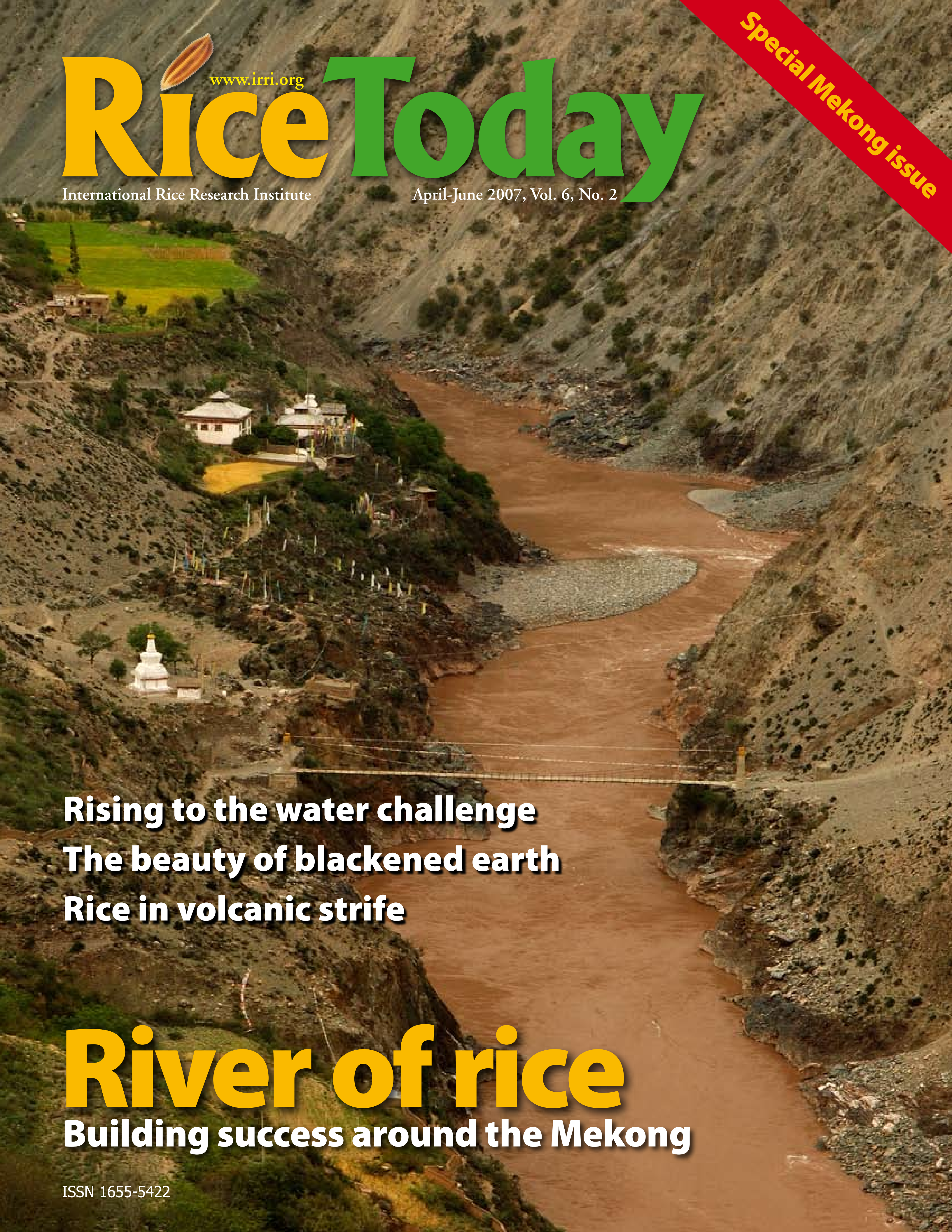

Rice Today

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Special Mekong issue

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Rice in volcanic strife

River of rice

Building success around the Mekong

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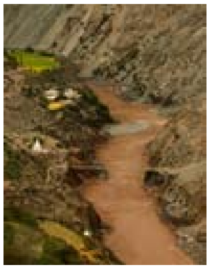
On the cover:
The Mekong River, the world's 13th longest (4,200 km) and 10th largest by volume, winds through extreme northwestern Yunnan Province, China, beginning its 3,400-km journey to the South China Sea through the six countries of the Greater Mekong Subregion. Learn about IRRI's work here on pages 14-22.



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Rice and life along the Mekong River

The astonishing success of the Green Revolution, particularly in India, is well known. Not so well known is how rice researchers have helped much of the Greater Mekong Subregion (GMS)—which comprises Cambodia, Laos, Myanmar, Thailand, Vietnam, and China's southern provinces of Yunnan and Guangxi—reclaim the food security it had lost during many years of strife.

In the 1970s, brutal totalitarianism caused widespread and devastating famine in Cambodia. Desperate farm families consumed their rice seeds and many traditional rice varieties became impossible to find. In the 1980s, the International Rice Research Institute (IRRI) reintroduced more than 750 traditional rice varieties to Cambodia from its seed bank in the Philippines—a vivid demonstration of the foresight that created the bank in the 1960s.

The reintroduction of indigenous varieties to Cambodia was only a first step toward recovery. In 1987, the Australian government, through the Australian Agency for International Development, began funding IRRI's activities to assist Cambodia in what eventually came to be known as the Cambodia-IRRI-Australia Project. Through the introduction of improved varieties, better crop management, and extensive training programs, the main project goal was achieved in 1999 when Cambodia became self-sufficient in rice for the first time in 30 years.

Likewise, the Lao-IRRI Rice Research and Training Project, funded by the Swiss Agency for Development and Cooperation (SDC), helped Laos achieve food security. When the project began in 1990, Laos was producing only 1.5 million tons of rice per year. Technical assistance, including the release of new improved rice varieties developed in Laos, increased rice production dramatically. The 5% annual increase in rice production outpaced the population increase of 2.4% so that, by 2000, Laos reached rice self-sufficiency, with record production of 2.1 million tons. By 2004, Lao farmers had attained an annual production of 2.5 million tons.

In addition, in 1995-2000, SDC funded the collection, identification, and preservation of indigenous rice accessions in Cambodia, Laos, Myanmar, Thailand, and Vietnam, along with other countries in Asia, Africa, and Central America. The most significant accomplishment in this effort was the rescue from oblivion of more than 15,000 rice samples from Laos, which are now maintained in-country by the Lao government's Agricultural Research Center, with a duplicate collection housed at IRRI's International Rice Genebank in the Philippines. These collections of rice biodiversity are not only invaluable sources of breeding material; they also serve as insurance against future disasters.

Vietnam became the world's second-largest rice exporter through ambitious irrigation schemes and the widespread adoption of high-yielding rice varieties from IRRI. Thailand, the world's largest rice exporter, incorporates breeding materials from IRRI as part of its own rice breeding program, and many of Thailand's top rice researchers were once IRRI scholars. In China, researchers at Yunnan Agricultural University collaborated with IRRI scientists to successfully combat the devastating rice blast disease by interplanting traditional and hybrid varieties.

All of these achievements laid a foundation for future success in the GMS, which received a major boost in January 2007 with the opening of the IRRI-GMS Office in Vientiane, Laos, and the dedication of new facilities at the Cambodian Agricultural Research and Development Institute in Phnom Penh. Beginning on page 14, read about what these developments will mean for many of the 300 million people living in the GMS.

Gary C. Jahn

Gary C. Jahn
IRRI representative and coordinator for the
Greater Mekong Subregion

IRRI Greater Mekong Subregion Office
International Rice Research Institute


GENE HETTEL

Perpetual funding for IRRI genebank

An unprecedented new agreement involving the annual dispersal, in perpetuity, of US$600,000 was unveiled on 12 March 2007 to help fund the protection and management of the world's thousands of rice varieties.

IRRI and the Global Crop Diversity Trust announced the historic agreement at a special dedication ceremony at IRRI's Genetic Resources Center (GRC), which houses more than 100,000 samples of rice, the biggest and most important collection in the world.

The agreement offers stable, long-term support to a collection of genetic diversity that is estimated to include at least 80,000 distinct rice varieties. The collection is kept in a special earthquake- and fireproof facility that is maintained at temperatures as low as –19 degrees Celsius.

On the same day, IRRI also dedicated the GRC to Te-Tzu Chang, the founder of the International Rice Germplasm Center—one of the predecessors of the GRC. Dr. Chang, who passed away last year in Taiwan, China, was a world authority on rice genetics and conservation. He spent 30 years at IRRI collecting and storing rice varieties from all over the world. From now on, the GRC will be known as the T.T. Chang Genetic Resources Center.


DEAN CHANG, eldest son of T.T. Chang, shows a genebank rice sample to his children, Nathan and Erica, as his mother, Nancy, looks on.

JOSE RAYMOND PANALIGAN

The agreement, the first major conservation grant made by the Trust, reflects the long-term vision of both organizations. "Short-term thinking about funding has wreaked havoc with effective conservation," said Cary Fowler, the Trust's executive secretary. "This agreement is probably unique among funding contracts in having no end date."

Under the agreement, IRRI has pledged to generate $400,000 annually to be invested in the genebank, which will unlock $200,000 from the Trust each year. The agreement allows for inflationary increases and will remain in force "indefinitely." Uses for the money will include acquiring any rice varieties not currently in the repository and making sure the storage systems for long-term conservation are up to international standards.

"The rice genebank is not just a scientific exercise in seed genetics but a major hedge against disaster that ensures that farmers throughout the world will always have the rice varieties they need to maintain food security," said IRRI's Director General Robert Zeigler. "Rice diversity, like all crop diversity, is at risk for the want of relatively small amounts of money. Given that we are talking about the biological base upon which the global food supply is built, it is extraordinary that the current situation is so precarious."

Mekong branch office opens


DR. JAHN (*left*) participates in a Lao *Basi* ceremony.

GENE HETTEL

The Luang Prabang, Laos, Branch of the IRRI-Greater Mekong Subregion (GMS) Office was officially opened at a ribbon-cutting ceremony on 7 February 2007. IRRI is expanding its activities in the GMS, which comprises Cambodia, Laos, Myanmar, Thailand, Vietnam, and China's southern provinces of Yunnan and Guangxi (see *Rice and the river* on pages 14-22).

Bounthong Bouahom, director general of the National Agriculture and Forestry Research Institute and Gary Jahn, IRRI representative and coordinator for the GMS, cut the ribbon in front of 40 guests, including representatives of Lao organizations that work with IRRI. The ribbon cutting was followed by a traditional Lao *Basi* ceremony, in which the community joins together to welcome and offer good wishes to new ventures.

The office is staffed by agronomist Benjamin Samson, accountant Ounheuane Phouthachit, and driver Sommay Yasongkua. Randy Ritzema and Hidetoshi Asai, Ph.D. students from the University of California, Davis, and Kyoto University, respectively, are also based in the new office.

Stocks falling, prices rising

The international rice market is on a bull run, with a continuous upward trend in prices since 2002. The price for medium-quality rice has reached nearly US$300, the highest level since 1996, and 70% higher than in 2001, when it reached record lows. The production of rice has remained below its demand for most years since 1998. Supply has therefore been matched with demand by depleting stocks, which have reached alarmingly low levels—close to those of the early-1970s oil crisis.

The tight supply situation compared with demand, and consequent high and rising prices, is causing serious concern for low-income rice-importing countries (such as Indonesia, the Philippines, and Bangladesh).

According to the December 2006 *Food Outlook* report of the Food and Agriculture Organization of the United Nations, cereal prices are at their highest levels in a decade.

Production and supply constraints, including typhoons, floods, drought, diseases, and insect attacks, resulted in stagnating rice production in Asia in 2006. As a result, little overall growth is currently expected in the region. The production forecast for Asia has been downgraded to 570 million tons—only half a million tons less than last season's level, but well below earlier expectations.

The report warned that global stockpiles at the close of the 2007 crop seasons are set to be cut to less than 105 million tons. This is slightly below their opening level, and counter to previous expectations of rebuilding. The change in outlook stems from deteriorating crop prospects in several major producing countries, many of which will be forced to further use their reserves to meet domestic consumption and, for exporters, export demand (see *Rice Facts* on page 37).

Increased yields with elevated CO_2?

ARIEL JAVELLANA

Two recent studies on the effects of elevated carbon dioxide (CO2) on rice give some cause for optimism about the impact of climate change on rice production. In issue 118 of the journal *Agriculture, Ecosystems and Environment, Shimono et al report the results of a* "Free-Air CO2-Enrichment" (FACE) experiment that examined the effect of atmospheric CO2 enrichment on lodging (falling over) in a Japanese variety grown in Iwate, Japan. As expected, under a high-nitrogen fertilizer regime—which may be necessary for the increased growth rates anticipated in high-CO2 conditions—plants grown under current CO2 conditions were more likely to lodge. However, under high CO2, part of the rice stem became significantly shorter and thicker, thereby protecting against lodging.

In issue 100 of *Field Crops Research*, Yang et al performed a FACE experiment to examine the effects of elevated CO2 on rice yields in Wuxi, China. The researchers found that nitrogen uptake under high-CO2 conditions was generally enhanced, leading to average yield increases of 13%. The authors suggest that, under conditions of higher atmospheric CO2, nitrogen fertilizer recommendations will need to be altered to take into account the plants' increased growth rate.

Although these results are encouraging for rice production, several studies have reported that potential gains may be countered by declining yields caused by the warmer temperatures predicted under higher CO2 conditions.

More GM problems in U.S.

As Bayer CropScience continues to face lawsuits from disgruntled rice growers over contamination of commercial stocks by the company's LLRICE601 genetically modified (GM) rice, another contamination event has unsettled the U.S. rice industry.

Trace amounts of another Bayer GM rice, LLRICE62, were found in Arkansas stocks of German company BASF's Clearfield CL131 rice, which is not GM. The U.S. Department of Agriculture consequently ordered no planting or distribution of CL131 seed.

The LLRICE601 contamination has hit U.S. rice growers, who have since faced export hurdles in GM-wary Japan and Europe. Now, with two of the most popular seed varieties banned (CL131 and Cheniere, the only variety so far subject to LLRICE601 contamination), a significant proportion of the seed supply is off the market. Industry analysts are worried that, with spring U.S. rice plantings already down an estimated 10–20%, U.S. rice supplies could be very tight in the coming crop year.

BRIEFLY

Early Chinese farming

Analysis of charred plant remains collected from the Yiluo valley, northern China, has revealed that modern rice (*Oryza sativa*) was introduced around 3000 BC, but at the time was not an important local crop. The study, reported in the 16 January 2007 *Proceedings of the National Academy of Sciences of the USA*, used radiocarbon dating to determine historical agricultural trends. Typical northern China agriculture, which emphasized dry crops (millets, wheat, legumes) with some rice, appears to have been established at the latest by the Early Shang period (1600–1300 BC).

Rice bran cuts cancer in mice

The *British Journal of Cancer* has reported preclinical evidence that rice bran has a positive effect on intestinal cancer. The study, conducted at the University of Leicester's Department of Cancer Studies and Molecular Medicine, demonstrated that, by consuming a daily dose of rice bran, the number of precancerous adenomas in the stomach and large intestine of mice was cut by half, on average, compared to mice on the control diet. The effect was dependent on the fiber content of the bran, about 29% in this case. The results were published in the journal's 9 January 2007 online edition. More research is planned.

GM rice for the Philippines?

The Philippine Department of Agriculture is reviewing an application for commercial production of the first genetically modified rice to be grown in the country. The Bureau of Plant Industry is investigating the technology, developed by Bayer CropScience, to check that it is safe for humans and the environment.

Rice boost for Brunei

A rice variety derived from a breeding line developed at IRRI is set to contribute to Brunei's rice production. Brunei Darussalam Rice One achieved good results in farm tests in four districts. The high-yielding (4–6 tons per hectare) variety is resistant to waterlogging, is fertilizer-responsive, and can be grown year-round. It also has a short field duration (around 90 days) so it can be grown two to three times a year under irrigated conditions. The grain size is similar to that of basmati rice and preliminary taste, texture, and scent tests were positive.

Chinese GM rice on hold

The commercial production of genetically modified (GM) rice in China has been put on hold again. A report by the Xinhua News Agency quoted Lu Baorong, a member of the State Committee for the Safety of Agricultural Transgenic Living Things, as saying that the application for commercialization was rejected in November 2006 "because some safety-related data were missing." However, a variety of pest-resistant GM rice was approved for experimental production, the last step before commercialization can be granted.

Human genes for pharmaceutical rice

The U.S. Department of Agriculture has given preliminary approval to the production of rice engineered to contain human genes. California-based biotechnology company Ventria Bioscience wants to grow the rice in Kansas, where officials have welcomed the project.

The rice would contain genes that produce human immune-system proteins—including antibacterial compounds found in breast milk and saliva—in its leaves. These would be harvested and refined for use in medicines to fight diarrhea and dehydration, which kill more than a million infants and toddlers each year in developing countries.

Environmentalists and food and consumer advocacy groups are worried that the genes could be transferred to food crops and enter the food chain. Although not inherently dangerous, there is potential for the proteins—especially if consumed in unregulated doses—to cause allergic reactions, say critics.

When Ventria Bioscience tried to grow the crop in southeast Missouri, Anheuser-Busch, maker of Budweiser beer and the largest domestic rice consumer in the U.S., threatened to boycott all rice from the state if the plan was allowed. However, because no commercial rice is grown in Kansas, there is no threat of contaminating other rice crops.

A Peruvian study, sponsored by Ventria Bioscience, concluded that children with severe diarrhea recovered 1.5 days earlier if the salty rehydration fluids they were administered were supplemented with the rice-grown proteins.

Ventria Bioscience claims that plant-based production is far cheaper than other methods, and would help make the medicine more affordable in the developing world.

The Department of Agriculture's draft environmental assessment, published on 28 February 2007, concluded that the project posed no undue risks.


JOSE RAYMOND PANALIGAN

INTO AFRICA: With the imminent closing of IRRI's book storage facility at the Institute's Philippine headquarters, more than 17,000 IRRI books (with a retail value of more than US$180,000) were sent via sea freight in February 2007 to IRRI's new East and Southern Africa Region office in Mozambique. From there, Joe Rickman, IRRI representative for the region, is redistributing the books—seen above being boxed at headquarters in preparation for shipping—to understocked libraries of local agricultural organizations. Glenn Gregorio, IRRI rice breeder based at the Africa Rice Center's office in Nigeria, is arranging a similar shipment to West Africa. There will also be smaller shipments to IRRI's 11 country offices in Asia. New IRRI policies on publication press runs and printing negate the future need for a book storage warehouse.

DNA on the cheap

To aid marker-assisted breeding programs in developing-country research institutes, IRRI has identified simple and cheap methods for extracting DNA from rice seedlings. Six methods were evaluated for yield, purity, time required, cost, and ability of the extracted DNA to be amplified to diagnostically useful quantities. The best results were achieved by the so-called NaOH-Tris method and an IRRI-developed method, but NaOH-Tris was almost one-third the IRRI method's price. The researchers, publishing the results in the journal *Plant Breeding*, therefore recommended the NaOH-Tris method for use in many applications of marker-assisted selection or high-resolution mapping.

The future of Thai rice

Government rice stocks were scheduled to be traded for the first time via the Agricultural Futures Exchange of Thailand (AFET) in March 2007. Rice futures contracts have been traded since late 2004 on the AFET, which would trade only 40,000–60,000 tons of the government's 3-million-ton stockpile. The move is designed to boost trading on the commodity futures exchange, which has fallen due to the declining prices of several key commodities, especially rubber.

No futures for Indian rice

Meanwhile, India has banned futures trading in rice and wheat in an attempt to curb the fastest inflation seen for 2 years. Trading was due to stop once existing contracts expired on the nation's three exchanges. Spiraling wheat, rice, sugar, and pulse prices, which put pressure on the government, prompted the move.

Australian rice doldrums

The U.S. Department of Agriculture Grain Quarterly Update 2007 has forecast Australia's 2007-08 rice production at 126 million tons—a dramatic decline of around 90% from the 1,048 million tons estimated for the previous year. The fall is largely due to an extreme shortage of irrigation water and severe drought conditions during the crop cycle.

Rice for East Timor

The Timorese government, with assistance from the United Nations, received a 300-ton rice shipment in February 2007, following a rice shortage and rising prices. Provided by the World Food Program, the rice was distributed and was set to be sold at US$2 per 5-kilogram bag. This contrasts with recent prices as high as $1 per kilogram. The shortage was thought to have been driven by a later-than-usual harvest in rice-exporting Vietnam.

Africa Rice presentations

Presentations from the first Africa Rice Congress, held in Tanzania from 31 July to 4 August 2006, are now available online at *www.warda.cgiar.org/africa-rice-congress/presentations.html*.

Cambodia honors former IRRI leaders

For their contributions to the revival of rice research and development in Cambodia, Prime Minister Hun Sen (photo, *right*) recognized former IRRI directors general M.S. Swaminathan and Ronald Cantrell by bestowing on them the Royal Government of Cambodia's Sahametrei Medal (pictured, *left*). The prime minister made the announcement during ceremonies that inaugurated the new facilities of the Cambodian Agricultural Research and Development Institute (CARDI) in Phnom Penh on 9 January 2007 (see *Research: Cambodia ushers in new era* on page 16). Dr. Swaminathan was one of the driving forces in CARDI's inception when, back in 1987, he proposed establishing the project design team to prepare a plan to set up CARDI. Dr. Cantrell, who was IRRI director general in 2000 when CARDI officially opened, was instrumental in strengthening IRRI's partnership with the fledgling institution.

GENE HETTEL (2)

Wolf Prize for Agriculture to IRRI Board member

ARIEL JAVELLANA

IRRI Board of Trustees member Ronald Phillips (*pictured*) has been awarded the 2006-07 Wolf Prize for Agriculture. Dr. Phillips, of the University of Minnesota, has served on the IRRI Board since 2004 and is currently chair of the Program Committee and vice-chair of the Executive Committee. He won the prize jointly with Michel Georges of the University of Liège, Belgium. Both winners, who will share an honorarium of US$100,000, were cited for their "groundbreaking discoveries in genetics and genomics, laying the foundations for improvements in crop and livestock breeding, and sparking important advances in plant and animal sciences."

Dr. Phillips was the first person to generate whole maize plants from cells grown in culture, which sparked the use of cell-culture methods to genetically modify maize plants and other cereals. Fundamental studies in Dr. Phillips's laboratory have identified cells and plants with increased levels of essential amino acids and led to the development of an efficient DNA sequence mapping system used by plant scientists in genomics research. Dr. Phillips is also world-renowned for his leadership and service in the field of plant science within international agricultural research communities and for his teaching and student training in plant genetics.

Award winner to join IRRI

The important role, and impact, of women in rice research has been highlighted with the awarding of the L'Oréal-UNESCO Women in Science awards for 2007 (UNESCO is the United Nations Educational, Scientific, and Cultural Organization). One of the women recognized—Gisella Cruz García, 29 (*pictured*), a Peruvian scientist studying at Wageningen University in the Netherlands—will carry out her Ph.D. fieldwork in cooperation with IRRI. She will join the Institute at its Philippine headquarters in late 2007.

L'ORÉAL-UNESCO

The award will enable Ms. Cruz García to further her studies on how rice production in the paddy fields of Kalasin Province, northeastern Thailand, could be improved, while protecting the value of other associated plants used for food and medicine by local residents.

IRRI Director General Robert Zeigler said there were two very important aspects to Ms. Cruz García's research. "She is one of the first researchers to try to quantify and model the plants—ranging from the truly wild to the intensively managed—in any agroecosystem. This is despite the fact that many of these resources are common to agroecosystems not only in Asia, but around the world. Second, her work will radically expand the modeling of agroecosystems and so enhance what we can achieve with crop modeling for rice as well."

"Little research has been done on the characterization of biodiversity in paddy rice agroecosystems," Ms. Cruz García explained at the award ceremony. "Because of this, one of the main benefits of the research will be more realistic modeling of such agroecosystems, with particular emphasis on aspects critical to human welfare such as associated species used as foods and medicines."

Lao Ministry honored

At the opening of IRRI's new Greater Mekong Subregion (GMS) Office on 12 January 2007, IRRI Director General Robert Zeigler presented the current Lao Minister of Agriculture and Forestry Sitaheng Rasphone (pictured, *left*) with a plaque recognizing Laos for its conservation of 15,000 unique indigenous rice varieties that will benefit future generations of farmers from Laos and beyond (See *Rice and the river* on pages 14-22).

Gary Jahn, IRRI representative and coordinator for the GMS, said that the collection is testament to a remarkable conservation effort that will serve as a valuable source of breeding materials and insurance against future disaster.

The seed samples are maintained by the Lao Agricultural Research Center, with a duplicate collection stored at IRRI's International Rice Genebank.

GENE HETTEL (2)

Siene Saphanthong (*left in photo*), former IRRI Board of Trustees member (1996-2001), was honored by IRRI in Vientiane, Laos, on 11 January 2007. IRRI Director General Robert Zeigler cited the retired Lao minister of agriculture and forestry for his vision, dedication, and commitment, which provided the foundation for establishing Lao rice research capacity and ultimately the country's rice self-sufficiency.

Keeping up with IRRI staff

Jerry Pat Crill, former IRRI plant pathologist, passed away on 17 January 2007 at his home on his beloved Little Manatee River, in Florida, USA. Dr. Crill headed IRRI's plant pathology program for 4 years starting in 1978.

Mahabub Hossain, head of IRRI's Social Sciences Division, has been recognized for his contribution to capacity enhancement in social science research at the Philippine Rice Research Institute (PhilRice). Dr. Hossain received a plaque of recognition from Arthur Yap, secretary of the Philippine Department of Agriculture, at PhilRice's National Research and Development Conference on 15 March 2007.

Former IRRI Principal Plant Breeder and World Food Prize Laureate **Gurdev Khush** has been appointed senior adviser at the biotechnology company Devgen. Announcing the appointment, Devgen Head of Research and Development Robert Ackerson said, "We are honored to be able to benefit from Dr. Khush's guidance and commitment." Devgen is currently in the process of expanding its rice-breeding activities.

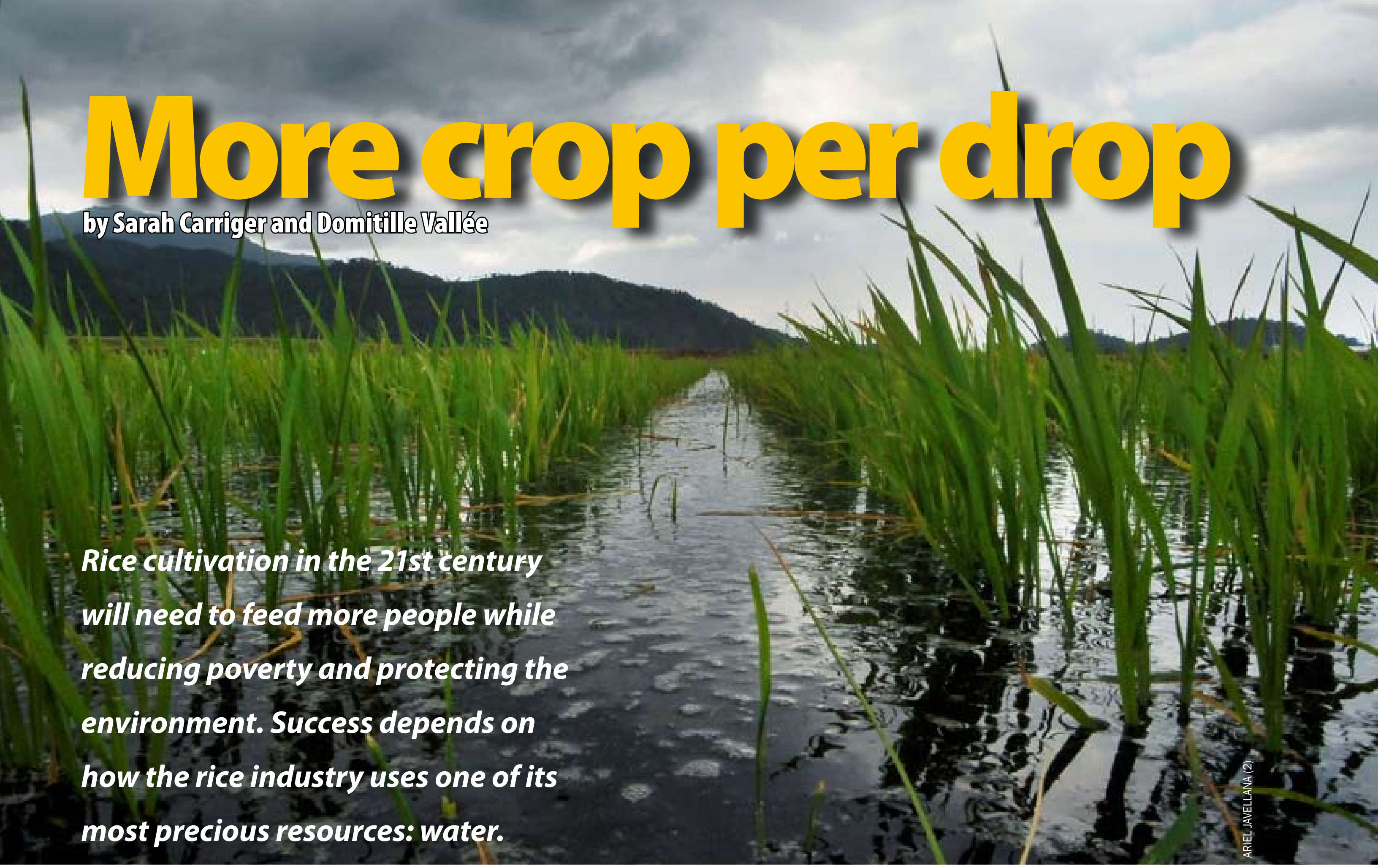
Arvind Kumar joins the Plant Breeding, Genetics, and Biotechnology Division (PBGB), where he will develop improved germplasm for drought-prone rainfed lowland environments and efficient screening systems for drought tolerance and weed competitiveness. He is also in charge of collaborating with scientists from NARES and from developed countries on drought-related research. **Hector Hernandez** has joined IRRI as director of human resources. **Bhagirath Singh Chauhan**, who will develop improved weed management options for rice in rainfed and water-limited environments, joined the Crop and Environmental Sciences Division. He is also responsible for investigating the seed biology of important upland weeds. **Joong-Hyoun Chin**, who will work on developing breeding and genotyping systems as well as rice tolerant of phosphorus-deficient soils, has joined PBGB. **Ramil Mauleon**, bioinformatics specialist, joins the Crop Research Informatics Laboratory as a postdoctoral fellow.

Did you know...

That the product commonly marketed as "wild rice" is not the same as the wild rice that IRRI scientists conserve and study? It's an aquatic cereal grain of the genus *Zizania*, which has been harvested and eaten by indigenous North Americans for centuries. Cultivated rice, along with several wild species possessing traits that IRRI researchers have bred into popular varieties, is of the genus *Oryza*. Although they belong to the same part of the grass family, *Zizania* and *Oryza* are not related closely enough to be what we consider "related genera."

THE FLOWER of *Oryza barthii*—also wild rice, but the same genus as cultivated rice, *O. sativa*.

ARIEL JAVELLANA



More crop per drop

by Sarah Carriger and Domitille Vallée

Rice cultivation in the 21st century will need to feed more people while reducing poverty and protecting the environment. Success depends on how the rice industry uses one of its most precious resources: water.

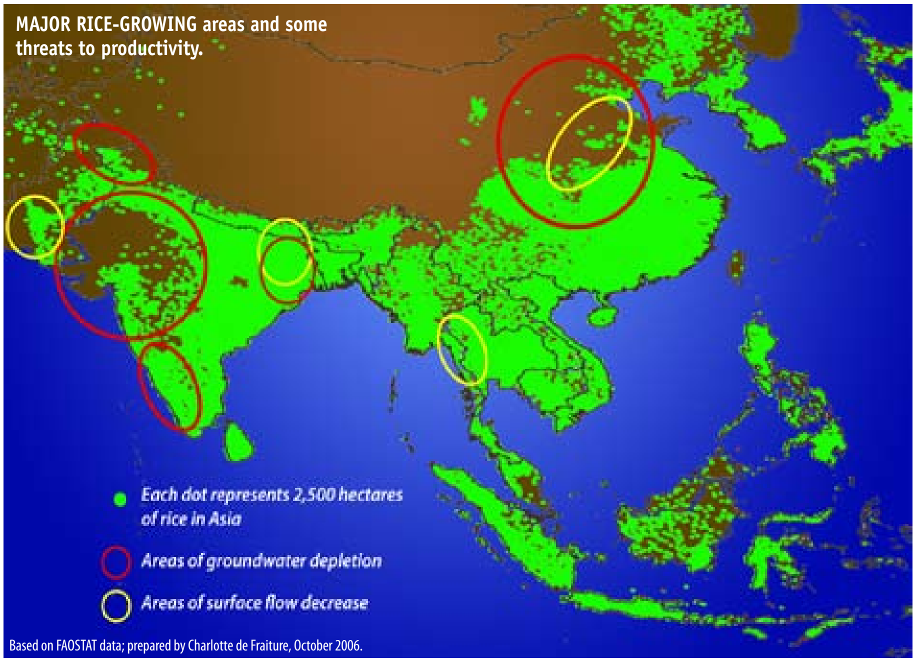
ARIEL JAVELLANA (2)

The challenge for rice cultivation in the next 50 years is to feed more people while keeping prices low to benefit poor rice consumers and reducing production costs to benefit poor growers. At the same time, water scarcity, drought, flooding, and salinity increasingly threaten the productivity of rice-based systems (see map, *right*).

How can we meet this challenge? Some solutions exist; others require more investment in research. No single solution will fit all situations. Solutions need to be evaluated based on impacts on the poor, on the environment, and on the often unrecognized ecosystem services that rice landscapes provide (see *At your service*, opposite).

Rice systems are also social systems. In many cases, they are based on hundreds, even thousands, of years of tradition. Unless solutions are designed and implemented with the active participation and support of the rice-growing communities, they will not be successful.

Rice is currently the staple food of around 3 billion people, and demand is expected to continue to grow as population increases—by 1% annually until 2025 in Asia and by 0.6–0.9% worldwide until 2050. While the bulk of the world's rice is grown and consumed in Asia, changing dietary preferences are also affecting rice consumption in other parts of the world. Rice demand is



MAJOR RICE-GROWING areas and some threats to productivity.

Based on FAOSTAT data; prepared by Charlotte de Fraiture, October 2006.

increasing the most rapidly in West and Central Africa—by 6% each year.

So, where will the rice come from to feed these additional rice consumers? To avoid destruction of natural ecosystems, increasing yields on existing crop lands are the best option. This includes both irrigated and rainfed land, although most of the additional production will come from irrigated lowlands, which already supply 75% of the world's rice.

In some major rice-producing countries, such as Bangladesh, the Philippines, and Thailand, there is still a large gap between actual and potential yield. In these countries, water and crop management technologies hold the most immediate promise. In other countries—namely, China, Japan, and Korea—the yield gap is already closing, and further yield increases are likely to come from genetic improvement. This means more research and investment in breeding programs. In irrigated lowlands with ample water supply, the development of hybrid rice has the potential to increase yield by 5–15%.

Many poor people spend 20–40% of their income on rice alone. The reduction in the price of rice—from US$1,000 per metric ton in 1960 to an average of around $250 over the past 5 years—may have done more to benefit Asia's poor than any other single factor. Keeping rice prices low remains in the best interests of poverty reduction in areas where rice is the staple food.

On the other hand, low prices can hurt poor rice growers. Most of the world's rice farming takes place on small family-owned farms, with average sizes varying by country from 0.5 to 4 hectares. And, in many areas, rice farming is the main source of employment. Increasing yields and reducing production costs are the first steps for many families to escape poverty. Rice-related policies, breeding programs, and water and land management technologies and practices need to take into account possible impacts—positive and negative—on the poor who depend on rice as a source of food and income.

Interventions affect men and women differently because the division of labor in rice cultivation is, in most countries, along gender lines. This means, for example, that in areas where women do most of the transplanting, changing to direct seeding can mean either an additional burden or a source of employment for women, depending on whether or not they are paid for their labor.

Purely technical approaches will not work. Any solutions need to take into account that, in many

What to do about water and rice?

Key findings for rice production from the comprehensive assessment of water management in agriculture include the following:

- Keeping rice prices low, while reducing production costs, is crucial for poverty reduction in rice-growing and -consuming areas.
- Rice systems provide both food and ecosystem services—such as flood mitigation, groundwater recharge, erosion control, and habitats for birds, fish, and other animals—which need to be recognized and protected.
- To keep up with the food needs of the world's increasing population, rice cultivation will have to adapt to water scarcity, drought, flooding, salinity, and climate change. Greater investment in research and extension is needed to meet these challenges.
- Solutions need to be tailored to the specific physical and socioeconomic context and evaluated in terms of impacts on the environment and on the health, income, and food security of poor rice growers—both men and women.
- Because of the hydrological connectedness of rice fields and because of the unique role rice cultivation plays in many cultures, solutions need to be developed with communities.

At your service

Depending on the method of cultivation and the physical characteristics of the landscape, ecosystem services provided by rice fields can include

- providing a habitat for birds, fish, and other animals, thus conserving biodiversity and supplying additional food sources
- recharging groundwater
- mitigating floods
- controlling erosion
- flushing salts from the soil
- providing water filtration
- sequestering carbon
- regulating temperature and climate

But rice cultivation can also have negative impacts on the environment—polluting groundwater and surface water with agro-chemicals, raising water tables in areas with saline- or arsenic-contaminated groundwater, and releasing greenhouse gases (such as methane and nitrous oxide) into the atmosphere.

Decisions increasing production and/or decreasing water requirements need to weigh both ecosystem services and negative environmental impacts.

FOR AN ESTIMATED 2,000 years, the rice terraces of the Philippine Cordilleras have provided communities with food and cultural and ecosystem services, but now they are under threat. In 2001, they were added to the UNESCO's list of World Heritage Sites in danger.

A WOMAN in Pothala, Nepal, enjoys the view of terraced rice fields, whose potential ecosystem services include groundwater recharge and flood and erosion mitigation—and perhaps scenic beauty, too.

BAS BOUMAN

communities, rice cultivation is at the heart of social and religious life.

Over the coming decades, farmers, policymakers, and researchers alike will need to adapt to several threats to rice productivity.

In the next 25 years, 15–20 million hectares of irrigated rice are projected to suffer from some degree of water scarcity—particularly wet-season irrigated rice in parts of China, India, and Pakistan. Even in areas where water is abundant, hotspots of water scarcity exist. Economic water scarcity, where lack of financing prevents harnessing water resources for productive use, limits cultivation of the 22 million hectares of dry-season irrigated rice in South and Southeast Asia.

Between a quarter and a third of the world's tapped freshwater resources are already used to irrigate rice. Pressure to reallocate water from irrigated agriculture to cities and industries is already affecting rice cultivation in many parts of the world. This type of transfer can be accomplished without a drop in rice productivity (see figure, *below*), but it requires a combination of supportive policies and the introduction of improved practices and technologies.

Increasing water scarcity may also force a shift in rice production to more water-abundant delta areas. And, in water-short areas, aerobic rice production—growing rice without a standing water layer—and irrigation regimes of alternate wetting and drying may come to predominate alongside a shift to nonrice dryland crops such as maize.

Droughts, flooding, and salinity are all current threats to productivity, particularly in rainfed areas, and they may increase in severity under climate change.

Frequent droughts afflict approximately 25 million hectares of rainfed rice, primarily in eastern India, northeastern Thailand, Lao PDR, and Central and West Africa.

Salinity affects another 9–12 million hectares—mostly in India, but also in Bangladesh, Thailand, Vietnam, Indonesia, and Myanmar. Salinity is a threat in deltas where sea water intrudes inland and in some aerobic rice production systems.

Some 11 million hectares of both irrigated and rainfed rice are prone to flooding. Even though rice is adapted to waterlogging, most varieties can survive complete submergence for only 3 to 4 days. The recent development by researchers at the International Rice Research Institute of submergence-tolerant rice, which can withstand 10–14 days of submergence with up to three times the yield of nontolerant varieties, offers hope to farmers in flood-prone areas (see *From genes to farmers' fields* on pages 28-31 of *Rice Today* Vol. 5, No. 4).

In areas prone to drought, salinity, and floods, the combination of improved varieties and specific management packages has the potential to increase on-farm yields by 50–100% in the coming 10 years, provided that investment in research and extension is intensified.

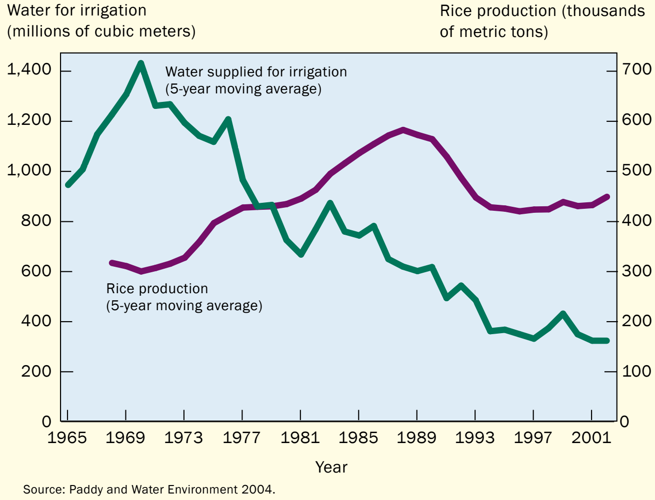
Groundwater development—most of it private and largely unregulated—has enabled small rice growers in many areas to prosper, but unsustainable pumping threatens the viability of these

How thirsty is rice, really?

Perhaps not as thirsty as you might think. At the field level, rice receives up to 2–3 times more water per hectare than any other crop, but not all of this water is "consumed" (evaporated from the field or taken up by the plants and transpired as water vapor).

Under flooded conditions, water productivity for rice is almost the same as that of wheat, when measured by the amount of water actually consumed through evapotranspiration per unit of grain.

Nonproductive outflows of water by runoff, seepage, and percolation are about 25–50% of all water applied in heavy soils with shallow water tables, and 50–80% in coarse soils with deep water tables. Though runoff, seepage, and percolation are losses at the field level, they are often captured and reused downstream and do not necessarily lead to true water depletion at the irrigated area or basin scale.



Source: Paddy and Water Environment 2004.

DECREASING IRRIGATION water supplied while increasing production in Zanghe Irrigation System, China.

IN WATER-SHORT AREAS, aerobic rice production—growing rice without a standing water layer—may come to predominate.

production systems. For example, in the North China Plain, water tables are dropping by 1–3 meters per year and in the northwest Indo-Gangetic Plain they are dropping by 0.5–0.7 meter per year.

Declining water tables due to overpumping threaten not only agricultural productivity but also human health, since many communities are dependent on groundwater for their drinking water. In Bangladesh and parts of India, falling water tables have been linked to contamination of groundwater with naturally occurring arsenic and fluoride.

Climate change may affect rice productivity in several ways. It is expected to increase the frequency of droughts and flooding, and to increase temperatures, which will have a negative impact on yields. Simulations find that for every 1 °C rise in mean temperature, there is a corresponding 7% decline in rice yield. Developing rice varieties that are less sensitive to higher temperatures is the only way to cope with rising temperatures.

FLOODED RICE FIELDS serve as a habitat for many species. The Ramsar Convention on Wetlands recognizes flooded rice fields as human-made wetlands. If such fields are converted to dryland crops or aerobic rice cultivation due to water scarcity, the impact on wetland biodiversity needs to be considered.

ARIEL JAVELLANA (2)

Of the potential threats, water scarcity and increasing competition for water in irrigated rice systems are perhaps the most pressing in terms of potential impact on overall production levels.

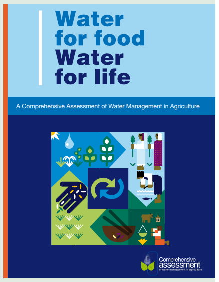
There are various strategies for reducing the amount of water needed to grow rice, but all of these options have different impacts in terms of environmental sustainability and ecosystem services. Take alternate wetting and drying, for example. Moderate regimes can reduce field water application by 15–20% without affecting yield, can reduce disease-causing vectors, and produce less ammonia volatilization and fewer methane emissions. But drawbacks include fewer options for informal reuse downstream; more weed growth and pests and a consequent need for more chemical applications and/or labor; reduction in soil fertility over time and, eventually, greater need for fertilizer; higher nitrous oxide emissions and nitrate leaching; and habitat loss for some species.

There is good scope to increase water productivity by lessening necessary total water inputs per unit of production—especially by reducing seepage and percolation losses. Currently, most breeding programs focus on rice breeding under ponded water conditions, but to address water scarcity and increasing competition for water, breeders need to start looking at high-yielding varieties under aerobic growing conditions and alternate wetting and drying regimes.

The biggest water savings at the field level come from reducing seepage, percolation, and surface drainage flows, but these may not result in savings at the irrigation system or basin scales. Water-saving measures at the field level include land leveling, farm channels, and good puddling and bund maintenance. Minimizing turnaround time between wet land preparation and transplanting can also save water by reducing the time when no crop is present, therefore minimizing water loss.

In irrigated systems, integrated approaches that take into account the options for reuse of water and for conjunctive use of surface water and groundwater offer the best way forward to improve total water-use efficiency at the system scale.

Water, food, and life



Water for food, water for life: a comprehensive assessment of water management in agriculture (edited by David Molden; published in 2007 by Earthscan with the International Water Management Institute; 688 pages).

How do we manage finite water resources to feed two billion extra people, eliminate poverty, and reverse ecosystem degradation? This book brings together the work of over 700 researchers in the most comprehensive and authoritative assessment of water resources ever written. Critically evaluating current thinking on water and its interplay with agriculture, the book charts the way forward with concrete actions from management to policy across all countries and territories. After framing the main issues and providing a comprehensive examination of trends and scenarios in world water management, the book critically examines the issues of water in poverty reduction, reforming institutions for sustainable water management, avoiding or mitigating ecosystem impacts, and improving water productivity. Thematic chapters follow, covering such key issues in water management as irrigation, groundwater use, inland fisheries, rice cultivation, land conservation, and river basin management and development.

The *Comprehensive assessment of water management in agriculture* is a 5-year initiative to analyze the benefits, costs, and impacts of the past 50 years of water development and management in agriculture, to identify present and future challenges, and to evaluate possible solutions.

For purchasing information, visit http://tinyurl.com/2qk2hl.

Sarah Carriger is a science writer and communications consultant. Domitille Vallée is an assessment facilitator at the International Water Management Institute.

This article is based on *Rice: Feeding the Billions* (authors BAM Bouman, R Barker, E Humphreys, and TP Tuong), which is Chapter 14 of the book *Water for food, water for life: a comprehensive assessment of water management in agriculture*. For more information, visit www.iwmi.cgiar.org/assessment.

Rice and the

by Gene Hettel and Meg Mondoñedo

A new research and development initiative is set to build on past successes and lay new foundations for prosperity in the countries that depend on the Mekong River for their rice

Wars ripped apart the social fabric of the Mekong basin in the 1960s and 1970s, bringing suffering and uncertainty to millions of Southeast Asians. However, several nations of the Greater Mekong Subregion (GMS), one of Asia's most important rice bowls, have made incredible steps toward recovering from those terrible times—thanks in no small part to rice research. The International Rice Research Institute (IRRI), with the enduring support of concerned donors such as the Australian Agency for International Development, the Swiss Agency for Development and Cooperation (SDC), and the Asian Development Bank, has helped the people of the GMS regain their food security in the aftermath of the conflicts (see *Rice and life along the Mekong River* on page 4 and *Research: Cambodia ushers in new era* on page 16).

The GMS includes Cambodia, Laos, Myanmar, Thailand, Vietnam, and China's southern provinces of Yunnan and Guangxi (see map, *above right*). IRRI's success here, while impressive, is incomplete and some dreams are yet to be fulfilled, according to Gary Jahn, IRRI's representative and coordinator for the Institute's new office in the GMS. With 25% of the Subregion's inhabitants (some 75 million poor rice growers and consumers) still below the poverty line, much work remains to be done.

"Poor rural families growing rainfed rice in unfavorable environments have not yet reaped the benefits of rice research," says Dr. Jahn. "These include farmers growing rice in drought- or flood-prone areas, in saline or other poor-quality soils, or in unsustainable slash-and-burn systems."

In 2006, some of these age-old problems of Asian rice farmers were accentuated with floods, drought, and pests that hit the GMS particularly hard. In Thailand, thousands of farmers saw their crops inundated by record flooding that also affected Cambodia and Laos,

river

A BOAT LADEN with rice sacks destined for a local market makes its way down the Mekong River in Cantho Province, Vietnam.

ARIEL JAVELLANA

while in Vietnam, farmers watched helplessly as insects destroyed rice worth millions of dollars in one of the worst pest outbreaks in recent history. Because these climate-related events are predicted to continue well into the future, IRRI researchers are accelerating their efforts to overcome these problems by tailoring the rice plant, or the way it is grown, for these harsh environments.

For example, IRRI and the GMS's six national agricultural research and extension systems (NARES; the institutions and organizations responsible for developing and disseminating rice technologies in IRRI's partner countries) have initiated many activities to improve rice production, especially in unfavorable areas, aimed at producing economic and environmental benefits (see table on page 17 and *People: providing help* on pages 18-19).

"The main challenge, in the immediate future," says Dr. Jahn, "is coordinating between and among various rice research and development initiatives in the Subregion. Since IRRI, donors, and the national governments have invested considerable capital and resources in conducting studies and designing projects, it is crucial that these efforts be complementary, rather than contradictory or competitive."

The mechanism to meet this challenge became a reality on

Research: Cambodia ushers in new era

A CROWD of more than 4,000 attended the dedication ceremonies at the Cambodian Agricultural Research and Development Institute in Phnom Penh.

GENE HETTEL (3)

The second week of January 2007 was truly a busy one in the Greater Mekong Subregion with not only the opening of the IRRI-GMS Office in Vientiane on Friday but also the official inauguration of the new facilities at the Cambodian Agricultural Research and Development Institute (CARDI) in Phnom Penh on Tuesday. The CARDI festivities only served to reinforce the view that significant progress is being made in the GMS.

Cambodian Prime Minister Hun Sen presided over the early-morning event, which was attended by a large crowd of more than 4,000 diplomats and ambassadors; international visitors; teachers and students; Buddhist monks; farmers; officials of the Ministry of Agriculture, Forestry, and Fisheries; and CARDI staff members.

The prime minister acknowledged IRRI's overall help in establishing CARDI through the very successful Cambodia-IRRI-Australia Project (CIAP). He also mentioned IRRI's reintroduction of more than 750 Cambodian rice varieties to the country—varieties that were lost during the years of war and hunger when people resorted to eating their seeds.

Agriculture, Forestry, and Fisheries Minister Chan Sarun reported on CARDI's achievements, which include doubling Cambodian rice production from 1.2 tons to 2.4 tons per hectare and more than doubling its scientific staff from 50 in 2000 to the current 121.

"Your presence today is testimony of great attention to agricultural research, which is a vital foundation for contributing to poverty reduction and national development," Dr. Sarun said.

Dr. Sarun also thanked CARDI's donors and development partners such as the Asian Development Bank (which provided the loan to build the new infrastructure), the Australian Agency for International Development, the Australian Center for International Agricultural Research, the Rockefeller Foundation, the McKnight Foundation, the Korea International Cooperation Agency, and the Canadian International Development Agency.

CARDI now has new research, training, administration, and dormitory buildings, plus the recently completed Plant Breeding Center (*below left*). Contrast this with the research facilities destroyed during the chaos of the 1970s such as the Toul Koktrap Station in Suay Rieng (*below right*). New main roads, fences, and irrigation and canal systems complete CARDI's improvement agenda.

In addition to new infrastructure, CARDI is also entering into exciting new collaborative projects, such as the PROVIDE (Poverty Reduction Options Validated In Drought Environments) project, in conjunction with IRRI and the nongovernmental organization Plan International (see *People: providing help* on pages 18-19).

GLENN DENNING

12 January 2007 in Vientiane, Laos, when a Memorandum of Understanding (MOU), which established a new IRRI office for the GMS, was signed and a ribbon-cutting ceremony marked the official opening. In signing the historic document, IRRI Director General Robert Zeigler and Lao Minister for Agriculture and Forestry Sitaheng Rasphone (*left and right, respectively, in photo*) confirmed that IRRI's framework for regional cooperation logically complements the Institute's continued strong relationship with Laos.

"This MOU gives full cognizance to the existing commitment of IRRI to rice research in the GMS," said Dr. Zeigler during the ceremony. "To this end, IRRI and the NARES of the six nations will formulate an agreed strategy for rice research collaboration and technology transfer to improve food security, reduce poverty, improve livelihoods, and protect the environment of the Subregion. Coordinating our research efforts here will increase the pace and quality of development."

Minister Sitaheng added: "This MOU is an important indication of the way both IRRI and Laos are positioning themselves to respond to regional challenges in rice research. The heart of that response is a research partnership for the benefit of Laos and its neighbors. Laos is proud to be selected as the hub for rice research in the GMS. It is a symbol of our progress in science and our reputation as a good neighbor."

The Agriculture Minister pointed out that the 16-year Lao-IRRI collaboration has resulted in the conservation of 15,000 samples of traditional rice varieties, the establishment of a National Rice Research Program, the release of 18 modern varieties, and a 70% increase in rice production since 1990.

Why locate the IRRI-GMS Office in Laos? There are several good reasons. All rice ecosystems of the GMS are represented in Laos, which has the greatest diversity of rice and the largest collection of indigenous rice accessions in the region. Laos is geographically the central GMS nation, sharing a common border with all of the other five countries. As such, Laos is close to the Mekong River Commission and other bodies dealing with the GMS. Further, there is high potential for the country to contribute to and gain from having a pivotal role in the GMS rice research networks, and capacity building in Laos needs to continue.

The Lao-IRRI Rice Research and Training Project (known simply as the Lao-IRRI Project), which concluded in December 2006, was the longest running bilateral project in IRRI's history (see *Genuinely Lao* on pages 22-27 of *Rice Today* Vol. 5, No. 2). Through the IRRI-GMS Office, technical support will continue for the research programs

IRRI activities in the GMS

Activity	Laos	Thailand	Cambodia	Vietnam	China	Myanmar
Aerobic rice development	✓	✓		✓	✓	
Salt-tolerant rice development		✓		✓		
Drought- and flood-resistant rice	✓	✓	✓	✓	✓	
Making upland rice sustainable	✓		✓	✓	✓	
Intensifying favorable rainfed rice	✓	✓	✓	✓		
Site-specific nutrient management		✓	✓	✓	✓	✓
Hybrid rice development				✓	✓	
Preserve national genetic resources and rice biodiversity	✓	✓	✓	✓	✓	✓
Interplanting rice varieties for disease control				✓	✓	
Insecticide reduction	✓	✓		✓		
Stem borer resistance				✓	✓	
Weed management in direct-seeded rice		✓		✓		
Postharvest handling and storage	✓		✓	✓	✓	✓
Improving research and extension linkages through ICT		✓	✓	✓	✓	✓
Characterizing and improving grain quality	✓	✓			✓	
Blast resistance	✓	✓			✓	

initiated in the Lao-IRRI Project. With generous support from SDC, the Lao-IRRI Project has also been one of IRRI's most successful efforts for building national research capacity, improving rice production, and preserving the diversity of rice germplasm (rice seeds and tissues).

As the IRRI-GMS Office also serves as the IRRI Country Office for Laos, it provides technical advice and support to the rice research program of the Lao National Agricultural and Forestry Research Institute (NAFRI). For example, IRRI is currently working with the program to develop landscape management systems for the sustainable production of rice in the uplands as part of a stable crop diversification program to replace slash-and-burn agriculture. It takes years for vegetation to return hillsides that have been slashed and burned. Airline passengers flying the 400-km route north from Vientiane to Luang Prabang can immediately see the consequences of the destructive practice (see centerfold, pages 20-21).

With the closing of the Lao-IRRI Project, the consensus is that establishing the GMS regional office in Vientiane will enable IRRI and NAFRI to build on the close working relationship developed over the past 16 years. The office in Vientiane is expected to attract

People: providing help

"There's not enough rice to feed my family," says Pong Leut, 45, a poor villager in Cambodia's Siem Reap Province as she and her neighbor, Khloem Neut, 41, make baskets along the roadside. Both women bemoan the serious rice shortage in Tatrav village.

"Our harvest lasts for only 6 months; then, for the rest of the year, we have to buy rice for our children," says Ms. Leut. "We make baskets to earn some of the money to buy our rice. We will be very happy if rice production here can be increased."

A collaborative project of the nongovernmental organization Plan International (Plan), the Cambodian Agricultural Research and Development Institute (CARDI), and IRRI is aiming to do just that—increase local rice production. The project is a shining example of new development initiatives being made in the GMS. During the second week of January 2007, *Rice Today* visited Siem Reap Province, about 50 minutes by plane northwest of the capital, Phnom Penh, to see firsthand how the new effort—called PROVIDE (Poverty Reduction Options Validated In Drought Environments)—is set to help this region's poor rice farmers.

PROVIDE is fully funded by Plan. The idea for this project began when Plan staff members Sandy Fortua, Eleanor So, and John McDonough saw the need to address rice problems in the villages where they were trying to boost children's education. It was clear that helping poor villagers to educate their children would depend on being able to produce enough rice without their children having to work on the farm at the expense of their schooling. To make matters worse, the target villages were often hit by drought, so failed crops and food shortages were common. So, Plan asked IRRI if anything could be done to improve the rice situation. CARDI was brought in as a partner with local rice knowledge and PROVIDE was born.

GENE HETTEL (4)

PONG LEUT and Khloem Neut (*left and right, respectively, in the foreground*), along with other Tatrav villagers and their children, welcome efforts to increase local rice production.

Along with CARDI entomologist Preap Visarto, we caught up with Plan community development facilitator Moeun Thearith and Ek An, leader of Tatrav, one of PROVIDE's six target villages. Home to around 220 very poor families, Tatrav is a typical village and, as such, provides a sharp contrast to nearby Siem Reap—gateway to Cambodia's number-one tourist attraction, the ruins of Angkor Wat and surrounding temples—where economic activity is booming.

Plan works world-wide to achieve lasting improvements for poor children in developing countries. According to Mr. Thearith, teaming up with CARDI and IRRI is a natural step given the influence of rice on families' economic fortunes.

Earlier in 2006, Gary Jahn, IRRI's GMS coordinator based in the Lao capital of Vientiane, visited the region with IRRI and CARDI scientists to identify PROVIDE's six target villages in Siem Reap and Kong Cham provinces and to assess their constraints to rice production.

"It became very clear that there are strong links among education, labor, water, and food security," says Dr. Jahn. "With an average farm size of only 0.5 hectare, most farmers don't donor funding because of the ongoing need for capacity building and more investment in infrastructure in Laos.

A few hours after the MOU signing, Drs. Zeigler and Jahn (*right and left, respectively, in photo*) cut the ribbon to formally open the IRRI-GMS Office, witnessed by representatives from the embassies of the five surrounding countries as well as Japan, the United States, the Philippines, and India. Also present were representatives from SDC, the Lao Ministries of Agriculture and Forestry and Foreign Affairs, and numerous nongovernmental organizations and international development agencies.

"We're very grateful to the Lao government for agreeing to host the office and providing such excellent cooperation and support," Dr. Zeigler told those assembled.

continued on page 22 ➤

WITH TATRAV VILLAGERS looking on, CARDI entomologist Preap Visarto (*right*) discusses the logistics of establishing the PROVIDE project with Moeun Thearith, Plan International community development facilitator (*left*), and Ek An, village leader.

PAO LY, protector of some of the previous season's rice crop, prepares to distribute some of the precious grain to her neighbors in Tatrav village.

have enough land to grow enough rice for their family's needs."

In some villages, the farmers are sending their children to schools built by Plan, but this is creating labor shortages back on the farm. As a case in point, Ms. Leut has asked one of her daughters to leave school and stay home to help on the farm.

Dr. Jahn explains that the lack of water forces farmers in this drought-prone region to use some highly labor-intensive crop management strategies, such as late transplanting with old plants, 100% hand weeding, and planting—and therefore harvesting—at the same time. This leads to a shortage of labor, since the villagers must each harvest their own fields instead of following the more traditional pattern of everyone helping harvest each field as it matures (something that is possible when diverse varieties are grown, and which are planted and harvested at different times). IRRI and CARDI researchers think that they can help by introducing faster maturing rice varieties—in some cases enabling two crops a year.

"We'd like to get some drought- and submergence-tolerant varieties into Siem Reap where water shortages and floods are both perennial problems," says Dr. Jahn. "Direct seeding in rows might be an option for some farmers."

After explaining the objectives of PROVIDE to Tatrav village leader Ek An and a group of interested farmers, Dr. Visarto believes the villagers are keen to be part of the project. "They are interested in learning how to increase rice production by using new technologies," he says, "and they are willing to participate if this will help solve their rice shortage."

Local involvement will be crucial, and not just in terms of farmers receiving training. Hong Hom, a 56-year-old father of five, has been recruited to play a key role in PROVIDE's Tatrav activities. As a school teacher who also grows rice, he is an ideal candidate. Mr. Hom is set to help with technology transfer, which will involve teaching and training farmers.

In March 2007, staff from IRRI, CARDI, and Plan met with extension workers and farmers in Tatrav and other project sites to present the findings of earlier surveys. The figures were grim: only a quarter of the farmers had enough rice for the whole year. Others coped by selling assets, seeking food from the forest, or simply tolerating their hunger. Two activities were proposed: developing a local version of Rice Check (a system that helps farmers carry out key management steps throughout the season, increasing yield and helping farmers to improve their management practices), and testing of new varieties. Initially, farmers will test CARDI-released varieties. Eventually, short-duration and newer high-yielding varieties from both CARDI and IRRI will be tested. Next, Plan and CARDI will select and brief farmer-participants; IRRI and CARDI will draw up detailed protocols; and CARDI will train Plan and extension staff, who will implement the project on-farm in the coming season.

Gene Hettel

Flying over northern Laos, airline passengers see smoldering, patchy hillsides—the result of slash-and-burn agriculture.

"To meet the needs of the growing GMS population, 20 years from now, average irrigated rice yields must increase by 60% and rainfed yields by 100%. Although this will be a major challenge, it is possible, and IRRI has done it before—in the 1970s, the Green Revolution raised rice yields in India by 30% and bought India the vital time to curb its population growth without suffering a recurrence of the devastating famines of the 1940s."

Working with the national research programs of the GMS, IRRI has developed a research strategy to reduce crop losses from floods, drought, and pests, while improving the yield potential and management efficiency of the most popular rice varieties. According to Dr. Zeigler, IRRI's most recent success in this area is the discovery of a gene that enables rice to survive complete submergence for 2 weeks (see *From genes to farmers' fields* on pages 28-31 of *Rice Today* Vol. 5, No. 4). The gene is being incorporated into several popular rice varieties, including a variety of Lao sticky rice.

"It's estimated that such innovations could save 20,000 to 70,000 hectares of rice annually in Laos alone," Dr. Zeigler added. "Projects of this nature are in the common interest of all GMS nations, and by working together we'll achieve better results faster."

After the ribbon-cutting, the guests joined a traditional Lao ceremony called *Basi*, during which white cotton strings are tied to people's wrists to symbolize happiness and prosperity.

To further showcase the new IRRI-GMS Office in Vientiane, the Consortium for Unfavorable Rice Environments held its sixth annual meeting in Vientiane on 21-22 February and the IRRI Board of Trustees is planning to hold its September 2007 meeting there as well.

A healthy rice industry is crucial to a prosperous GMS. Building on the achievements that came before it, the IRRI-GMS Office is set to help this vision become a reality.

Technology: small machine solves big problem


MARTIN GUMMERT

Observers at a recent training and field demonstration on using a new small-scale combine harvester (*pictured*) were excited about what they saw. The demo, which took place in front of farmers, machine operators, extension workers, manufacturers, machine service providers, local consultants, and government officials in Prey Veng Province, Cambodia, on 31 January–4 February 2007, is another indication of advances being made in the Greater Mekong Subregion (GMS).

The Postproduction Work Group of IRRI's Irrigated Rice Research Consortium, through an Asian Development Bank-funded project, has teamed up with Nong Lam University in Ho Chi Minh City, Vietnam, and the Provincial Department of Agriculture in Prey Veng. They are working to transfer the technology to farmers in Cambodia and neighboring Laos to help them minimize their rice harvest losses and costs.

According to Martin Gummert, IRRI postharvest development specialist, harvesting costs have increased recently in many provinces of Cambodia and Laos.

"Urbanization and attractive labor markets in neighboring Thailand are causing increasing labor shortages during the peak harvest season," he says. "Farmers are competing with each other for the same few available laborers from cutting and threshing to cleaning and hauling to their homes. The total cost for these activities is US$65–70 per hectare. The estimated local operating cost for the mini combine is around $35 per hectare, leaving a good margin to provide profit to the operator and reduce the current high harvesting cost for farmers."

The demonstrations, conducted in three areas in Prey Veng, were met with positive responses from Prey Veng Governor Ung Samy and officials from the Departments of Agricultural Engineering and Agricultural Extension, as well as potential operators and more than 150 villagers. Combine specialists from the Vietnamese manufacturer and Nong Lam University provided training on maintenance and machine use, and helped the local Provincial Department of Agriculture team demonstrate the combine.

In Vietnam and the Philippines—countries facing similar problems—mini combine harvesters are gaining popularity among farmers.

"The combine has a capacity of 1–1.5 hectares per day and costs less than $5,000," says Mr. Gummert. "It consists of a cutter-bar, a small axial-flow thresher, and a built-in cleaner that delivers threshed, pure grains straight into a sack. The machine, which needs only three operators, is highly mobile, can be used in flooded fields, and can be serviced by local machine shops."

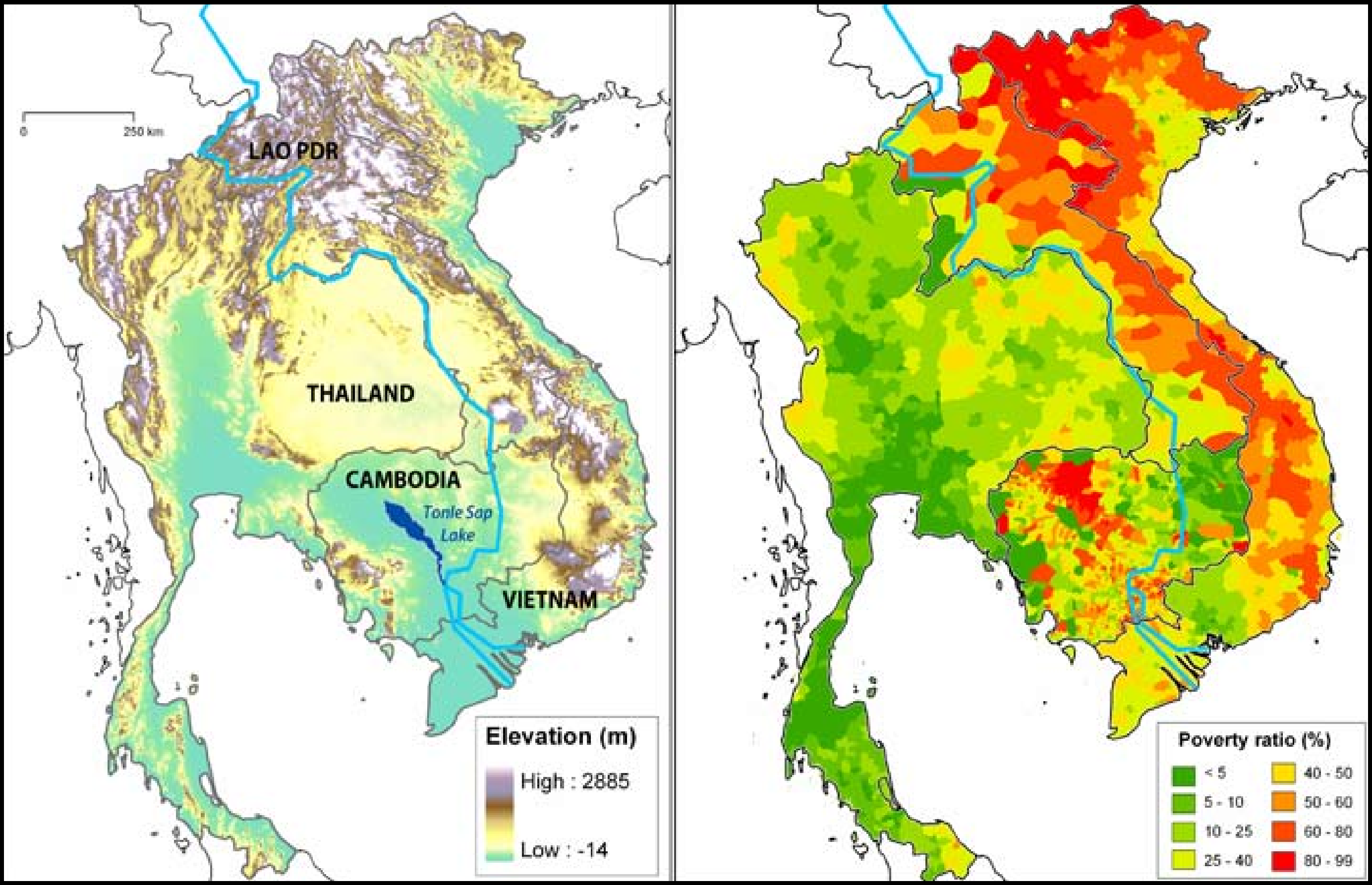
"Farmers can benefit in two ways from the mini combine," says Meas Pyseth, an IRRI consultant based in Cambodia. "First, they can get their crop harvested cheaper; second, they can sell more and better quality grain because they can reduce the shattering of overmature grain and maintain good quality through timely harvesting."

According to Mr. Gummert, this activity is an example of the integrated approach of IRRI's postharvest group to provide rice farmers with options to maximize their profits.

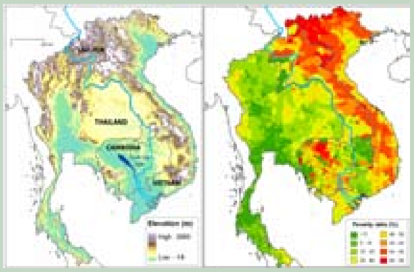
"We work with the relevant international and national stakeholders from the private and public sectors to introduce appropriate technologies," he explains. "We then arrange technology options and capacity building for farmer intermediaries. We also encourage support for local small and medium enterprises that will ensure after-sales service to farmers. The result is a sustainable improvement in farmers' income."

Welcome to the first of what will be a regular *Rice Today* Maps page. Each issue, the magazine will feature a map generated by IRRI's geographers, who use geographic information systems (GIS) and other computer tools to analyze spatial variation in rice production and the factors that influence it. While technologies developed at IRRI help farmers on the ground, the information gained through satellite images and geographic modeling can help us see the big picture and ensure that research, funding, and policies focus on appropriate technologies and strategies in the right places.

Poverty and elevation in the Greater Mekong Subregion



Data sources: Minot N, Baulch B. 2005. Spatial patterns of poverty in Vietnam and their implications for policy. Food Policy 30:461-475; Fujii T. 2004. Commune-level estimation of poverty measures and its application in Cambodia. WIDER Research Paper 2004/48; van der Weide R. 2004. How poverty came on the map in Lao PDR. World Bank; Healy AJ, Jitsuchon S, Vajaragupta Y. 2003. Spatially disaggregated estimates of poverty and inequality in Thailand. World Bank.



To develop effective poverty reduction strategies, we need to understand what the geographic patterns of poverty are, and what causes these patterns. A first step is poverty mapping. Here, we show a detailed map of the poverty ratio in four countries in the Greater Mekong Subregion. The poverty ratio is the percentage of the population that has an income (or level of consumption) below the national poverty line. Thailand is least poor, but its mountainous areas are poorer than its lowlands, just like in Laos and Vietnam. It is remarkable how similar the situation is on each side of the Vietnam-Laos border. In Cambodia, the situation is less clear, with poor areas in some highlands but also in the large floodplain of the Tonlé Sap Lake.

Text and map: Robert Hijmans, IRRI Social Sciences Division.

Less salt, please

by Peter Fredenburg

Farmers hampered by salt-affected soils in Bangladesh are set for relief as researchers breed salinity tolerance into locally popular rice varieties


IRRI

DR. ISMAIL (*right*) shows former Bangladeshi Minister of Agriculture M.K. Anwar (*center*) and IRRI senior economist Mahabub Hossain how researchers select for salt-tolerant rice plants in an IRRI greenhouse.

Salt makes its way into the rice paddies of coastal Bangladesh every which way. During the dry season, when the flow of fresh water out to the mouth of the Ganges is weakest, saltwater rides inland on the tide and saline groundwater rises and spreads laterally across the delta. Salinity is less prevalent during the monsoon but can still poison rice crops as it lingers in the soil, percolates into paddies from the brackish ponds of neighboring shrimp farmers, and, during drought, rises as in the dry season.

"Nearly 1 million hectares along the Bangladesh coast are affected by varying degrees of salinity," reports Zeba Islam Seraj, a professor of biochemistry and molecular biology at the University of Dhaka. "Salinity gradually declines as you go from west to east, from Satkhira, which is highly saline, through Khulna, Barisal, and Noakhali, where salinity is moderate but widespread. Continuing further to the southeast along the Chittagong coast, there are some pockets that are highly saline."

FAIZABAD (India) farmer Bismillah Khan shows the rice he obtained from the salt-tolerant variety he grew in an on-farm trial. His regular, nontolerant crop is in the field in which he stands. The combination of salt stress and drought meant he had to harvest his crop early and feed it to his cattle. The good performance of the new varieties encouraged him to invest in supplementary irrigation, which allows a good crop even under the prevailing harsh conditions.

Dr. Seraj is a co-principal investigator of a project in the Generation Challenge Program (GCP)—an initiative to use molecular biology to help boost agricultural production and, consequently, the quality of life in developing countries—that aims to revitalize marginal rice lands by discovering and breeding into popular rice varieties genes for tolerating soils that are saline or deficient in phosphorus (see *Opposites attract ... attention* on pages 34-36 of *Rice Today* Vol. 5, No. 2). As the focal collaborator in Bangladesh, she is responsible for the molecular evaluation and selection of rice lines bred by the Bangladesh Rice Research Institute (BRRI) to insert into popular farmers' cultivars the gene *Saltol*, short for "salt tolerance."

Using marker-assisted selection, which allows rapid screening of large numbers of plants, the International Rice Research Institute (IRRI) and its collaborators in the GCP project have mapped *Saltol*—which accounts for 40–65% of the salt tolerance observed—to a small segment of rice chromosome 1. Importantly, *Saltol* and the other identified loci confer salinity tolerance at the seedling stage.

"This is essential in the monsoon season, when salinity tolerance is mainly needed during seedling transplantation and for a few weeks thereafter, until the monsoon rains have washed the salt from the soil," explains Abdelbagi Ismail, the IRRI senior plant physiologist who is the principal investigator of the GCP project.

Rice is susceptible to salinity during two periods of its growth cycle. The first is the seedling stage and the second begins a few days before panicle initiation and ends with flowering and pollination. As Dr. Ismail explains, salt tolerance at the seedling stage is sufficient for the crop grown in the monsoon season, known as *aman*, from June or July to October, provided that there is no drought. This is the traditional season for rice cultivation in Bangladesh, but the spread of tube wells in recent years has allowed farmers to irrigate and grow a second crop in many areas. For this expanded *boro* (dry) season, farmers seed rice in November and transplant seedlings in December and January.


ABDELBAGI ISMAIL (3)

A FIELD SITE in Uttar Pradesh, India, offers a glimpse of the highly saline soils that confound farmers. Use of salt-tolerant varieties together with proper management—which includes application of organic manure—allowed rice to be grown in these soils for the first time ever (*crop at back*). A screening nursery at the Central Soil Salinity Research Institute Regional Station in Lucknow (*inset*) shows the stark difference in performance between salt-tolerant and regular varieties under salt stress.

"The seedlings initially grow slowly due to the cold of winter, and the rice is finally harvested in April or May," says Dr. Seraj. "Boro rice needs to be slightly cold tolerant and photoperiod insensitive"—that is, bred to ignore the lengthening or shortening of daylight hours, which plants use to stay synchronized with their natural growing season. Short-duration high-yielding varieties are preferred because of the high cost of pumping irrigation water.

As the boro season coincides with high river water salinity, which begins to rise in February and peaks in April and May, rice grown in this season must tolerate not only moderate salinity during the seedling stage but also much worse salinity during the critical period from panicle initiation to flowering. As food security and farmers' well-being in Bangladesh depend increasingly on boro rice, rice varieties that yield well under high salinity stress are needed more urgently than ever.

The GCP project aims to breed *Saltol* into at least one aman variety and one boro variety already popular with farmers. M. Abdus Salam, the chief scientific officer and head of BRRI's Plant Breeding Division, has crossed a derivative of the traditional variety Pokkali called FL378, which has the *Saltol* gene, with popular aman varieties, and these will be grown out at BRRI's research campus at Gazipur in July 2007. Initial crosses of FL378 and boro varieties are under way, and seeds will be available in April 2007. As Dr. Salam makes the crosses and backcrosses to advance the breeding material, Dr. Seraj will collect leaf samples for testing with newly developed molecular markers (easily detectable stretches of DNA) for both *Saltol* and the popular variety background. Based on the results of this marker-assisted selection, she will advise Dr. Salam and the BRRI team on which plants to use in further crosses.

The aim is to develop improved varieties that are identical to popular farmers' varieties in every way except that they have the *Saltol* gene and so are able to provide a reasonably good yield under conditions of moderate to high salinity in which salt accounts for 0.4–0.5% of the soil.

Dr. Seraj notes that the various coastal soils of Bangladesh display a range of mineral deficiencies and toxicities. "Some are high in calcium and magnesium, or low in zinc, potassium, and phosphorus, or have toxically high levels of boron and sulfur," she says. "We'll need to develop many different rice varieties that tolerate these specific local stresses if we are to cover the coastal region as a whole."

Salinity and other soil problems in coastal Bangladesh have severely limited the introduction of modern high-yielding rice varieties, as few are adapted to the difficult growing conditions there. Along the severely salt-affected southwest coast, where rice cultivation is largely restricted to the rainy season for lack of fresh water in the dry season, 16 of the 20 most popular varieties are landraces (traditional farmers' varieties), despite offering very low yields of only 2–2.5 tons per hectare.

"The popular landraces of this region are well adapted to the prevailing growing conditions, including soil salinity," observes Dr. Seraj.

Dr. Salam is the site coordinator for a sister project led by Dr. Ismail under the Challenge Program for Water and Food (CPWF), which aims to harness the productivity potential of salt-affected areas of three river basins, including the Ganges. In that project, the partners use the newly developed lines that have the *Saltol* locus and also search for additional sources of saline tolerance.

"*Saltol* and other genes conferring tolerance at the seedling stage could be sufficient for the wet season," Dr. Ismail observes. "However, for the boro season, additional genes for higher tolerance during flowering and pollination are needed."

It is no coincidence that Dr. Salam—who was the 2006 recipient of IRRI's Senadhira Rice Research Award—will handle, through farmer participatory varietal selection, the final testing of the GCP's *Saltol* varieties in 2008.

"The two projects actually work closely together to maximize the benefits," explains Dr. Ismail. "The molecular markers for *Saltol* developed through the GCP will help speed the breeding progress of the CPWF project, and the material will be further tested and scaled out through CPWF activities, as well as other networks. Neither of the two projects could achieve this without the other."

Adapted from GCP 2006 Partner and Product Highlights*, published by the Generation Challenge Program (www.generationcp.org).*

Black soil, green rice

by Stephan M. Haefele

An extraordinary type of soil from South America has implications for both rice production and the environment in Asia

In the 1870s, scientists exploring Amazonia in South America made an unusual discovery. Working independently, James Orton, Charles Hartt, and Herbert Smith described patches of black or dark brown soils, varying in size from 5 to more than 300 hectares, within a landscape otherwise typified by highly weathered reddish or bleached soils.

A detailed report from Smith, a geologist, characterized these "dark earths in Amazonia" as having a top-layer of a fine, dark loam, up to 60 centimeters thick. He also described them as the best soils of the Amazon, producing much higher crop yields than surrounding soils, and speculated that they owed their fertility "to the refuse of a thousand kitchens for maybe a thousand years." That they were human-made was indicated by the abundance of fragments of Indian pottery that "cover the ground ... like shells on a surf-washed beach."

Despite the unusual nature of these findings, they initially failed to excite many scientists. Almost a century later, however, Wim Sombroek, a renowned Dutch soil scientist, sparked international interest by including several pages on the "terra preta" (black soil) and "terra mulata" (brown soil) in his influential 1966 book on Amazon soils.

Several studies have since confirmed that the dark color of terra preta and terra mulata is caused by the incorporation, by humans, of black carbon (also called biochar)—incompletely burned organic matter such as charcoal. The soils were created by Amerindian populations 500–2,500 years ago and some of the carbon in terra preta soils dates back to 450 B.C. Their high fertility compared to surrounding soils is attributed to the high levels of soil organic matter (which includes biochar), higher nutrient concentrations, high nutrient- and moisture-holding capacity, and lower acidity. Amazingly, the soils have generally sustained this fertility to the present despite the tropical climate (in which soil organic matter tends to rapidly degrade) and frequent or periodic cultivation.

But what has all this to do with rice in Asia? Terra preta and terra mulata are limited to Amazonia, they are not used to grow rice, and they represent a technology predating modern agriculture. The answer is that people started to wonder whether this ancient indigenous technology could offer solutions to some of the problems of modern agriculture.

Poor soils comparable with soils in Amazonia can be found in tropical regions around the globe, including Asia, where they are—unfortunately for farmers—depressingly abundant. Such soils benefit greatly from the incorporation of organic matter but its rapid decomposition in the humid tropics makes this a very labor-intensive and short-lived solution.

Addition of biochar to soils has similar positive effects—it increases nutrient availability, boosts nutrient- and moisture-holding capacity, and contributes plant-available nutrients—and is reported to last for centuries. If researchers can confirm this much-delayed decomposition in modern agricultural systems, biochar could contribute to sustainable production increases in some of the most disadvantaged agricultural environments, which are frequently characterized by very low yields and widespread extreme poverty.

The delayed decomposition of biochar could also help with another, more recent problem. It is widely agreed that global climate change is related to an increase in atmospheric carbon dioxide (CO_2) concentration. If some of the atmospheric carbon fixed by plants could be locked up in soils (a process known as carbon sequestration) instead of being returned to the atmosphere

FIELD WORKERS incorporate biochar into an experimental plot at the IRRI farm in Los Baños, Philippines.

JOEL SIOPONGCO

STEPHAN HAEFELE holds a pile of biochar—essentially charcoal—that has been produced from rice husks.

JOSE RAYMOND PANALIGAN

through decomposition, the buildup of carbon in the atmosphere could be slowed. And, in flooded rice soils, where the decomposition of organic matter produces methane—30 times more potent as a greenhouse gas than CO_2—this effect would be even greater.

This sounds very exciting—but can it be done? To start with, the amounts of biochar needed are enormous. Agronomic trials have achieved good results with biochar applications equivalent to 8 tons of carbon per hectare. The top 30 cm of terra preta contains more than three times as much carbon from biochar—an average 25 tons per hectare. Assuming a biomass carbon concentration of 36% (typical for rice straw) and carbon loss during charring of 50%, to obtain even the 8-ton level, 44 tons of dry biomass (plant matter) per hectare would need to be converted into biochar. To reach the 25-ton terra preta level, 138 tons of dry biomass is required.

In most Asian rice lands, the only feasible source for such large quantities of biomass is rice residue left over after harvest and milling. The total amount of rice residue produced each year in Asia is estimated at 549 million tons of rice straw and 110 million tons of rice husks. Rice residue is used for several purposes (such as organic fertilizer, fuel, fodder, and building material), but its use is dwindling. Today, it is often perceived as more of a problem than a valuable resource. Worse, the most convenient way to eliminate rice residue, field burning, is a waste of resources and causes severe air pollution in some regions.

This leads to another question. Usually, biochar is the product of burning at low temperatures (280–500 °C) and restricted oxygen supply. Consequently, local biochar production by farmers in simple earthen mounds or pits could also cause considerable air pollution. However, relatively clean biochar production from rice husks can already be achieved with, for example, an improved rice husk furnace like the one pictured (*right*).

Developed at the International Rice Research Institute (IRRI), this type of furnace produces carbonized rice husks as a by-product of the paddy drying process. Some large rice mills in Thailand have already perfected this approach. Using rice husks to produce energy and biochar simultaneously, these mills reduce their fossil fuel bill and carbon emissions, and sell the biochar by-product to producers of bio-fertilizers. A similar solution under development is the use of pyrolysis—decomposition caused by heat in the absence of oxygen—of biomass for energy production where biochar is a by-product.

These examples also show that biochar from rice residues is already used in many Asian countries. In Japan, biochar from rice husks (called *kuntan*) has been used in agriculture for a long time (mainly for seedbeds and as a soil amendment for upland crops and orchards). Use of biochar from rice husks as an additive to the culture medium of ornamental plants and in vegetable gardens is common and several nongovernmental organizations promote the use of it in organic farming.

It appears that biochar can increase the "greenness" of rice-based systems and that it can be integrated into existing rice production. Especially on bad soils, it offers new opportunities to sustainably improve system productivity and farmer livelihoods. Applied on a larger scale and beyond unfavorable environments, it could also reduce the negative effect of rice-based systems on the global climate. And, if the use of rice residues for energy *and* biochar production is combined, rice producers, rice consumers, and the environment could all profit. Much research remains to be done, but the possible prize seems worth the effort.

Dr. Haefele is a senior agronomist in IRRI's Crop and Environmental Sciences Division.

THIS MODIFIED rice husk furnace, developed at IRRI, produces biochar as a by-product of the paddy drying process.

MARTIN GUMMERT

The rice man of Africa

by Savitri Mohapatra

Growing up in Sierra Leone, rice researcher Monty Jones was encouraged to become a priest. It's lucky for Africa he didn't.

MONTY JONES with the plaque presented to him at the Africa Rice Center's inaugural lecture in his honor.

R. RAMAN (WARDA) (3)

With his gentle smile and calm demeanor, Monty Jones doesn't look like the proverbial wild-haired scientist. But there is no doubt that the New Rice for Africa (NERICA) breakthrough made by him, in partnership with national and international scientists, has changed forever the way the world looks at African rice and rice research.

Going boldly where few scientists had gone before, Dr. Jones and his team succeeded for the first time in producing fertile progenies—later dubbed NERICA—from the crossing of Asian (*Oryza sativa*) and African (*O. glaberrima*) rice species. Crossing different species is notoriously difficult because of the high probability of sterility in the offspring.

The popular NERICA varieties outperform their parents, inheriting high yields from the Asian parent and the ability to thrive in harsh environments from the African parent.

Thanks to this remarkable achievement, Africa was catapulted almost overnight from relative obscurity among the international rice research and development community into the limelight.

Dr. Jones made the NERICA breakthrough during his tenure as a senior scientist at the Africa Rice Center (WARDA) from 1991 to 2002. He is currently the executive secretary of the Forum for Agricultural Research in Africa (FARA), based in Ghana.

For its NERICA achievement, WARDA received several awards, including the Consultative Group on International Agricultural Research (CGIAR) King Baudouin Award in 2000 and the United Nations Award for South-South Triangular Partnership in 2006.

The NERICA breakthrough also earned Dr. Jones the World Food Prize in 2004—the first ever won by an African. "Working closely with colleagues at WARDA and the CGIAR system, through sheer personal tenacity, Monty Jones succeeded where all others before him had failed," stated the World Food Prize Committee.

In his supporting letter to the World Food Prize Committee, Sir Gordon Conway, chief scientific adviser for the United Kingdom's Department for International Development, wrote, "Dr. Jones' ability to combine cutting-edge science with on-farm work has yielded significant benefits for the many poor rice farmers

FARMERS in Benin celebrate a bumper crop of NERICA rice.

in Africa who were by-passed by the Green Revolution.”

In addition to the World Food Prize, Dr. Jones has had many “firsts” to his credit. He was among the first agricultural scientists to understand that Africa needed to do its own research and develop technologies adapted to its specific conditions rather than importing wholesale solutions from outside.

He was also among the first to realize the value of Africa’s indigenous rice species as a rich reservoir of genes for resistance to several local stresses and to develop and apply new tools to increase the efficiency of the rice breeding program in Africa.

At a time when participatory approaches were relatively unknown in Africa, Dr. Jones introduced and promoted participatory varietal selection and community-based seed systems to accelerate NERICA varieties’ dissemination.

He had several “eureka” moments

During a recent ceremony organized by WARDA to honor him, Dr. Jones spoke of some turning points and memorable moments in his life, offering a glimpse of the man at work.

Reminiscing about his childhood and his very religious upbringing in Freetown, the capital of Sierra Leone, with parents who had “white-collar jobs,” Dr. Jones said he had no contact with agriculture. But he dreamed of helping to produce food that would help feed the world. His mind made up, he decided to pursue his studies in agricultural science against the wishes of Irish Fathers who urged him to enter the priesthood.

In the 1970s, Dr. Jones received a fellowship from the Food and Agriculture Organization of the United Nations, allowing him to move to the U.K. to study at Birmingham University. There, he received a master’s degree (1979) and a doctorate in plant biology (1983). In 2005, in recognition of his work, the university conferred upon him the honorary title of Doctor of Science. He said that the 1985 “rice riots” in Sierra Leone, catalyzed by a shortage of rice, strengthened his resolve to become a rice researcher.

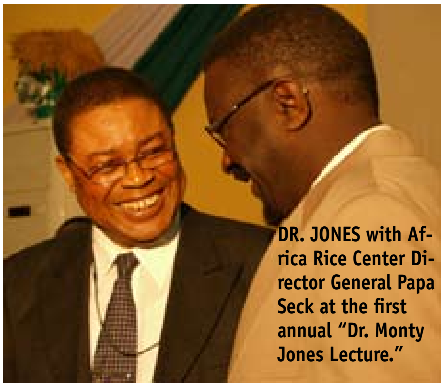
Before joining WARDA in 1991, Dr. Jones worked on mangrove rice in the Rice Research Project in Rokupr in his home country. There, he first saw farmers growing African rice and he became fascinated with its hardiness—a fascination that sowed the seeds for the NERICA development.

Dr. Jones recalls that when he proposed a program to the WARDA board to cross the African and Asian rice varieties in 1991, some members thought it was “too ambitious.” However, he eventually received the go ahead and the rest is history.

Dr. Jones said that even now he remembers very vividly the excitement he felt when he first saw that seven out of the 48 crosses he had made had produced a few fertile plants. “Some even had 98–100% fertility,” he recalls.

From that time onward, Dr. Jones said he had several such “eureka” moments, as he noticed one by one the desirable characters of the two parents that had been transferred to the progenies. Several international rice scientists could not believe it when he told them that a few NERICA lines had more than 300 grains per panicle, compared with the Asian rice varieties that have on average 100 grains.

Dr. Jones and his team continued to break new ground, as they learned to use anther culture—a technique that allows breeders to obtain pure breeding lines without the numerous cycles of inbreeding or “backcrossing” usually needed—to produce highly fertile lines in around 2 years, one-third the time required for conventional selection. “There was often an element of luck in our research,” he says, modestly referring to their success in producing callus—a mass of undifferentiated cells that can be used to grow genetically identical copies of plants with desirable characteristics—by experimenting with coconut milk as a medium.



DR. JONES with Africa Rice Center Director General Papa Seck at the first annual “Dr. Monty Jones Lecture.”

After the excitement of research, is Dr. Jones happy with his present work as FARA secretary? “I must confess I miss research,” he says. “But I don’t regret the decision I took, because now I am continuing to do what I like very much—facilitating agricultural research at the continental level.”

He was happy that his legacy continues to live on at WARDA, where Dr. Moussa Sié, in close partnership with national program scientists, has recently developed NERICA varieties for lowlands.

To honor Dr. Jones, WARDA recently launched an annual “Dr. Monty Jones Lecture” and presented him with a plaque recognizing his “outstanding achievement in rice research and exemplary dedicated service to Africa.”

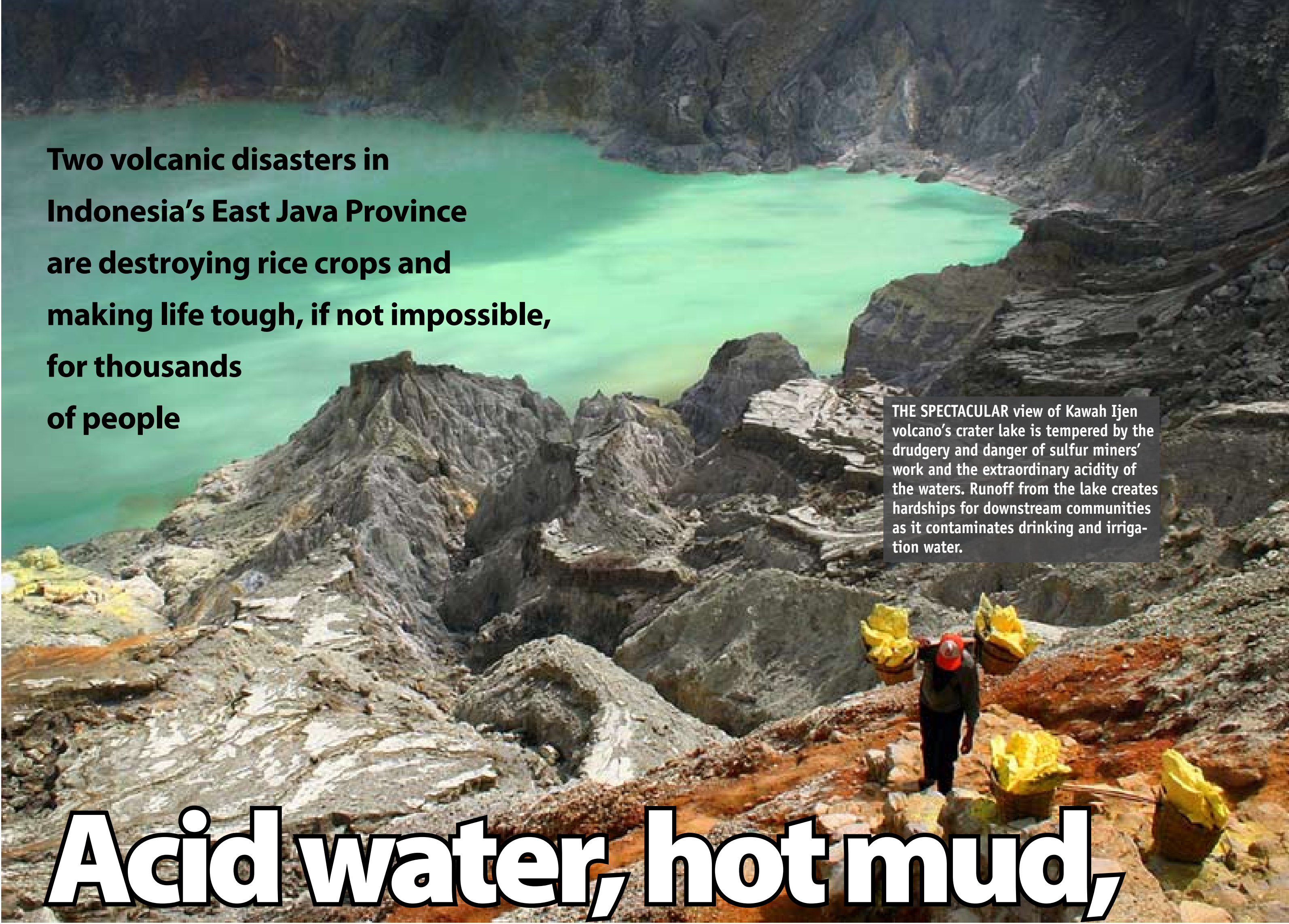
Paying homage to him, WARDA Director General Papa Abdoulaye Seck observes, “Dr. Monty Jones has demonstrated by his remarkable contribution that it is possible to reshape the agricultural map of our continent through the African creative genius.”

Dr. Jones may not look like a stereotypical scientist, but perhaps he possesses some of the eccentricity that seems to go hand in hand with scientific greatness. At the WARDA ceremony, he confessed that he used to speak to his NERICA plants, praising them for their performance. Whatever he did, it worked.

Acid water, hot mud, and damaged rice

Two volcanic disasters in Indonesia's East Java Province are destroying rice crops and making life tough, if not impossible, for thousands of people

by Duncan Graham



THE SPECTACULAR view of Kawah Ijen volcano's crater lake is tempered by the drudgery and danger of sulfur miners' work and the extraordinary acidity of the waters. Runoff from the lake creates hardships for downstream communities as it contaminates drinking and irrigation water.

CISKA TOBING / WWW.FLICKR.COM/PHOTOS/CISKATOBING

Volcanoes are a double-edged sword for the rice farmers of East Java. In many areas, volcanic ash helps create rich, fertile soils that allow farmers to plant three crops per year. But just as easily as they can provide, so can volcanoes damage and destroy.

Two volcanic calamities in the Indonesian province of East Java are getting worse, with no speedy solutions in sight. Together, the disasters have dramatically affected the lives of thousands and destroyed large areas of productive land.

It's not possible to blame human error for the first problem—the continuous leaching of acid water from the Kawah Ijen volcanic lake at the east end of Java. The pollution of downstream rivers and wetlands has been known for many decades but only now has the impact been measured.

The second crisis is more recent, with the repercussions yet to be fully understood. The eruption of subterranean hot mud around an exploration gas rig is alleged to have been caused by flawed drilling procedures.

East Java, just south of the equator, is home to around 38 million people, with about 70% earning their living directly and indirectly from the land. The most important cash crops are rice, sugar, and tobacco, with fruits and vegetables grown on the cooler uplands.

A chain of six volcanic ranges runs east to west, with some peaks regularly belching smoke and ash. Along with the rich volcanic soils, heavy rains between October and May also make East Java a farmer's paradise.

Paradise becomes lost, however, in the land surrounding one of the volcanoes, Kawah Ijen. The volcano's crater lake, one of the biggest in the world, holds about 36 million cubic meters of hyper-acidic water saturated with a potent mix

DENTAL FLUOROSIS blackens the teeth of children living in an area where drinking water has been contaminated by runoff from Kawah Ijen. The condition is a symptom of exposure to high fluoride levels.

of numerous minerals. It's about 200 meters deep and the water temperature varies between 20 and 40 degrees Celsius. Although regularly replenished by rain, the waters are not diluted. Gasses burping from the bowels of the earth through the water continually create extreme pollution.

About 50 liters of water per second leak from the lake into the Banyupahit-Banyuputih (bitter and white) River. This flows down to Asembagus on the Straits of Madura. There, more than 3,500 hectares of rich land are irrigated from the dammed river. The favored crop is rice—but this is acid-sensitive. Around 70% of plantings fail. Sugar cane is more tolerant but less profitable.

The water fails all standards for irrigation and drinking. No fish skim the waterways, no reeds whisper in the breeze. This is toxicity on a grand scale. The long-term effects on the 50,000 people who live in the area are not known, but in some districts up to 90% have black teeth. This condition is caused by an excess of fluoride, a compound added in tiny doses to the water supplies of many nations to reduce tooth decay.

Skin and eye problems are also easily visible. But what's happening to people's bones and brains? Are any of the minerals retained in the body? More study is needed to determine the other effects.

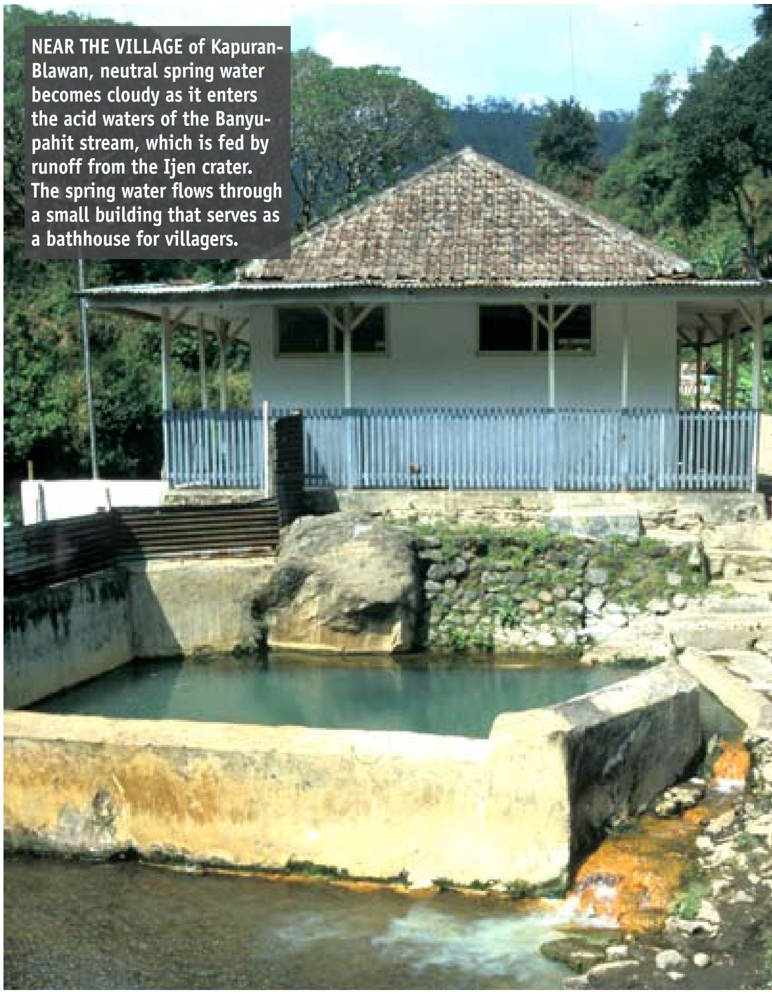
According to Indonesian government vulcanologist and geochemist Sri Sumarti, the problem was identified almost a century ago. In 1921, the Dutch built a sluice near the outfall. When the lake was full, the gate was lowered and excess water flushed out to sea after downstream farmers were alerted.

"The crater lake last overflowed in 1976," says Dr. Sumarti. "The sluice has been renovated since then and could be used but that solution is no longer appropriate. We don't know why the lake levels are decreasing but its probably seepage through the porous ground. The level is now 15 to 20 meters below the sluice."

Vulcanologist Manfren van Bergen from Utrecht University in the Netherlands says the Dutch started watching volcanoes seriously and keeping records of activity after Kelut Volcano erupted in 1919, killing about 5,000 people near Kediri in central East Java. Kelut also had a crater lake, and the fountain of hot mud and rock devastated 15,000 hectares of good land.

"After Independence (in 1945), the Dutch were unwelcome for a while, but the records of volcanic activity were preserved in Holland," says Dr. van Bergen. "Long-term information is critical in forecasting events."

Now that international relationships have improved, the old statistics are available and nearly US$800,000 has been allocated to research on Kawah Ijen. Researchers sought solutions at a workshop in the East Java



NEAR THE VILLAGE of Kapuran-Blawan, neutral spring water becomes cloudy as it enters the acid waters of the Banyupahit stream, which is fed by runoff from the Ijen crater. The spring water flows through a small building that serves as a bathhouse for villagers.

DUTCH RESEARCHERS inspect a rice field damaged by acid runoff from Kawah Ijen.

THOM BOGAARD, UNIVERSITY UTRECHT, AND ANSJE LÖHR, OPEN UNIVERSITY NETHERLANDS (3)

BEFORE THE SIDOARJO mud eruption, this tree was surrounded by rice fields. A recent study claims that the volcanic mud eruption (*centered at the plume of steam on the left*) was caused by the oil drilling rig a few hundred meters away (*right*).

GREG FANSLOW

capital of Surabaya in August 2006. The meeting was also attended by affected farmers and government officials, many of whom offered obvious and imaginative proposals to solve the acid-water problem.

A proposed big engineering project never started. It would take at least 55 kilometers of piping to drain the lake and send the water to the sea. The pipes would have to be made of acid-proof materials and would be prohibitively expensive.

Diluting the acid is also impossible. This would take mountains of limestone, and, according to environmental scientist Ansje Lohr from the Netherlands Open University, even then the gasses would continue to percolate.

Dr. Lohr has worked on a survey of 23 villages in the area. This found only a "partial awareness" of the problem, despite the black teeth and the sulfur-yellow water. Surprisingly, many said the water was not distasteful—maybe because it's the only water the locals have ever known. Even families who bought drinking water or who had an uncontaminated well were still affected by swallowing water while bathing.

"There are many unanswered questions because there's been little research," says Dr. Lohr. "Cattle graze the area, so will *bakso* (a meat ball soup) made from the beef be contaminated? And what about vegetables and cereals grown with the acid water? We don't know. Most farmers depend on irrigated water. They want to grow rice, but most of it dies. The people are getting really poor."

The priority, according to soil technologist Budi Widianarko from Soegijapranata Catholic University in Semarang, Central Java, is to get clean drinking water to the villagers.

"We can't handle the two issues of public health and finding a long-term answer simultaneously," says Dr. Budi. "Access to safe water is critical. Any new wells must be free from future contamination. Solutions for agriculture are more complicated. The pollution is causing more and more problems, economically, socially, and in people's physical and mental health."

Dr. Budi forecast that in the long run government subsidies would have to be paid if people were to stay in the area. These could make up the difference between profit from a rice crop and a cane harvest so farmers would concentrate on producing sugar.

But should the people remain? If the risks to their well-being are acute, the impact on health unknown, and the chances of making a good living remote, then maybe the long-term solution is to relocate the farmers and abandon the land.

Could the water's minerals be extracted and sold? Utrecht

University geoscientist Thom Bogaard thought gypsum could be recovered, but, again, the cost might exceed the value of the mineral.

"More research is required," says Dr. Bogaard. "This isn't just important for Kawah Ijen but for all volcanoes in Indonesia. About 10% have acid lakes. People are moving higher and higher to make a living from the land. The danger is that one solution could create another problem. Any answer has to be sustainable."

But there's another scenario that's beyond all the planning and report writing. Kawah Ijen is dormant—not dead. If it explodes again, any attempt by humans to control nature will vanish in a hail of volcanic ash and storms of acid water.

Mud on your rice

Meanwhile, around 200 kilometers to the northwest of Kawah Ijen, another part of East Java is suffering from volcanic pollution. There is mounting evidence, however, that this disaster has human fingerprints on it.

On 29 May 2006, at the start of the dry season in the district of Sidoarjo, motorists on a toll road 30 kilometers south of Surabaya City were surprised to find their travel impeded by mud oozing out of rice fields and onto the road.

A few hundred meters to the west, a plume of smoke, gas, or steam could be seen above the paddy where the green seedlings were being drowned by the rising black water.

The first explanation, offered by a company drilling for gas a few hundred meters away, seemed plausible. A major earthquake centered near Yogyakarta in southern Central Java two days earlier had caused widespread destruction. Although this occurred 300 kilometers away, it was said that the subterranean jolt had been sufficiently powerful to fracture an exploration well being drilled by a mining company, Lapindo. The result was an eruption of mud and fumes.

An anxious public was reassured that there were really no worries. The outflow was already lessening and would soon cease.

But it didn't.

The mudflow continued unabated through 2006. In late November, an underground natural gas pipeline ruptured under the vast weight of mud on the land surface above it, causing a huge explosion that killed 13 people.

In January 2007, some nine months after the eruption began, a study led by the U.K.'s Durham University[1] put a great deal of speculation to rest, when a team of experts reported that the eruption was almost certainly caused by faulty drilling practices in the gas exploration borehole a few hundred meters away.

The Durham group estimated that the outpouring has continued at rates of 7,000–150,000 cubic meters a day. As of February 2007, mud had covered around 400 hectares, wiping out large areas of rice paddy and displacing more than 13,000 villagers from their homes. At the time of writing, 25 factories had been inundated and many mosques closed. The Durham University researchers also predicted that an

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[1] Davies RJ, Swarbrick RE, Evans RJ, Huuse M. 2007. Birth of a mud volcano: East Java, 29 May 2006. *GSA Today* (February 2007).

THE STEAMING SITE of the Sidoarjo mud eruption.

GREENPEACE/VINAI DITHAJOHN

HOUSES FLOODED by volcanic mud near the Sidoarjo eruption (*both photos*).

GREENPEACE/VINAI DITHAJOHN (2)

area of at least 10 square kilometers will collapse to form a crater.

Schools, public buildings, and homes have been drowned. The toll road and railway—both vital north-south corridors—have been frequently closed as embankments, rapidly built to check the mud flood, have failed.

Sometimes, embankments have collapsed under the pressure of the mud. At other times, angry villagers have smashed the levees to prevent their farms from being sacrificed to ponds being built in a bid to contain the flood. The government expects that a further 300 hectares of agricultural land will be needed to hold the mud.

Though the wound in the earth is invisible, the location is obvious. It's in the center of the boiling black lake, where the bubbling mass is most dense and the gray gas cloud is thickest.

According to Sardiyoko, executive director of the Indonesian Forum for the Environment, the mud contains heavy metals and phenols that will make the land unfit for future farming should the mud flow cease.

Lapindo has tried to put a positive public relations spin on the tragedy. First, it claimed the mud could be used for house bricks. Then, it reportedly commissioned a TV soap opera showing how people overcame their difficulties when confronted by the mud.

But, in the real world, the farmers watch in horror and dismay as their fields, crops, and livelihoods are smothered by the unstoppable ooze poisoning their paddy. They've been offered compensation of around 5 million rupiah a hectare ($550) for Lapindo to lease the land for two years. But the funds are allegedly being distributed slowly, with many victims claiming the money is insufficient.

Where's it all coming from, and for how long? These are the questions the bystanders ask as they fidget on the footbridge. Obviously, the bowels of the earth, but surely these are limited? Geological experts differ, but the answer so far is, apparently not.

This is the stuff of science fiction films. In the movie, the army would now be shelling the mud flow, the air force dropping bombs. For a long time, the reality was nothing so dramatic, just long lines of trucks dumping dirt to form tens of kilometers of banks while 1,400 soldiers guarded against vandals.

In mid-September, Indonesian President Susilo Bambang Yudhoyono announced that a special team would be employed to try and stop the mudflow, but the word elsewhere is that the mud could keep flowing for years. The problem is being bounced between the national government, which doesn't want to use taxpayers' money, and the company, which says it has budgeted only $70 million to contain the mud and compensate affected farmers.

Two attempts to drill holes and plug the damaged well have failed. Plans to treat the effluent and pipe it 20 kilometers to the ocean have been met with dismay by environmentalists and prawn farmers downstream who fear that toxins in the discharge will cause a marine disaster.

In February 2007, three geophysicists at the Bandung Institute of Technology, Bagus Nurhandoko, Satria Bijaksana, and Umar Fauzi, announced a plan to stem the mudflow. Beginning in late February, authorities began dropping concrete balls attached to 1.5-meter-long metal chains into the neck of the crater. The plan is to start slowly with 5–10 chains per day, eventually increasing the rate to 50 per day, until about 1,000 have been deposited.

Dr. Umar believes that the contraptions will force the mud to flow around the chain-balls and slow its flow. The scheme was criticized by other engineers who point out that the process could increase the subterranean pressure and force the mud to find another path to the surface. However, in the absence of other quick, affordable ideas—this method, to be paid for by Lapindo, costs only 4 billion rupiah ($440,000)—the consensus seems to be that the plan is worth a try.

As uncertainties about the future of the Sidoarjo eruption increase, so do the ever-increasing piles of mud. Meanwhile, as more and more buildings, streets, and rice fields are swallowed, the lives of Sidoarjo's residents have been changed forever.

Duncan Graham is an Indonesia-based writer specializing in multicultural issues in Indonesia.

Rice Genetics Collection CD

The Rice Genetics Collection CD features the proceedings of past symposia and other selected literature containing nearly 4,400 pages of searchable information on rice genetics and cytogenetics published by IRRI and its partners since 1964. In addition to the five rice genetics symposia held at 5-year intervals since 1985 (*Rice Genetics I-V*), the Collection includes classic publications that truly kicked off significant reporting on these subjects in the early 1960s:

- The *Symposium on Rice Genetics and Cytogenetics,* held at IRRI on 4-8 February 1963, was the first-ever international conference solely devoted to rice genetics, cytogenetics, and taxonomy. The proceedings were published in 1964 by the Elsevier Publishing Company.
- The technical bulletin on the *Present Knowledge of Rice Genetics and Cytogenetics*, written in August 1964 by renowned geneticist T.T. Chang, provided the first effort to bring together in one medium the voluminous multilanguage literature on these important subjects.

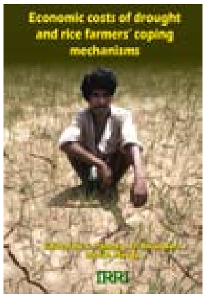
Also included are 22 issues of the *Rice Genetics Newsletter*, published in 1984-2005 by the Rice Genetics Cooperative, and a 642-page supplement to Rice Genetics IV, *Advances in Rice Genetics*.

The most recent information contained on the CD is the proceedings of the Fifth International Rice Genetics Symposium, where distinguished geneticists delivered plenary lectures covering topics from classical genetics to the most advanced research on the sequencing of the rice genome and functional genomics. Symposium sessions reviewed the latest advances in rice research and stimulated in-depth discussion on key issues, including classical genetics, genome organization, genetic diversity, applied genetics, genetic modification, regulation of gene expression, functional genomics, and molecular mapping for biotic and abiotic stresses.

Economic costs of drought and rice farmers' coping mechanisms

Edited by S. Pandey, H. Bhandari, and B. Hardy; published by IRRI; 203 pages; developed countries US$18, developing countries $6.

Drought is a major constraint affecting rice production, especially in rainfed areas across Asia and sub-Saharan Africa. At least 23 million hectares of rainfed rice area (20% of total rice area) in Asia are estimated to be drought-prone. Even in traditionally irrigated areas, which account for almost 75% of total rice production, drought is becoming an increasing problem because of water scarcity resulting from rising demand for water for competing uses. Drought imposes a serious economic burden on society and has been historically associated with food shortages of varying intensities, including those that have resulted in major famines in different parts of Asia and Africa.

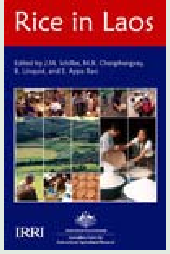


The main objective of the study described in this book was to estimate the economic costs of drought in three major rice-growing countries of Asia (China, India, and Thailand), document farmers' risk-coping mechanisms in drought-prone rice-growing areas of Asia, and recommend suitable interventions, both technical and policy, for effective drought management.

The book provides a general discussion of the drought problem in the rainfed rice production system in South and Southeast Asia; presents a literature review about the definition, economic costs, and coping mechanisms for drought; and describes the analytical methods used for characterizing drought, estimating the aggregate and household-level impacts of drought, and examining farmers' drought-coping mechanisms. Results of the three country studies and a synthesis of findings and implications for drought-mitigating interventions are presented.

The authors conclude that scientific progress—on understanding how rice plants respond to drought and in developing biotechnology tools—has opened up promising opportunities for drought mitigation through improved technology. However, agricultural research in general remains grossly underinvested in the developing countries of Asia. This is cause for concern, not only for drought mitigation but also for promoting overall agricultural development.

Rice in Laos



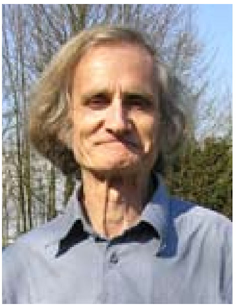
Edited by J.M. Schiller, M.B. Chanphengxay, B. Linquist, and S. Appa Rao; 457 pages; developed countries US$33, developing countries $11.

This book documents the long association of Laos and its people with rice. Drawing on historical, cultural, and agricultural contexts, the book details some of the key advances in rice-related research since 1990. It is the result of a collaborative effort among international and Lao researchers, with the support of Australian Centre for International Agricultural Research and IRRI.

Innovations in rural extension

Review by Robert Chambers

Van Mele P, Salahuddin A, and Magor NP, eds. 2005. Innovations in Rural Extension: case studies from Bangladesh. *CABI Publishing, CAB International, Wallingford, UK, and Cambridge, Mass., USA.*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This inspiring book shows how far some have come from the early days of technology transfer. For here are presented illustration after illustration of a participatory and pluralist paradigm so different that it seems odd to apply the same label—extension—to both the earlier monolithic mindsets and monocultures of methodology, and the contrasting rich panoply of approaches described here.

Poverty Elimination Through Rice Research Assistance (PETRRA) was a 5-year (1999-2004) project funded by the U.K. Department for International Development. The project was managed by the International Rice Research Institute (IRRI) in close collaboration with the Bangladesh Rice Research Institute (BRRI). Its philosophy and practice were learning by doing. During its life, it approved, managed, and supported 45 subprojects—on pro-poor policy (6), technologies (19), and uptake and extension (20). It is these latter that provide the experience and material for the book. This was an exercise that set out to learn by conducting research on a variety of approaches to extension itself.

This is a far cry from older orientations. The first major section, on gender, gives long overdue prominence to women in South Asian agriculture. The book stands on its head the old linear or pipeline paradigm in which research innovates and passes on innovations to extension for promotion and spread. In the place of such old mindsets and methods are a range of practices and approaches that stress listening, learning, negotiating, and facilitating, as well as training of facilitators.

We have here accounts of experiences and comparisons among a rich variety of extension approaches. Innovations include integrated rice-duck farming and various aspects of seed systems—building a rice seed network, a value-chain approach for aromatic rice, and much more. These are but some manifestations of the diversity and originality that flowered with this project.

Required reading for all who fund agricultural research and extension

PETRRA was pathbreaking. For many, it will be the final synthesis that is most striking. There, the editors confront and discuss the issues of extension, complexity, and poverty; of creativity and flexibility; and of motivation. They point to the professional pride and personal satisfaction of having worked through a problem with farmers as a major motivation for researchers and extensionists.

Perhaps the most important section, which could have the biggest impact, concerns donors and flexibility, projects, service providers, and potential champions. Lessons and warnings are laid out. Among these, one that stands out is the incompatibility of logframe approaches with conditions of uncertainty and the fostering of creativity. This book should be required reading for all who fund agricultural research and extension.

Paradigmatically, *Innovations in Rural Extension* has opened up as never before the need and potential for methodological pluralism. It shows such a wide range of complementary choices of what to do, and it compares their costs and effectiveness. For too long, agricultural extension has been in the doldrums, and agriculture a diminished priority among aid agencies.

The big practical question now is whether normal extension services, without special project support, can adopt or adapt some of PETRRA's rich repertoire of approaches. At least those aid agencies that wish to help poor farmers will now know that so much can be achieved with vision and appropriate continuity of support, facilitation, leadership, and staff. May PETRRA and this book inspire many others to follow and do likewise.

And, if any donor agency is looking for a cost-effective investment, it would be hard to do better than to provide the means to make this book cheap and accessible, and to send a great many copies with a covering letter to those concerned with agricultural research and extension policy and practice around the world.

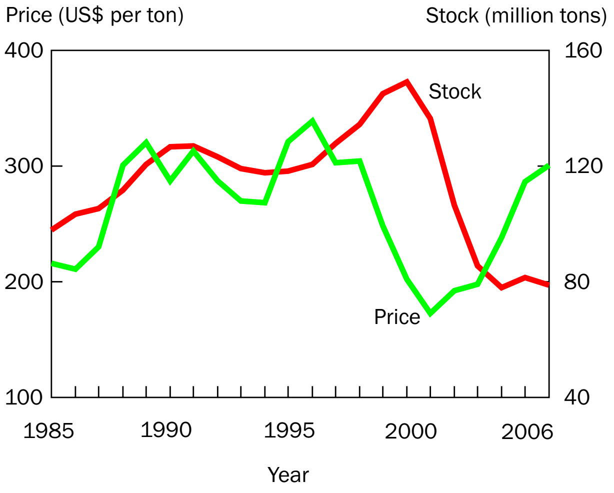
Robert Chambers is a research associate at the Institute of Development Studies, Sussex, UK. He is a co-editor of Farmer First *(1989), which makes the case for a farmer-first mode to complement conventional procedures for research and transfer of technology.*

RICE FACTS

A balancing act

by Mahabub Hossain
Head, IRRI Social Sciences Division

How do we produce enough food to feed a growing population in the face of declining growth in cereal yields?



Trends in international rice prices and stocks (end-period), 1985–2006.
Sources: *Stocks data*: Papanos RS. 2007. The Rice Report (28 February 2007 issue). The Rice Trader LLC. Houston, TX, USA. *Price data*: Development Policy Group. World Bank online.

Population growth is the dominant determinant of the demand for staple food. World population has more than doubled since the 1950s and has already surpassed 6.5 billion. It may increase another 3 billion before stabilizing in 2100. Over the next quarter century, the world population is projected to increase by 1.95 billion, mostly in the developing countries and in regions where poverty and hunger are widespread, such as sub-Saharan Africa and South Asia.

Developed countries may not need to increase cereal production any further as most now have a stationary population, with some experiencing an absolute decline—although this situation may change if petroleum prices continue to increase. The demand for maize and cassava, for example, may increase rapidly as they are used as raw materials in the fast-growing bio-fuel industry for the production of the petroleum-substitute ethanol (see *Food or fuel?* on page 42 of *Rice Today* Vol. 6, No. 1).

Developing countries, on the other hand, continue to struggle to achieve and maintain food-population balance. The potential for increasing the supply of food by expanding the land frontier has long been exhausted, particularly in Asia, where 60% of the world's population lives. Land-saving technical advances that increase crop yield (productivity per unit of land per season) and the expansion of irrigation infrastructure have been the dominant factors behind the increase in the supply of staple food over the past 4 decades.

However, the potential for increased land productivity, like that initiated in the irrigated and favorable rainfed environments by the Green Revolution in the late 1960s, has almost been exhausted. Since the late 1980s, there has been a drastic slowing of yield growth for all cereal crops (see table, *below*). The growth in yield has decelerated from 2.4% to 0.9% per year for rice, from 3.8% to 1.3% for wheat, and from 2.7% to 1.6% for maize. For rice, yield growth has decelerated substantially since 1990 in China, India, and Indonesia, which together account for nearly 60% of global rice production and consumption. This slowing of yield growth is due to technological progress reaching a plateau in the irrigated ecosystem, limited expansion of irrigated area due to the growing scarcity of water, and continuing low yields in rainfed ecosystems due to the nonavailability of technologies suitable for unfavorable environments.

Since 2000, rice production has been growing at a slower rate than consumption, leading to depletion of stocks and an upward trend in rice prices in the world market (see figure, *above*). In early 2007, the price of medium-quality rice was 75% higher than in 2001. The rapidly growing rice prices now pose a threat to food security for poor consumers in many low-income countries in Asia, such as Indonesia, Bangladesh, and India.

Growth (%) of cereal yield, area, and production, developing countries: 1970–90 and 1990–2005.

Cereals	1970–90			1990–2005		
	Yield	Area	Production	Yield	Area	Production
Rice	2.35	0.49	2.84	0.92	0.31	1.23
Wheat	3.75	0.88	4.62	1.27	–0.35	0.91
Maize	2.65	0.97	3.61	1.64	0.66	2.3
All cereals	2.68	0.73	3.41	1.2	0.21	1.41

Source: Analysis of trend with FAO time series data.

These developments raise concern about the developing world's ability to achieve and sustain food security in the future. The Green Revolution helped buy time in the continuous struggle to provide food for growing populations. But time is running out. The most promising strategy for sustaining food security in the face of growing population pressure is increasing the productivity of increasingly scarce land and water.

For rice, research must deal with several difficult problems: raising the yield ceilings of the current available rice varieties, protecting past yield gains in the irrigated ecosystem, and—using recent advancements made in genomics, genetics, and biotechnology—developing high-yielding varieties for rainfed systems that are tolerant of drought, submergence, and problem soils.

The speed and extent to which the rice research community can meet these challenges will depend on the level of resources that can be mobilized to support crop improvement research in the public sector.

PETER JENNINGS

Rice revolutions in Latin America

In 1962, scientists at the International Rice Research Institute (IRRI) debated the cause of low and stagnant rice yields in the tropics: was it variety or crop management? This debate ended with the release of the semidwarf IR8 in 1966, initiating the Green Revolution. The same variety, in the same year, extended this revolution to Latin America, beginning in Colombia and spreading rapidly through the tropics and later to the temperate areas.

The Green Revolution in the Americas was genetic with little contribution from agronomy. Its impact was approximately two additional tons per hectare. On a national basis, this spectacular advance terminated within a few years when essentially all of the irrigated and favored upland ecologies converted to semidwarf varieties. From then on, yields did not increase. On individual farms, the revolution ended after the first harvest. Replanting with IR8, or any other semidwarf, did not result in higher yield. It was a momentous, one-time contribution followed by a persistent yield barrier lasting some 30 years.

On individual farms, the Green Revolution ended after the first harvest

During this period of stagnancy, national yield averages in a few Latin American countries increased modestly, reflecting a shift from favored upland to irrigated cultivation. Neither higher yielding varieties nor improved crop management played a role. In tropical Asia, national averages slowly and steadily moved upward after the Green Revolution. I suspect this reflects better water management and conversion from rainfed and other less productive ecologies to irrigated rice.

An inability to further increase yields engendered another round of debate. The majority view, contending that more productive varieties were needed, led to massive investment during the past 25 years in biotechnology and genetics and under-investment in crop management. The implicit thought is that greater yield capacity is required for higher farm productivity. At the Latin American Fund for Irrigated Rice (FLAR), we hold the minority view that the constraint today is agronomic, not genetic. Our contention is based on two observations.

First, the release of nearly 400 semidwarf varieties over three decades did not increase farm yield. Further, we contend that none of the newer semidwarfs surpasses IR8, Jaya, or Bg-90, the first modern varieties, in yield capacity. Second, every year, a few farms scattered around the hemisphere yield 9-11 tons per hectare or more—roughly double national averages and an indication that existing varieties have considerable unexploited yield capacity. Thus, the problem is not yielding ability.

To narrow this yield gap, FLAR, with support from the Common Fund for Commodities, initiated a crop management program in 2003 under the leadership of agronomist Edward Pulver. This began the identification of six regional agronomic deficiencies: inappropriate seeding dates missing peaks of solar radiation after panicle initiation; extremely heavy seeding densities causing lodging, disease, and pest attacks; repeated aerial spraying rather than seed treatment to control insects; deficient weed control; poor fertilization practices including the application of urea into water; and late establishment of permanent irrigation.

Solutions for each deficiency were packaged together for on-farm demonstrations. After three years, results from several hundred thousand hectares in several counties confirm that an Agronomic Revolution is now in progress. This second revolution, devoid of any genetic contribution, has so far had an impact equal to that of the Green Revolution, increasing farm yield by roughly two tons on average.

Well-managed farms, now yielding 8-11 tons per hectare, confirm that the yield constraint since the introduction of modern varieties in the 1960s has been poor crop management. The key to Dr. Pulver's approach lies in the simultaneous reduction of multiple farm constraints as contrasted with typical agronomy directed toward individual problems.

FLAR believes that once the Agronomic Revolution is widely adopted, productivity will again become stagnant. We contend that the new productivity constraint will revert to varietal yield capacity, as it was pre-Green Revolution. Thus, the present problem of poor crop management, now being resolved, will be succeeded by the need for more productive varieties. FLAR has combined two underappreciated traits—delayed leaf senescence (ageing), or "stay-green," and huge panicles—while maintaining heavy tillering capacity. We expect the enhanced yield capacity of this new plant type will catalyze a second genetic Green Revolution.

Thus, we observe alternating yield constraints: firstly genetic (pre-Green Revolution), then agronomic (post-Green Revolution) followed by the need for a second genetic Green Revolution. Many years separate these quantum leaps in productivity and each advance is achieved with little contribution from the other discipline. In part, this results from the failure of breeders and agronomists to develop strategy jointly. Further, the decades of little progress following the adoption of semidwarfs indicate a misidentification of the yield constraint as institutions directed resources inappropriately. Researchers, like generals, often fight new battles with strategies and tactics of previous wars.

Dr. Jennings, a principal scientist with FLAR, founded the breeding program at IRRI (1961-67), where he discovered the semidwarf gene and led the breeding of IR8.

The 4th International Rice Blast Conference

Changsha, Hunan, China, 9-14 October 2007
www.4thirbc.org

Rice blast, caused by the fungal pathogen *Magnaporthe grisea*, is one of the most destructive plant diseases worldwide. Due to blast's high variability, loss of resistance in rice cultivars presents a serious problem to sustainable production.

Since the 3rd International Rice Blast Conference, held in Japan in 2002, significant progress has been made in understanding the defense mechanisms of rice and pathogenicity of the fungus. Complete genome sequences of both rice and the blast fungus are now making the rice-blast pathosystem a premier model for understanding plant-fungal interactions.

The Fourth International Rice Blast Conference offers a timely and exciting opportunity for reviewing progress and charting future research to enable better control of this important disease.

Organizing Committee:

- Guo-Liang Wang (Chair), Ohio State University, USA and Hunan Agricultural University
- You-Liang Peng, (Co-Chair), China Agricultural University, China
- Barbara Valent, (Co-Chair), Kansas State University, USA
- Fernando Correa, International Center for Tropical Agriculture, Colombia
- Ralph A. Dean, North Carolina State University, USA
- Yulin Jia, Dale Bumper National Rice Research Center, USA
- Shinji Kawasaki, National Institute of Agricultural Sciences, Japan
- Marc-Henri Lebrun, CNRS-Bayer Crop Science, France
- Yong-Hwan Lee, Seoul National University, Korea
- Hei Leung, International Rice Research Institute, Philippines
- Nicholas J. Talbot, University of Exeter, UK
- Jin-Rong Xu, Purdue University, USA
- Youyong Zhu, Yunnan Agricultural University, China

The International Rice Blast Conference

The 2nd International Conference on Rice for the Future

7-9 November 2007

Queen Sirikit National Convention Center, Bangkok, Thailand

The first International Conference on Rice for the Future was held in Bangkok to mark the UN's International Year of Rice in 2004. The second International Conference on Rice for the Future will also be held in Bangkok and is set to confirm the role of rice as the world's most important food crop. The 2007 conference will focus on rice as a designer crop for healthier products.

Themes: The conference will cover a number of research themes from breeding and genomics to human nutrition and health. It will also look at the latest developments in the breeding of rice varieties tolerant of biotic and abiotic stresses.

Lecture Highlights

"New solutions to old problems and future challenges: What science can do to make the Asian rice industry more productive"
By Dr. Robert S. Zeigler, International Rice Research Institute (IRRI), The Philippines

Biotechnology - The rocky road to success
By Dr. Jim Peacock, CSIRO-Plant Industry, Australia

Multidisciplinary Approaches to Better Understand the Genetic Basis of Drought Tolerance in Plants
By Dr. Jean-Marcel Ribaut, Generation Challenge Programme, C/O CYMMYT, Mexico

Plant Functional Genomics in Drought Stress Response
By Dr. Kazuo Shinozaki, RIKEN Plant Science Center, Japan

Current and Future Prospects for Marker Assisted Selection in Plant Breeding
By Prof. Patrick M. Hayes, Oregon State University, USA

Genetics and Genomics Approaches to Unraveling the Molecular Basis of Broad-spectrum Resistance to *Magnaporthe grisea* in Rice
By Assoc. Prof. Guo-Liang Wang, Ohio State University, USA

In Quest for the Origin of Aromatic Genes in Rice
By Assoc. Prof. Apichart Vanavichit, Kasetsart University, Thailand

Call for Papers: Prospective authors of oral and poster presentations are invited to submit abstracts in English for consideration by **31 July 2007** at http://www.biotec.or.th/bioasia2007

The 2nd International Conference on Rice for the Future will be held concurrently with the 6th Asian Crop Science Association Conference and BioAsia 2007 Thailand, the international trade show. Registrants to the 2nd International Conference on Rice for the Future can attend all conference sessions of the 6th Asian Crop Science Association Conference and the trade show.

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Department of Agriculture

Rice Department

Kasetsart University

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