming communities. In the mountainous country of Bhutan, a few farming communities located at the top of a steep watershed often use the lion's share of an entire community's water source. Extensionists' conflict resolution skills increase the chance of peacefully resolving any quarrels over water rights. Researchers share the results of their studies, and use farmer feedback in their analysis.

On-farm trials illustrate how all the RNR components work together. Farmers, extensionists, and researchers conduct trials in farmers' fields to identify promising varieties not only of rice, but of other crops in the rice farming system. These promising varieties increase yield, resist disease, or offer other desirable characteristics such as drought tolerance, quicker maturity, or optimal straw length. The ideal straw length is short enough to prevent the rice plant from lodging (becoming top heavy and falling over in the field) and long enough to satisfy the preference of the farmer's livestock for a longer rice straw as its fodder.

The teamwork of farmers, extensionists, and researchers during the 1995 blast epidemic shows the cooperation and communication that the three groups have built over the years. Today, farmers provide vital information to researchers through their involvement in Gaynekha Field Days and other blast pathogen research efforts.

J. Gorsuch

Mr. Pasang, a farmer, stands in his pepper field and kindly offers the author and members of the tour group some of his delicious, freshly harvested cucumbers.

A field day with research information

At Gaynekha Field Days, farmers learn about improved blast-resistant varieties and give input on the materials they have already tested. Their selection of test materials provides practical information for researchers and extensionists.

The RNRRCs' first field day in 1996 taught a valuable lesson in participatory research. Due to the large number of seed materials to discuss and disseminate, as well as the 3- to 4-hour walk each way between their farms and the research centers, farmers lacked enough time to give their input.

Researchers and extension staff learned their lesson: keep the information simple and allow enough time for farmers to contribute their perspective to the discussion. Two years later at the 1998 field day, participants discussed fewer materials. As a result, farmers were able to share their important observations about the test materials.

In October 2000, farmers again shared their views at the last field day of the Gaynekha five-year blast nursery project. In addition to giving input about seed materials and farming techniques, farmers indicated that they want the Gaynekha program to be renewed. This input had important bearing on MOA policy decisions; the program is continuing. Promising blast and cold-tolerant rice lines are now tested widely in farmers' fields, and they are likely to be released for general cultivation in 2002.

Trying new practices: from skepticism to success

Bhutan's farmers make valuable contributions by serving as role models. Coming from a long line of tillers of the soil who use traditional farming practices, farmers resist new farming techniques until they see a peer successfully using them. Early adopters of new farming technology inspire others to develop and improve their farming practices and inputs. Farmers from different communities frequently visit each other on study tours to see a farmer's successful implementation of an improved technology.

Village meetings: face-to-face

"What we have been doing together jointly has had an objective of solving [an] initially diagnosed problem [in this case, of hillside degradation]." Sangay Duba, head of the Bajo research center, describes an upcoming village presentation in the Lingmuteychu watershed. "We would like to see to what extent we have been able to address [the problem]."

Researchers and extensionists assess their progress by getting farmer feedback in the course of implementing the activity, says Sangay Duba. "Are there any new priorities that have emerged within the community so that in the next phase of the project we refocus and develop new activities to address those emerging ones. And also should we continue on the old problems that they have given us. To what scale, and what activities should we work on with them?"

Nowadays, fewer farmers practice ad hoc farming. Zeko Penjor, a farmer, basically does research, according to Sonam Jamtsho, district agricultural extension officer for the Punakha *Dzongkhag* (District). "Zeko Penjor listens to extension agents and researchers [explain] what works and how things happen and [acts upon] that [information]." In turn, the farmer adds his own research input. His field demonstrates how growing chilies in raised beds can help reduce the incidence of blight in his region. Several local farmers now grow chili plants in raised bed nurseries at their own farms.

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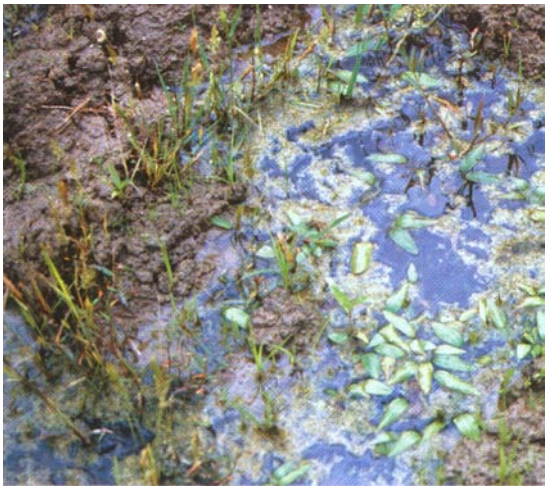
Sangay Duba, program director of RNRRC-Bajo (standing), makes a point during a discussion of water management in Lingmuteychu watershed.



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Sochum (*Potamegeton distinctus*), a tenacious weed, growing in a rice field.

At a recent study tour in Paro, one of Bhutan's cities, several farmers from the Lingmuteychu watershed area learn about a new weed control practice. A farm in Paro demonstrates how five handweedings (instead of the usual practice of one) per crop season decreases the incidence of *sochum*, a tenacious weed. After seeing for themselves the effectiveness of this treatment, they begin using it too.

Farmer involvement impacts government policy and local practices in other parts of Bhutan too. In 1998, RNRRC-Bajo conducted a participatory rural appraisal (PRA) of the Lingmuteychu watershed area. Researchers and extensionists introduced for discussion a possible change in management strategy for the area's forest, in which each community would be responsible for managing its adjacent forest. The villagers responded uniformly: We're not interested.

Why? Communities prefer the present arrangement of having the MoA's Department of Forestry Services (DFS) protect the forest. DFS enforcement has reduced conflict between communities, and villagers are skeptical whether they would see any benefit if they once again protected the forest themselves. Under the current permit system, a person can extract forest products from any part of Bhutan so long as she or he has a permit. Prior to DFS's patrolling the forest, villagers protected nearby forest themselves, confronting people from other communities to verify that they had permission to come and take away resources; in some cases, villagers had to turn away people from neighboring communities, which created intervillage tensions.

However, villagers signal that they may yet decide to test some form of community forest management. Farmers have learned from each other. Villagers from the Omtekha slope made a study tour of Kotokha and Dawakha, villages that had instituted forest user groups. The Omtekha villagers had been skeptical that such organizations could function well. After seeing how well the other villages' groups were able to address the needs of the community, the Omtekha villagers returned to their homes eager to start a group of their own. User groups had made a government forest into a community forest owned by the state but managed by local villagers.

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This researcher (left) and extension agent share information and resources. Here they examine a farmer's seedling in a field.

Streamlined sharing of farmer input in Bhutan

In a country where most farmers have no telephones or electricity, extensionists play a vital role in transmitting information between farmers and the rest of the MoA's staff. The Annual Regional RNR Review and Planning Workshop, one example of these collaborative efforts, brings together researchers and extension staff from RNRRC-Bajo's jurisdiction in the west-central region. Extension staff share input from farmers and suggest focal points for research efforts. Researchers present their latest study results and new knowledge.

For farming communities located closer to the Bajo research station, RNRRC-Bajo also conducts farmers' field days on a regular basis. Farmers spend several hours walking down from their villages to learn about the latest technologies that are available to them. In addition, RNRRC-Bajo calls farmers to its station on an ad hoc basis if a trial produces results that need to be seen immediately. Farmer feedback lets researchers know whether their efforts have the proper focus.

RNRRC-Bajo researchers and extension staff go directly to the villages whenever possible. Thanks to the Bhutan-IRRI Project's recent purchase of a Toyota pickup truck, researchers and extension staff can travel to a village within one or two hours. Fewer people have to make a 3-hour walk to RNRRC-Bajo or a 4-hour walk up the steep slope to the villages.

"All along there have been group meetings with farmers for sharing information," observes Sonam Jamtsho. "Now those meetings (district level assembly) are more frequent, saving time because extension agents don't have to go to every single farm. Now researchers can directly work with farmers. Field people used to wait for the district to coordinate meetings. Now they coordinate their own meetings if a problem comes up."

In addition to providing valuable input for training and research activities, Bhutan's farmers make important day-to-day decisions about their own communities. The farmers' villages form their own user groups. These groups decide on the best way to use their resources. They also devise ways to prevent people outside the village from unlawfully taking their resources and, in some instances, have brought their cases to the country's judicial system.

The village selects a member who demonstrates the necessary skills and who has the respect of community members. This person becomes the village leader, or *tshogpa*, implementing decisions of the user group and serving as a messenger between the community and people outside the community. If an officer within the MoA wishes to make a presentation to a village, that officer contacts the village leader who in turn informs everyone else in the village.

In addition to the agricultural ministry's interpersonal dissemination of information to farmers, the Information and Publication Service (IPS) provides informational pamphlets to extension staff and farmers, and translates technical advice from English into *Dzongkha* and other local languages.

All of these methods of information transmission help farmers from day to day. Deo Kumar, extension agent for Kabji *Gewog* (district block), explains further, "[Extensionists] provide training and advice on planning crops – spacing, drainage system. We also introduce new varieties and explain how to follow improved practices."

"Currently researchers, extensionists, and farmers are working together on on-farm trials for improved nutrient management," adds Sonam Jamtsho. "Since I first started doing extension work in this area, farmers' activities have changed to include doublecropping, and more crop intensification with better management practices [such as] irrigation, water management, and weed management."

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In Bhutan, many rice seedlings are transplanted in May and June.

For Sonam Jamtsho, farmer involvement means significant changes in communication among people in the RNR sector. "Information flows in both directions — from farmers to researchers, from researchers to farmers, with extension as the conduit. Farmer input is important for [setting] research priorities."

Local committees provide the main medium through which farmers give this input. Namgay Gyaltshen is the chairperson of a users group committee in Limbu *Gewog* (district block). Established in 1992, his users group committee includes citizens from a number of villages. Through an interpreter, Namgay explains the activities of the users group. "We meet once a year for weeding and cleaning, and also determine what sort of maintenance is required. If further action is required after the meeting, I follow up, for instance by acquiring seedlings for the community to plant today. Then the community transplants them."

How did Namgay Gyaltshen become chairperson of the users group? "[First] my village chose me to be their village headman. As village headman, I made a proposal to the Punakha *Dzongkhag* (district) for a local forestry project. The project was approved, and because I had initiated it, the villagers appointed me chairman for community forestry. Now my community and others get funding from the *dzongkhag*."

As users group chairperson, Namgay receives all initial contact on behalf of the group. Villagers appoint their chair to an indefinite term. They keep a chair so long as they feel that she/he serves their interests. Villagers also appoint committee members. "The committee members [of lesser rank] recently changed because they didn't take any initiative. I constantly had to supervise. The community decided to change the members."

What now for the users group? "There's no funding from outside the district. This makes funding within the district scarce," explains Namgay through an interpreter. "[My dream is] to strengthen conservation efforts here in the village, plus to extend the planted area to have long-term maintenance of natural resources for future use, especially timber species for future house construction."

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Namgay Gyaltshen, users group chairperson, hopes to secure outside funding for long-term, sustainable, locally managed maintenance of his village's natural resources. Over time, sustainable resource management would ensure that settled areas contain enough resources for future generations to use.

With continued long-term support for community forestry projects in Namgay Gyaltshen's region, Namgay and his fellow villagers would continue replacing degraded areas near their village with valuable trees, to be used by future generations. By encouraging farmers to use their village's social infrastructure, Bhutan's RNR sector is setting in place an activist farmer. Active community involvement and the necessary resources can only improve a local group's ability to realize its vision for the future. ■

Blast

1995 epidemic in Bhutan

RNRRC photo

(Foreground, right) Farmers, extensionists, and researchers screen for blast resistance in this field.

Bhutan's first recorded outbreak of rice blast swept through the higher elevations (1800-2700 m) in 1995. The epidemic affected just under 1800 acres of rice fields in Bhutan and resulted in a loss of nearly 1100 metric tons of rice. Hundreds of farmers lost their entire rice crop that year and risked having no seeds to plant in 1996, due to having no harvest in 1995.

Scientists from IRRI went to identify the cause of the epidemic and find ways to prevent future outbreaks. Bhutan had already begun assessing the damage as well as options for alleviating farmers' losses. The visiting scientists helped develop strategies to prevent such outbreaks in the future.

Doing battle against rice's number one foe

One positive outcome of the crisis was that Bhutan's agricultural ministry and the RNR sector proved capable of responding effectively to the crisis.

The Ministry of Agriculture (MoA) formulated a long-term strategy to contain any future rice blast epidemics. The shuttle breeding program, initiated in 1987 in collaboration with IRRI, had identified promising lines for medium-altitude and high-altitude rice environments in Paro.

Broad objectives of the shuttle breeding program were and continue to be

- Development and identification of materials having cold tolerance, easy threshability, good grain and straw yields, and desired cooking and eating characteristics for high-altitude to medium-altitude rice ecozones
- Screening and development of improved rice materials which have specific resistance to blast and other minor diseases

The Bhutan-IRRI Project shifted its shuttle breeding program to Gaynekha in 1996 as part of its blast prevention strategy. At its new location in Gaynekha, the program had the additional objective of screening and developing blast-resistant varieties.

Rice blast disease is the most destructive disease of rice and exists in virtually all rice-growing countries. "Blast" describes affected fields, which appear to have been "blasted" by a flame-thrower. Blast is caused by the fungus *Pyricularia grisea* and can affect all aboveground parts of the rice plant. Early in the crop cycle, plants may develop "leaf blast" or "(leaf) collar blast." In later developmental stages of the rice crop, "(stem) node blast," "base of the panicle neck blast," and/or secondary panicle branches "panicle blast" can occur. Node and neck blast epidemics are the most economically damaging as they occur when the crop enters the reproductive phase. The blast fungus is usually present every year.

Several factors can cause an epidemic:

- Susceptibility to local blast fungi
- Drought stress in the seedling nursery combined with long dew periods
- Low-to-moderate temperatures
- Infected seed, straw, or stubble brought in from outside the farm
- High doses of nitrogen
- High planting densities

Most blast prevention efforts focus on developing blast-resistant rice varieties.

Gaynekha is an ideal "hot spot" site because of frequent reports of blast occurrence in the area; it is secluded in a deep gorge and is therefore set up to expose new rice materials to blast infection while preventing the spread of blast inoculum to other areas. The screening site at Gaynekha is helping to develop blast-resistant varieties of rice.

In 1996, researchers evaluated 465 lines of rice and 118 entries of local germplasm. Thirty-eight of the lines and 66 of the germplasm entries showed some promise of being blast-resistant. Of the 14 best lines, farmers and researchers selected seven for retention. Of the 66 germplasm entries, 20 went to IRRI for the shuttle breeding program. Farmers evaluated and selected entries during a field day that the RNRRCs had organized to solicit farmer input.

Farmers, extensionists, and researchers join forces: farmers' selections

Farmer field trials generated helpful information to identify which varieties are blast-resistant. "At harvest we conducted another field day and together we selected the varieties," said Tirtha Katwal, a researcher at RNRRC-Yusipang who helped create the screening site at Gaynekha. "All farmers... were from the same locality, the same district block. Through these efforts, we have identified two varieties which have possibilities of being adopted by the farmers. Their taste was not as good as that of the local ones, but they were very hardy in terms of blast resistance, and yields were quite high compared with the local varieties."

In 1996, the first test lines were nearly ready for harvest. The Thimphu *Dzongkhag* (district) and RNRRC-Yusipang organized a field day to involve the ultimate end users, the farmers. Thirty-three farmers from the Gaynekha and Chang *Gewogs* (district blocks) of Thimphu *Dzongkhag* selected and evaluated rice materials.

In 1997, the research center in Bajo and the Gaynekha screening site evaluated farmers' selections in initial observation nursery trials. Sixteen entries showed the greatest uniformity, earliest maturity, strongest blast resistance, and other favorable plant characteristics. Two of the resistant entries had the highest recorded yield: 2.58 t a^{-1}, as compared to

RNRRC photo

Blast screening fields.

1.98 t a^{-1} for local varieties and 2.19 t a^{-1} for Chumro, a popular variety introduced from Nepal.

"Research[ers], extension[ists], and farmers selected lines based on farmers' criteria," explained Tirtha Katwal. "[Overall,] participatory plant breeding was the goal." Yield, disease resistance, and height were characteristics that farmers wanted. "Every year there were farmers' field days at the station, and in farmers' fields. Five varieties were now growing in the farmers' fields, under farmers' management. We hoped to release, if the varietal release committee agreed, [two lines in which] the farmers had already shown keen interest."

Winning the war on blast: future outlook

Bhutan's farmers, extensionists, and researchers have come closer to developing blast-resistant, cold-tolerant, high-yielding, improved rice varieties for farmers in high-altitude (1800–2700 m) rice ecosystems. By 1999, they had identified a total of 17 promising blast-resistant lines. These lines have been undergoing evaluation in farmers' fields in eight of Bhutan's *dzongkhags* (districts). There have been strong indications that Bhutanese agriculturists could identify and release blast-resistant and improved rice varieties by the year 2003.

These blast-resistant varieties will be a major victory for high-altitude rice farmers who lost their crops in 1995. It may not be possible to eradicate blast completely, but at least farmers might have an effective weapon for defending their livelihoods against this small but highly destructive plant pathogen. ■

New crops

more food, less poverty

J. Gorsuch

Piles of puffed rice for sale at Punakha market.

Not long ago, daily Bhutanese meals consisted almost exclusively of chilies, soft cheeses, and maize. A family also would eat the local short-grained red rice if it had grown enough. Occasionally, an egg and some chicken, pork, beef, or yak meat also spiced up the meal. Today, there are many additional options, thanks to changes in cropping patterns brought about by the Bhutan-IRRI Project.

How did this dietary revolution begin? Researchers and extensionists encouraged crop diversification to improve soil health and increase food production. This change in cropping generated new types of food that farmers could sell locally or in Thimphu, the capital city. Market forces, associated with the buying and selling of this food, initiated Bhutan's transformation from a bartering system into a cash-based economy.

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Oats, a new livestock fodder in Bhutan.

Along with the change in cropping patterns came other fundamental changes. The Bhutanese family's everyday diet became more diversified. Families who used to eat only rice, cheese, chilies, and maize were now growing and eating additional vegetables such as radishes, bulb onions, aubergines, potatoes, tomatoes, beans, and many other foods. They also were beginning to sell their vegetables for cash instead of giving away what they couldn't use at home.

With the rapid growth of cities such as Thimphu, farmers were shifting away from subsistence farming and toward a cash crop system. Suddenly farmers could earn enough money to send their children to school by cropping more intensively on less land. They no longer had to sharecrop so much additional acreage. Currency began replacing some of the bartering that had taken place before.

Initially, the Bhutan-IRRI Project looked at Bhutan's agricultural research development from a rice-as-commodity perspective. As the project progressed, in addition to working on varietal improvement of rice, it looked at cropping patterns — what farmers grew, how they grew it, and when.

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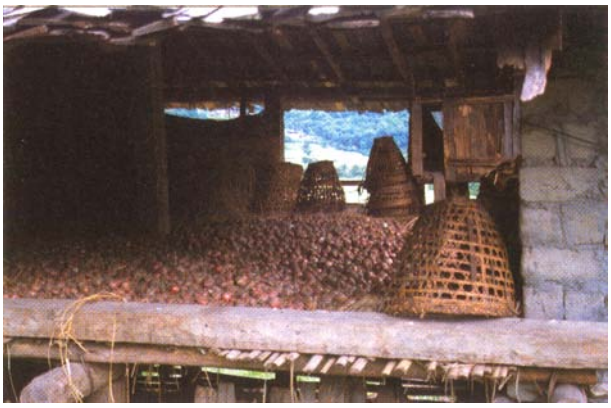
A farmer's compost heap typically combines cow manure and leaves.



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Some Bhutanese farmers have begun growing bulb onions and storing them in structures such as this one, until the time comes to sell the crop at the market.

To be or not to be organic: soil nutrient trials

Within a single crop cycle, rice farming robs the soil of vital nutrients such as nitrogen, phosphorus, and potassium (NPK). Nutrient depletion makes it difficult to increase yields over time or to grow more than one crop of rice per year. Over time, yields decline unless the farmer somehow replaces the nutrients. Soil fertility research is one of the main factors that have contributed to Bhutan's success in growing more crops.

One popular solution was to let the rice fields lie fallow during winter and have cattle graze them. Together with national extension staff and farmers, researchers began testing alternative cropping strategies.

They compared the benefits of organic and inorganic nutrient replacement methods. Farmers, extension staff, and researchers set up control rice crops using the traditional nutrient input, farmyard manure. Others cropped using chemical NPK inputs. The result was that a few farmers developed a preference for inorganic fertilizer, but the majority of the study's participants preferred to use farmyard manure.

Why? Bhutan's small scale of farming is one reason. Also, traditional land inheritance customs tend to divide land among several people over time. Each generation gets a smaller piece, and individuals sometimes end up holding several noncontiguous pieces of land, scattered miles apart. These land use factors make it difficult for anyone in Bhutan to farm on a large scale and therefore it is much more expensive to use inorganic inputs than to use farmyard manure.

The number of inorganic fertilizer users did not increase between 1980 and 1991, yet the amount of fertilizer used did increase. Several farmers with larger than average farms adopted this new technology. Many others, however, expressed concern that chemicals might kill precious microorganisms which maintain soil health. Soil hardening is also a major concern.

Mahesh Ghimiray, plant breeder at RNRRC-Bajo, comments, "Farmers have adopted large-scale use of fertilizers in their cash crops such as potatoes and apples, but not really in rice cultivation. All they do in rice is to topdress an average [of] 30–40 kg N ha^{-1} at the tillering-to-panicle initiation stage." So far, yields for inorganic nutrient users have increased. These farmers hope that the higher yields will continue.

Combining crops for richer soil and higher output

Rotating a nitrogen-adding legume (bean or pea) with a rice crop is another way to restore nutrients to a farmer's soil. Bhutan-IRRI's testing of various vegetables as partners to rice in the annual cropping cycle led to a change in cropping patterns. From 1986 to 1992, doublecropping (growing more than one crop per year) in Bhutan rose from zero to between 11% and 16% of all land area. Many Bhutanese farmers now grow rice in the summer and vegetables from late fall to early spring. Other important crops are mustard and wheat.

Kitchen gardens at Lingmuteychu watershed

The Lingmuteychu watershed region is just outside Bajo. Here, researchers study Bhutan's integrated farming system within a defined area. RNRRC-Bajo conducts agroforestry research at the national level, and RNRRC-Yusipang conducts mainstream forestry research. Forest ecology plays a crucial role in the daily life of a watershed dweller. Leaves from the forest provide compost material for soil regeneration; tree roots prevent soil erosion.

Case Study One
Wangmo: A rice, vegetable, and chili farmer

J. Gorsuch

Wangmo is one of many Bhutanese farmers who changed from subsistence farming to commercial farming.

Wangmo owns five acres of land. She farms it with her husband, sister, and brother-in-law. Money from their off-season chili crop pays for the lorry (truck) that her husband uses to deliver farm produce to nearby markets or to Thimphu, the capital city.

The yield of Wangmo's farm is higher than average: 3,200 kg a^{-1} of rice, compared with the average of 2,000 kg a^{-1}. She achieves this yield using improved rice varieties such as IR64, as well as inorganic nutrient inputs (NPK).

Case Study Two
Mr. Pasang: A commercial farmer

Mr. Pasang grows rice as well as a variety of vegetables: cucumbers, peppers, bulb onions, chilies, beans, and aubergines.

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Mr. Pasang changed from subsistence farming to commercial farming with encouragement from extension services. Revenue becomes sufficient when he farms at a larger (two-acre) scale. The produce travels to the market via vegetable wholesale businesses such as Wangmo's (Case Study One). Wholesalers deliver Mr. Pasang's produce to Thimphu, the capital city. Mr. Pasang brings his first chili crop of the year to the nearby market and gauges the price, so that he fetches the best possible price from the wholesaler. Mr. Pasang earns more income than his neighbors, who still farm at the subsistence level. He practices integrated farming, preferring compost made of leaves and farmyard manure rather than inorganic nutrients.

The watershed area is a testing ground for introducing new tree crops, such as peaches, into the rice farming system. "The last batch sold like hotcakes," comments Mr. Sangay Duba. The peach variety in front of us today originated in India. Grown in Bajo, its trees produce early and each peach sells for 3 Ngultrums (Nu) each. Expatriates and locals snatch them up in the local market. Because the peaches are fresh, they are a respectable competitor for people's Nu.

The peach is one of many horticultural crops that the Bhutanese test-grow. Citrus, grapes, pears, mandarins, avocados, apples, apricots, mangoes, and other crops promise ecological and dietary benefits.

RNRRC researchers graft new varieties onto fruit trees in the station nursery. RNRRC-Bajo then gives several fruit trees to watershed households. Farmers' families grow trees in their kitchen gardens and give feedback. Kitchen gardens encourage small-scale production in the watershed, both for home consumption and for cash generation through sales in the local market. Horticultural trees produce food and help repair soil erosion in the watershed area.

"Mainly the new crops earn more income. Additional income helps the farmers to send their children to school and gives the family more options," states a farmer named Mr. Dorji through an interpreter. Mr. Dorji grows oranges and other fruit in his orchard. In the winter, he grows wheat, mustard, and buckwheat. In the summer, he grows rice and vegetables. These crops are all new; until recently, he only grew rice.

Perhaps Mr. Dorji best sums up recent changes in Bhutan's cropping patterns. "The total yield from the farm and total income for the farmer has increased." With such tangible benefits for the farmer, it seems likely that more farmers will diversify the types of food they grow and eat, building a stronger market economy and a brighter future for their children. ■

J. Gorsuch

Farmers find business opportunities and a variety of foods at local markets.

Home-grown improved varieties

increasing the rice yield in Bhutan

G. Hettel

Farmers in Bhutan integrate rice farming and livestock production.

Work to systematize Bhutan's breeding and varietal improvement began as early as 1967 with collaborators from India, on an ad hoc basis. In 1982, Bhutan took a significant step toward setting up a continuous research effort by establishing CARD at Bajo, Wangduephodrang.

Beginning with Phase I of the Bhutan-IRRI Project in 1984, researchers introduced and tested high-yielding improved varieties from other countries with similar climates, such as Nepal and the Republic of Korea. They also collected, evaluated, and preserved several local varieties of rice. Farmers liked the option of trying out new varieties in their fields because this option was relatively nondisruptive to their long-standing practices.

The IRRI-coordinated International Network for Genetic Evaluation of Rice (INGER) provided much of the seed used in improved variety trials. Bhutanese researchers sought improvements such as higher yield and related traits such as cold tolerance, blast resistance, and grain quality. Initial evaluations took place in INGER's well-established yield nurseries. Later on, Bhutan's own yield nurseries were the site of most studies.

In 1985, Bhutan and IRRI began the shuttle breeding program. Bhutan sent germplasm (seeds/plant material) for its local varieties to the Philippines, where IRRI plant breeders cross bred them with some of their improved varieties and sent back F_2 seeds for field evaluation/selection in Bhutan.

After using more than 40 traditional Bhutanese varieties as parents, the shuttle breeding program generated a lot of materials. By 1992, researchers introduced and evaluated 5,440 varieties at various re-

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RNRRC-Yusipang's seedbed near Thimphu. Here, farmers help identify rice varieties that have potential for use in Bhutan.

Grain yield (t ha^{-1}) of released varieties in farmers' field trials, 1995-98.

Breeding line/variety	1995	1996	1997	1998	Mean	% yield increase over local check
Bajo Maap-1	5.95	5.6	7.12	6.98	6.41	19.6
Bajo Maap-2	6.79	6.64	4.93	6.27	6.12	14.2
Bajo Kaap-1	7.22	5.84	6.78	7.09	6.73	25.6
Bajo Kaap-2	6.8	6.83	7.81	7.17	7.15	33.4
Local check varieties[a]	5.85	5.27	4.99	5.31	5.36	-

[a]Variety names: Zakha, Tan Tshering, local Maap, local Kaap. Source: Improved Rice Varieties Released for the Medium Altitude Valleys of Bhutan.

search stations in Bhutan. Less than 1/3 of the materials were found to contain the sought-after traits, but Bhutan now had a germplasm resource base upon which to build.

In the early 1990s, rice consumption was on the rise in the Kingdom of Bhutan. It made up about half of all cereal consumption. A steady growth in population indicated that rice consumption and imports would continue to rise. Domestic rice crop productivity was very low at 2 t ha^{-1}, and only met 52% of demand.

The Renewable Natural Resources Research Centers (RNRRCs) have been working with the Bhutan-IRRI Project toward the goal of increasing Bhutan's self-sufficiency in rice production. Due to the country's steep terrain and other factors, it is not possible to increase the acreage of rice. However, it is possible to increase yield by growing rice more intensively on existing acreage, using improved, higher yielding varieties of rice.

The year 1999 marked a milestone in Bhutan's rice improvement efforts. Through the rice varietal improvement breeding program at the RNRRCs, Bhutan formally released four promising lines for cultivation in mid-elevation (700–1500 m) valleys. Some of these lines are the result of crosses between IR64 — the most widely grown rice variety in the world — and local red and white rice varieties. These are the first ever high-yielding varieties developed entirely within Bhutan. The table compares yield performance of the new lines with a control group of farmers' local varieties, in on-farm trials. On average, the improved lines yielded 23.1% higher than the local checks. Bajo Kaap-2 produced the maximum average yield (7.15 t ha^{-1}) among the test lines. Two lines, Bajo Maap-1 and Bajo Maap-2, have red pericarp, whereas the other two are white-grained. Farmer feedback on the lines proved that they have cooking and eating characteristics similar to their local varieties. The new lines are also highly tolerant of rice blast disease.

Rice farming in Bhutan is by necessity a small-scale endeavor. Of Bhutan's total land mass (46,500 km^2, about the size of Switzerland), about 8% is arable and already under cultivation. The kingdom's mountainous terrain and its policy of capping land ownership at 25 acres per farmer makes expansion of the area under cultivation unlikely.

Better rice for integrated farming

Farmers in Bhutan view crop and livestock enterprises as "almost inseparable." Livestock farming generates farmyard manure that is useful for crop production, and crops generate plant material that is useful for fodder. The forest, in turn, provides leaves and pine needles for compost and livestock bedding material.

J. Gorsuch

RNRRC-Yusipang seedbed near Thimphu, a site for farmers' field days. Farmers' selections grow here and in other test fields.

As varietal improvement research continues, more farmers in Bhutan express their preference for qualities in the rice plant that would enhance their integrated farming system. Rice straw is an important source of food for cows during the winter months. Farmers notice that, during feedings, their cattle select medium-length straw rather than short straw. Farmers also want early-maturing varieties, which can be harvested in the mountain climate before the weather turns cold. Cold tolerance at the seedling and flowering stages are other desirable traits, as well as disease/insect resistance and the traditional taste, fluffiness, and redness found in the local rice.

Researchers selected the most promising lines and found volunteer farmers to plant them in their own fields. Partly under the farmers' own day-to-day management practices and partly under the supervision of researchers, most initial trials were conducted at a dry medium altitude of about 1000 to 1800 m. As this microclimate was only one of many in Bhutan, researchers eventually realized the opportunity to conduct more trials in a more diverse range of settings.

Lessons learned: local rice varieties and improved rice yields

Results suggested that farmers had already maximized the yield potential for their local varieties. They had had many generations to refine their farming techniques. Even with farming techniques introduced by researchers, such as the use of organic soil nutrients, yield actually decreased.

How did an increase in soil nutrients lead to a decrease in plant productivity? Rice plants grew up bigger, causing them to lodge. Lodging is an undesirable quality because it makes evaluation and harvesting of plants very difficult. It also can cause grain shattering (loss of rice grains) when the plant leans too close to the ground.

By the early 1990s, there were more trial results. These results indicated that improved varieties yielded at least 1 t ha^{-1} more than local cultivated varieties under farmers' traditional cropping techniques. The use of improved rice varieties has no doubt increased rice production, enhancing household food security and even producing small surpluses for the market.

G. Hettel

Threshing rice the traditional way, by hand. Rice varieties developed in Bhutan combine taste and color from local varieties with the higher yield of improved varieties, promising that in the future, the Bhutanese will thresh greater quantities of rice that have locally favored characteristics.

Impact: Bhutan develops new rice varieties

During the 1990s, researchers in Bhutan developed new varieties. These new varieties included Bhutanese germplasm and therefore had some of the qualities preferred by Bhutanese farmers. Some varieties produced high-yielding, white, long-grained rice and others produced red, short-grained, fluffy rice for medium to high altitudes.

Nearly all of Bhutan is feeling the impact of these pioneering efforts in varietal improvement. Nationwide, about 20% of the area under cultivation is growing the new varieties. In Wangdue-Punakha Valley, that figure is even higher at about 40%.

Over time, Bhutan's varietal release process has become more encompassing. Formerly, the Variety Releasing Committee, having more of a research and regional focus, decided which varieties of seed to release to farmers. In 2000, Bhutan's National Seed Board began as a resource for the entire nation.

The difference is that the Seed Board helps the RNR sector by standardizing the caliber of available seed. Seed Board-approved seed must meet economic and ecological criteria set by the Board. The variety under consideration must offer an improvement over local varieties in some way, have an acceptable taste, or generate higher yield.

The *dzongkhag* (district) extension supported a production evaluation trial at farmers' fields in four locations to screen for improved, blast-resistant varieties. The research team evaluated three new and promising lines along with three control (check) varieties. The new lines showed good tolerance for blast compared with local varieties.

Farmers also are involved in blast screening efforts. At a farmers' field day in 1998, several farmers expressed a keen interest in growing the advanced line IR66412-B-38-4. Various farmers in different *gewogs* of Paro *Dzongkhag* tested this line, each farmer using his/her own management techniques. As might be expected, the variety's performance varied according to individual farmer management. The variety showed a slightly late maturity, a lack of uniformity in maturity, and a difficulty to thresh. However, the variety consistently demonstrated a strong resistance to blast, and it does not shatter (drop its grains easily), meaning that farmers can wait for the maturity of late-maturing tillers.

In all, 12 improved varieties are now available to Bhutan's farmers. Currently, the most popularly grown one is IR64, developed by IRRI and valued for its high yield and compatibility with mid-altitude growing conditions. Because of the significantly higher yield of new varieties, farmers are motivated to continue their high rate of involvement in selecting rice lines.

Participatory plant breeding: farmer as teacher

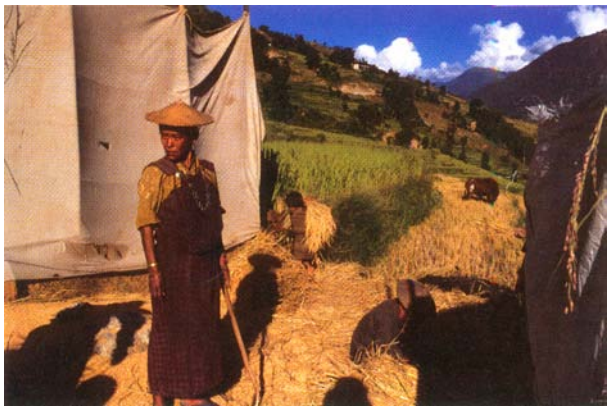
The people most concerned with the results of participatory plant breeding are usually farmers, extension agents, and researchers. At field days throughout the year, farmers and extensionists come to the research station fields and select varieties that seem the most promising for planting in farmers' fields.

Farmers often teach the research and extension staff. In one instance, a farmer selected a crossbred improved line that contained local qualities. Researchers did not consider this particular line to be good because some of its traits, such as height, were not uniform. The farmer took the seed back to his field. Over several generations of cropping, he selected seed from the best plants and grew it, developing a plant with several qualities that were desirable to researchers — and, most importantly, to farmers.

The collective effort of researchers at IRRI, in Bhutan, and elsewhere to set up a breeding program in the mountain kingdom is an example of successful technology transfer between the international community and Bhutan, and among farmers, extensionists, and researchers within its borders. In helping Bhutan to set up the basis for generating its own varieties, the Bhutan-IRRI Project has helped the country draw nearer to its goal of increased self sufficiency. ■

Rice harvesting (right). Improved rice lines developed in Bhutan will be able to resist blast in high elevation regions, while increasing yields to make the most desired qualities of rice — fluffy texture and reddish hue — more widely available to the Bhutanese, including people in remote regions (below).

G. Hettel



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Linkage

Bhutan shares tools and ideas with international organizations

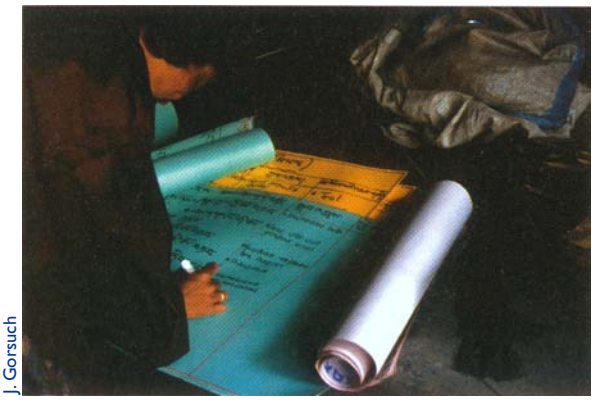
For decades, agricultural scientists have based research efforts on their best estimate of farmers' needs. A one-way flow of information from researcher to farmer produces technology that is not always useful to farmers. Today, more two-way dialogues are happening at the individual and organizational levels. The Bhutan-IRRI Project helps the Royal Government of Bhutan (RGoB) to understand and articulate the needs of Bhutan's farmers, extension staff, and researchers. Bhutan now has valuable connections with donor agencies and governments that are interested in basing agricultural research on a better understanding of farmers' needs.

The growing presence of highly trained Bhutanese is facilitating the transfer of technology inside Bhutan and in the world at large. This cooperation allows Bhutanese agriculturists to share knowledge, and to understand breakthroughs in farming practices, improved varieties, and, on a more modest scale, farm machinery. This understanding allows them to adapt these developments to the particular conditions of a farmer's field.

Farmer-to-farmer exchange

Part of the genius of Bhutan's renewable natural resources (RNR) technology transfer is its powerful use of peer information. A farmer who successfully uses a new farming technology can host a study tour for fellow farmers, who are skeptical about using it themselves until they see a peer applying it to his/her farm and getting larger or better quality crop yields.

One can readily see the effect these study tours have on farmers' fields. In one case study, a farmer with a large-scale chili plantation in Kabji *Gewog* (district block) is a role model for other farmers. After learning about the drainage bed nursery system from RNR researchers and extension staff, he successfully employs the techniques of raised beds and drainage borders. Later, farmers from the watershed come to see his farm. Formerly skeptical, they leave the study tour highly enthusiastic to get started using raised beds in their own plots. They see with their own eyes how raised bed nurseries, utilized by a farmer who is very much like themselves, really do promote better drainage, a higher density of plants, easier handweeding, and less disease among seedlings.



J. Gorsuch

A research assistant writes out presentation materials in English and Dzongkha for her talk in Dompola village, Lingmuteychu watershed.

Collaborating institutions and projects

Several externally funded projects complement the Bhutan-IRRI Project and are based in Bhutan's Renewable Natural Resources Research Centers (RNRRCs). They round out the resource base for RNRRC-Bajo's watershed research within the Bhutan-IRRI Project.

Many of these development efforts fund a particular research center in Bhutan. RNRRC-Khangma receives support from the International Fund for Agricultural Development (IFAD), by way of IFAD's Second Eastern Zone Agricultural Project (SEZAP, which works with six *dzongkhags* [districts] in eastern Bhutan). RNRRC-Jakar receives backing from a project for livestock research in central Bhutan, funded by the Swiss Agency for Development and Cooperation

(SDC, a major donor to the Bhutan-IRRI Project). RNRRC-Yusipang receives support from an SDC endeavor for forestry research.

Another important donor, German funding agency GTZ, funds and administers the Bhutan-German Sustainable Renewable Natural Resources Development Project (BG-SRDP). The project supports RNR extension programs in the Punakha and Wangduephodrang *dzongkhags*. GTZ provides basic fencing materials for regeneration of degraded areas in the Lingmuteychu watershed. The agency is also instrumental in aiding Bhutan's efforts to standardize and establish baseline measurements of its natural resources.

A key contributor toward efforts to track Bhutan's natural resources, the Danish International Development Agency (DANIDA), an agency supporting land use planning, helps Bhutan develop increasingly accurate topographical maps. In addition to making maps, the kingdom plans to set up a farmer information database, something like a farmer census listing labor, livestock, machinery, and other items per farm family. This information would give decision makers a more finely honed sense of the country's capacity for research and development activities.

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GTZ: **"The German Agency for Technical Cooperation." GTZ staff members Reinhard Wolf (left) and Abilal Baskota discuss the map in front of them, a baseline measurement of Bhutan's resources.**

That information would help people such as Deo Kumar, extension agent for Kabji *Gewog*. In a country where so much land is the domain of wild animals and insects, research from the Integrated Pest Management Development Project aids the Bhutan-IRRI Project's pest management component, as well as extension agents.

"Here in paddy, right now, there are stem borer pests in the plant nursery," Deo Kumar observes. The Integrated Pest Management Development Project, funded by the European Union, carries out research and extension on integrated pest management. It supports one national plant protection center and two regional centers. These studies grapple with the difficult problem of keeping undomesticated animals away from farms; many farms border on natural forest.

Like a wild animal, rainfall patterns are unpredictable and problematic for farmers. Because rice is such a water-intensive crop, water management is another critical research area in Bhutan. The Water Management Research Programme (WMRP) began in 1997 with assistance from the Netherlands Development Organization (SNV). It has a national mandate to perform water management research with its coordination based at RNRRC-Bajo. The program has had strong links with the Bhutan-IRRI Project. Although WMRP ended in December 1999, the Bhutan-IRRI Project builds on WMRP's work by studying water management in the Lingmuteychu watershed.

Horticultural research efforts are another way to improve the conditions of integrated rice farming systems such as the Lingmuteychu watershed. Farming communities receive ecological benefits from having tree roots grow in the nearby ground and hold the area's soil in place. The nationwide Horticultural Development Project, assisted by the United Nations Development Programme, links with RNRRC-Bajo to support its research on fruits such as citrus, stone fruit, and others.

Communities in the watershed now are test-planting material that RNRRC-Bajo produces in its station test fields. The research center in Bajo is the focal center for vegetable field crops research, and collaborates with projects supported by the Asian Vegetable Research and Development Center and the International Potato Center (CIP).

Along with vital support from donors, the Natural Resources Training Institute (NRTI) and the RNRRCs are important technology transfer resources for many Bhutanese. NRTI provides vocational instruction in agriculture. Its trainees are former students of the regular educational system, leaving their formal studies due to a lack of interest or other factors. These agricultural apprentices receive training at various vocational training centers, including NRTI. The institute produces written extension training materials, extracted from RNRRC research information. NRTI often invites guest lecturers from the research centers to instruct trainees in the researcher's area of expertise. In return, RNRRC staff develop contacts with Bhutan's future extension staff.

NRTI and the RNRRCs also work together as a team to offer refresher courses for current extension staff. These courses introduce the latest technologies in forestry, livestock, and agriculture. Given the number of students (60 per year) who have graduated from NRTI's training for new extension staff over the past 15 years, refresher courses will become increasingly important in Bhutan.

What inspired Bhutan's decision makers to establish these vocational training opportunities? Many of Bhutan's schoolchildren come from farming families. However, the parents of these children prefer for them to go to school rather than stay home and learn to farm. Over time, this preference causes a farm labor shortage. At the same time, some children drop out of school and then lack both an educational background and farming skills.

The agricultural research centers and NRTI shoulder a share of the state's concern about school dropouts. RNRRC-Bajo's approach is proactive and it complements NRTI's. The Bajo center works with primary schools to offer horticultural experience in the actual schoolyard. In Wangduephodrang Valley, several schools have fruit trees and vegetable plots on their property. Formal agricultural training gives children a farming experience they seldom receive at home, and provides an option for them later on should they decide to pursue a career in agriculture instead of their regular studies.

Bottom line: project management and funding

Sangay Duba, head of RNRRC-Bajo, notes that the IRRI-managed Bhutan-IRRI Project has offered a lot of advantages. IRRI's management of project funds has been "exemplary for us. IRRI management enables RNRRC-Bajo to build the national contribution to the research system. The IRRI-managed budget has allowed Bajo to build [the] RGoB's contribution to recurrent and some capital costs."

IRRI also has been able to ensure the quality of equipment that Bhutan buys, and sends scientists to Bhutan quickly in the case of urgent developments, for instance during Bhutan's rice blast epidemic of 1995. RNRRC-Bajo has appreciated the timely, rapid access to project funds when IRRI administered the project, and also the flexibility.

A testament to both the progress and the continuing need of Bhutan's resource management sector, RNRRCs have prepared themselves for a major change in the Bhutan-IRRI Project's day-to-day administration.

In 2000, the project management arrangement changed. The RGoB took over administering the work initiated by the Bhutan-IRRI Project. RNRRC-Bajo hopes that the new financial management system will continue to be timely, allowing the project to meet its objectives on time. Given agricultural research's seasonal activities such as rice transplanting, timely access to resources is especially critical.

Bhutan's government knows that the output of its research system is substantial. It currently contributes 7 million Nu (about $163,000) annually to Bajo, its flagship research center. Now the Ministry of Agriculture plans to distribute funds on a program-by-program basis. The Research and Development Department will have a funding pool for which each RNRRC makes a case in order to get funding. SDC supports this change, and funds field crop research under this system. So long as the total budget is substantial, national administration of funds will go smoothly, allowing information sharing and technology transfer to continue improving the lives of future generations. ■

Community-based natural resource management

environmental protection through teamwork

Now that Bhutan has resources in place to sustain its own renewable natural resources (RNR) research system, decision makers can foster a localized, grassroots approach to Bhutan's natural resource problems. The kingdom continues its quest for long-term sources of funding, but it is a powerful testament that Bhutan's leadership now has a foundation on which it can build, bringing more knowledge and resources to the community.

Community-based natural resource management (CBNRM) centers scientific investigations on a well defined local area, which minimizes logistical problems during research. These localized studies strengthen farmer participation, support a more interdisciplinary approach to research, and reinforce linkages between farmers, extensionists, and researchers. The goal of this approach is to understand better the interaction between resources and users on the scale of a watershed, as well as the interaction between and use of off-farm and on-farm resources.

To initiate CBNRM in Bhutan, researchers have focused on the Lingmuteychu watershed, an area above the Wangduephodrang Valley, since 1997. Major research themes at this location include

- Agroforestry and community forestry
- Crop-livestock interaction
- Field crops establishment and management
- Institutional and social analysis
- Integrated nutrient management
- Resource mapping of Lingmuteychu watershed
- Water management

Agroforestry / community forestry and water management efforts show how community education and empowerment can result in more sustainable and productive uses of land.

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Village women carry baskets of tree seedlings along the slope at Lingmuteychu watershed. These seedlings offer hope for restoring degraded areas.

Community forestry: history, hope

Not long ago, the Bhutanese celebrated two special events on the same day: their King's coronation anniversary and Social Forestry Day. At the Lingmuteychu watershed, about 55 local villagers and Bajo researchers planted several varieties of native trees. More than 1,000 poplar, oak, *leucaena*, and pine seedlings became planted offerings in honor of the two national holidays. This local event played a small but important part in the country's progress toward self-sufficiency and sustainable resource use.

This community forestry planting is part of the Bhutan-IRRI Project's effort to protect the nation's natural resources and to understand better the role they play in the integrated farming system. In 1998, the Bhutan-IRRI Project and the Bhutan-German Sustainable RNR Development Project jointly conducted a participatory rural appraisal (PRA) of the Lingmuteychu watershed area. For the first time, researchers studied Bhutan's forest resources in depth. Participants identified badly degraded land that needed long-term care if it were someday to provide a livelihood for future generations.

Forestry as part of integrated farming: greening the Omtekha slope

Gazing at the bristly grass and streaks of red clay soil, it's hard to imagine the Omtekha slope as the lush forested area it once was. Today the slope is degraded due to overuse, with local villagers cutting down trees faster than they can grow back. It's now used primarily as a grazing area for cattle.

The Bhutan-IRRI Project's tree plantings aim to reverse the degradation of forest areas that are closest to farms. Damage to these areas has caused soil erosion, as well as a lack of nearby leaves for use as compost in the integrated farming system. Also, villagers must now go farther from their village to gather timber for house construction. Some areas traditionally dismantle and reconstruct their farmhouses about every 25 years (the lifespan for untreated timber as well as the approximate amount of time it takes for the next generation to start his/her own family and take over the farm).

"With the barbed wire fencing alone the grasses' natural regeneration can occur," observes Mr. Sangay Duba, program director for RNRRC-Bajo. With help from BG-SRDP, the Bhutan-IRRI Project has set up barbed wire fencing to keep grazing cows out of the area designated for regeneration. To minimize the degradation of the Omtekha slope, the local community has committed to reforesting degraded areas that were formerly used for grazing. The labor force of village volunteers supplies about 30 workdays of labor per household, per planting season. Adds Sangay Duba, "A community nursery maintained by the user group of villagers allows them to grow any species that they wish to grow."

Excessive tree logging contributes to land degradation. DFS has a mandate to protect all of the country's forests from illegal harvesting of trees. It recently introduced scientific forest management plans to help its few hundred forestry officers more effectively patrol a large acreage of woodland.

Even those who cut down trees legally are contributing to the problem. Understandably but also unfortunately, villagers select the best individuals of the best tree species for their daily use, taking many hardwoods and leaving less desirable species. Over time, this preference for hardwoods depletes forest quality and biodiversity.

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No irrigation here: carrying water for tree seedlings on Lingmuteychu slope.

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One last soak to prepare tree seedlings for transplanting on the dry, wind-exposed slope.

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A newly planted tree seedling represents hope for the site's future.

Early CBNRM efforts are showing some encouraging indications that a little community awareness goes a long way toward reversing the degradation of these forests. The 1998 diagnostic PRA of the Lingmuteychu watershed not only identified degraded areas, it also increased farmers' awareness of the impact their actions can have on others. Farmers now think twice before felling a tree, aware of the implications that action would have for future generations.

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Availability of water varies greatly from season to season in Bhutan.

Water management: community property rights, community involvement

Rice transplanting uses more water than any other part of the rice cropping cycle. Farmers maintain more than 100 mm of standing water in rice fields after transplanting. Traditional water allocation practices among community members, as well as local rainfall patterns, constantly test the resourcefulness of Bhutan's farmers.

One challenge to achieving CBNRM objectives is the lack of regulations that address the more intense cropping patterns adopted in recent years. The Land Law of Bhutan, enacted in 1979, covers certain aspects of forestry, irrigation, and grazing. However, it does not address conflicts that arise between long-standing, informal community agreements and the RGoB's goal of equitably distributing resources such as water.

Some informal agreements, in place for several generations, allocate water resources based on the actions of distant ancestors. Descendants of a community member who worked on building a water canal several generations ago may have more water rights than the descendants of villagers who didn't volunteer to build the canal. These agreements allow a few farms in an area to get most of the irrigation water, even if other farms have a greater need. Bhutan is currently reviewing its laws and considering ways to promote sustainable use of the kingdom's resources while continuing to honor its traditions.

In 1997, researchers conducted a diagnostic study of priorities and conflicts among Lingmuteychu watershed communities that share a single water source, the Limtichu. The Limtichu originates as a spring out of a rock face, at about 2400 m above sea level on the Antakarchhu and Darchula ranges. Rainfall is the

The Rice Transplanting Process

Farmers in Bhutan start their seedling beds several months in advance of the rice transplanting season. Seedling beds give the rice seeds a chance to germinate and begin growing in a more protected environment. Farmers must transplant their seedlings from the beds to the paddy fields between late June and mid-July. To transplant rice, the farmers gather seedlings from the seedling beds and bundle them together. They then plant seedlings in a flooded field at regular intervals, spacing them several centimeters apart. Bhutanese farmers harvest their crops of rice by the end of October, just before the weather turns very cold.

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Farmers bundle rice seedlings. CBNRM helps farmers to manage water more effectively so that they can continue growing the food they need.

only source for the spring; no permanent snowfield feeds into the Limtichu.

Researchers found that water shortages during rice transplanting are the main constraints to crop production in the watershed. The diagnostic study team decided to carry out a water balance study at the watershed level to gather information on water shortages. A better understanding of these water shortage patterns would help villagers and researchers to plan the most effective intervention activities. The water balance study surveyed flow in the Limtichu, conveyance efficiency of some irrigation channels, and farmers' management practices. It also looked at on-farm water use in wheat and mustard, irrigation of winter crops, irrigation canals, and soil erosion and gully formation due to irrigation/drainage/tail water.

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Wood shingles are among the many products the villagers make from local trees. Villagers use rocks to hold shingles in place during strong winds.

Overall, water shortages in the watershed are due to the one month difference between the peak transplanting period (June) and the peak monsoon period (July). Farmers cannot plant their currently used rice varieties after June because of cold temperatures that would occur at the crop ripening stage.

Researchers found that farms located closer to the water source can access enough water to meet the farms' needs. Farmers farther down from the source increasingly face water scarcity. Researchers also found that farmers were using too much water during transplanting, and maintained too much standing water afterwards. Further studies showed that using a lower, more optimal water level also helped control the incidence of *sochum*, an aquatic, broadleaved weed.

Grassroots input: farmer committees at village level

As more local villagers combine modern technology with traditional practices, they make a greater number of decisions at the community level, beyond the boundaries of their own land plots. The organization of Bhutan's RNR sector encourages regular input from community members in the form of community committees. These committees meet regularly: some once a year, others as frequently as once a month. Coupling scientific knowledge and community involvement has proven an effective, flexible way to address resource issues of a region, even as those issues change over time.

"At the local level we have what we call [the] Block Development Committee," explains Sangay Duba, program director of the research center in Bajo. "It is made up of the *gup* who's the chairperson, *chepeons, tshogpas*, the school headmaster, and the extension agents." Nado, a participant at Social Forestry Day, is the *gup* for Limbu *Gewog* (district block), which encompasses six villages. In each village, she/he has a *chepeon* who communicates with farmers, the *gup*, and people outside the village. Sangay explains further, "We have field representatives, elderly from the villages who are really experienced. [The] assistant *gup* we call *mangiap*, who acts on behalf of the *gup* in his absence. He can also make some decisions."

Kinlay Dorji, a farmer, describes through an interpreter his own involvement. "When the reforestation project started in 1996, our goal was to manage the tree plantation according to our management plan." Kinlay is a users group chairperson. His group meets at least once or twice a month; if important matters come up, the group meets more frequently. "We want to protect our resources for future use, for grazing, community use, etc."

How was he chosen? The village identified a person who could read and write in *Dzongkha,* and had forestry experience and respect. Kinlay tells of the user group's achievements. "Four to five years ago the land was degraded and we villagers never thought of having this plantation. With the Bajo research center's input, we now have 30 acres of reforestation project. The village would cooperate with the financiers on future projects. We are very grateful to RNRRC-Bajo, IRRI, IDRC, and SDC."

Bhutan's continuing transformation demonstrates how much change the country is accomplishing in a fairly short time. In just a few decades, Bhutan is learning to combine landmark scientific breakthroughs, such as improved rice varieties, with its own centuries-old sustainable resource management practices. In the future, Bhutan's progress is certain to inspire developing countries and donors to use both local tradition and modern know-how to meet the day-to-day needs of our world's people. ■

J. Gorsuch

Traditional songs link past, present, and future on Social Forestry Day.

Glossary of acronyms and terms

Agrobiodiversity	A new program (1997) of Bhutan's Ministry of Agriculture. Agrobiodiversity will be linked to the Rice Biodiversity Program and its main output will be to set up a gene bank linked to the national herbarium.
BG-SRDP	Bhutan-German Sustainable RNR Development Project
CARD	Bhutan's Center for Agricultural Research and Development, founded in 1982 and later transformed into RNRRC-Bajo. It was the first-ever center designed to undertake systematic agricultural research in Bhutan.
CIP	Centro Internacional de la Papa (International Potato Center) in Peru, one of 16 centers within the Consultative Group on International Agricultural Research (CGIAR) system.
DFS	Department of Forestry Services, part of Bhutan's RNR Sector
Dzongkha	The national language of Bhutan
Dzongkhag	Yargay Tshogchung districtwide discussion forum for farmers in Bhutan, established in 1981
GDP	gross domestic product
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit, GmbH (German Agency for Technical Cooperation)
Gewog Yargay Tshogchung	Areawide discussion forum for farmers in Bhutan, established in 1991
IDRC	International Development Research Centre — a Canadian agency supporting applied interdisciplinary research on natural resource management. A major donor to the Bhutan-IRRI Project.
IFAD	International Fund for Agricultural Development, an agency that supports RNRRC-Khangma.

IRRI	International Rice Research Institute — a major collaborator on the Bhutan-IRRI Project. It is one of 16 centers within the Consultative Group on International Agricultural Research (CGIAR) system.
lodging	The process by which a plant becomes top heavy and leans close to the ground. Lodging makes it difficult toevaluate and harvest plants. It also can cause shattering (loss of seeds).
MoA	Bhutan's Ministry of Agriculture
NPK	Periodic table symbols for the elements nitrogen, phosphorus, and potassium. These three elements are essential components of crop soil.
NRTI	Bhutan's Natural Resource and Training Institute
Nu	Ngultrum, the national currency of Bhutan. Its exchange value is the same as that of India's currency, the rupee.
PRA	Participatory rural appraisal — a farming systems analysis method by which farmers share, enhance, and analyze their knowledge of environments, production systems, practices, and constraints
REID	Research, Extension and Irrigation Division of the Ministry of Agriculture
RGoB	Royal Government of Bhutan
Rice blast disease	The most destructive disease of rice. It exists in virtually all rice-growing countries. The fungus *Pyricularia grisea* causes rice blast disease, which can affect all aboveground parts of the rice plant. Manifestations of blast earlier in the crop cycle may include "leaf blast" or "(leaf) collar blast." In later developmental stages of the rice crop, the fungus can infect other parts of the rice plant, causing "(stem) node blast," "base of the panicle neck blast" and/or secondary panicle branches "panicle blast." The name "blast" describes the appearance of affected fields that appear to have been "blasted" by a flame-thrower. Node and neck blast epidemics are the most economically damaging as they occur when the crop enters the reproductive phase. The blast fungus is usually present every year in most areas. Several factors must exist in order for an epidemic to develop.
RNR/RNRRC	Renewable natural resources/Renewable Natural Resources Research Center

SDC	Swiss Agency for Development and Cooperation, a major donor to the Bhutan-IRRI Project.
SNV	Netherlands Development Organization
Social Forestry Day	June 2 every year, it is the anniversary of the coronation of Bhutan's King Jigme Singye Wangchuck as well as a celebration of the nation's forest. On this day, communities throughout Bhutan plant trees in honor of their King and their forest.
Tashi Delek	An auspicious greeting in Dzongkha meaning good wishes, congratulations, and may many good things come to you.

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more information about Bhutan's RNR sector

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