PROJECT 4

Managing resources under intensive rice-based systems

The highly productive favorable irrigated environment produces nearly three-quarters of the world's rice. Increased production due to improved rice varieties, expanded irrigation, improved management, reduced losses due to pests, and higher rates of fertilizer use in the two major intensive rice production systems—double cropping of rice and the rice-wheat rotation—have resulted in Asia's rice production doubling over the past three decades.

Yield growth in recent years, however, has stagnated. If this stagnation continues, producing enough rice to satisfy a growing population of urban poor and rural landless will become increasingly difficult, especially when combined with postharvest losses. Further, as laborers continue to move away from farms to find jobs in the cities, farmers will face worsening labor shortages and a consequent increase in labor costs. At the same time, shortages of irrigation water and misuse of agrochemicals are causing environmental concern.

Current irrigated rice yields in rice-rice and rice-wheat systems average 5 tons per hectare. This is well below the estimated potential yield of 8 tons per hectare of popular rice varieties. Without new knowledge, techniques, and practices, it will be difficult for farmers to bridge this gap and achieve both increased profitability and minimal environmental impact.

Environmentally sound, socially appropriate technologies and machinery can help increase farmers' income and livelihood as well as enhance or sustain the productivity of favorable environments. In addition to integrating management of soil, water, weeds, pests, and diseases, such technologies must also conserve biodiversity and environmental health. Fully developing these technologies requires research on crop physiology, nutrient cycling, pest ecology, the rice crop in its environs, and mechanization systems—all within the context of farmers' management approaches and limitations.

Output 1: Crop and soil management practices and strategies developed and deployed for sustaining productivity, enhancing profitability, and minimizing environmental impact in intensive systems

In 2006, we established principles and approaches for site-specific nutrient management (SSNM) that are now being used for locally adapted nutrient management recommendations and practices in seven countries: Bangladesh, China, India, Indonesia, Myanmar, the Philippines, and Vietnam. This included the revision of fertilizer recommendations of NARES, nongovernment organizations, and the private sector. This process has also enhanced

partnerships between NARES and the private sector. Environmental benefits are being seen through the production of more rice per unit of nitrogen lost (as a greenhouse gas or nutrient) from rice fields. Farm-level productivity and profitability of rice production have increased in several major rice-growing areas of Asia. In addition, we developed an SSNM Web site that contains locally adapted recommendations for the same seven countries, including multiple areas for some countries.

Principles and practices were developed for integrated management of crop residues with nutrients, water, and tillage for optimal nutrient supply and input-use efficiency, and minimal greenhouse gas emissions. This included new recommendations for nitrogen management with straw incorporation and new recommendations for minimizing greenhouse gas emissions.

Output 2: Improved pest management practices developed and deployed to increase productivity and conserve and enhance the environment

IRRI researchers measured stem borer abundance under different field conditions and identified germplasm with variation in resistance to this pest during the booting phase, when damage leads to the greatest yield loss. A farmer participatory study in the Philippines was begun to determine the environmental and management factors associated with stem borer damage. Evaluations of varietal mixtures and interplanting for tungro and blast control were completed and made available to NARES and advanced research institute scientists. A management strategy for tungro was developed and presented to a farmers' discussion forum and is now being evaluated on-farm. Variety mixtures were evaluated for suppression of tungro in fields and the greenhouse. The seed mixture of varieties Matatag 9 and IR64 at a ratio of 3:1 can be recommended in tungro-endemic areas to achieve yields in conditions of high disease pressure that are similar to those of IR64 grown under low or no tungro pressure. Interplanting one row of high-quality glutinous rice in every four to six rows of high-yielding hybrid rice continues to be adopted in Yunnan Province and has expanded to Sichuan and other provinces in China. Interplanting for rice blast control has extended to a total area of 1.6 million hectares in Yunnan, Sichuan, and other provinces since 2000. Based on survey results from 202 counties, efficiency of blast control has reached 70% and fungicide application has been reduced by almost 60%, resulting in improved farmers' income through increased yield and reduced costs. In Yunnan, the diversification concept has been extended to control diseases and insect pests of other major crops, such as wheat, barley, and broad bean. In a span of 4 years, the area grown with such crop mixtures in Yunnan has reached more than 470,000 hectares.

We determined shifts in weed species resulting from the change from transplanting to direct seeding in two countries (India and Bangladesh). Over four cropping cycles of direct seeding, there were increases in the annual grasses *Ischaemum rugosum* and *Leptochloa chinensis* and the annual sedge *Fimbristylis miliacea* with wet seeding while the perennial sedge *Cyperus rotundus* increased in dry-seeded rice. The establishment method for wheat, grown in rotation with rice, also had an effect on the weeds in rice. Zero-tillage for wheat encouraged *C. rotundus* while the annual grass *Echinochloa colona* declined. Equivalent studies began in Indonesia and the Philippines. This information is helping to define management strategies to respond to undesirable shifts in weed populations, and assist with the development of integrated measures.

In Vietnam, 135 episodes of the "IPM soap opera"—with storylines designed to educate farmers on the best integrated pest management (IPM) practices for reducing pesticides—were developed and broadcast over radio stations Voice of Ho Chi Minh City, Voice of Vinh Long, and Voice of Cantho. In Vinh Long, the series contributed toward a 30% reduction in insecticide sprays. In Lao PDR, 104 episodes were

developed and broadcast over National Lao Radio. Overall, improved disease management due to mixed planting, refined focus for the development of weed management, and host-plant resistance to stem borers advanced knowledge that is leading to improved management options. Through the use of mass media, IPM information became more widely available to farmers.

Output 3: Mechanization systems that improve the efficiency and sustainability of rice production developed

Postharvest management practices, improved storage technologies, market information, and quality-enhancing production technologies for reduced losses and improved quality were made available for wide-scale delivery in Indonesia, Cambodia, Lao PDR, Vietnam, and Myanmar. Specifically, market information was posted on village price boards in four villages in Vietnam and eight villages in Cambodia on a monthly basis; farmer field trials were conducted on a hermetic storage bag—known widely as the "superbag," and which allows cereal grains to be safely stored for extended periods—in Indonesia, Vietnam, Lao PDR, and Cambodia; superbag production was established in Indonesia and planning for production began in Vietnam; manufacture of the cheaply produced IRRI moisture meter was established in the Philippines and Vietnam; and promotion of laser leveling continued in Vietnam and Myanmar.

The transfer of appropriate drying systems from Vietnam to neighboring countries with similar climatic conditions continued and manufacturers in Lao PDR, Myanmar, and Cambodia started producing flat-bed dryers with a 4-ton daily capacity for the commercial sector and farmers' group usage. In Lao PDR, a manufacturer made 30 units of a low-cost farm-level dryer. Commercial prototypes of a labor-saving rice hull furnace for use with the flat-bed dryer were installed in Vietnam at farmers' cooperatives for long-term evaluation. Laser-assisted land leveling, a technology for more accurate leveling of rice fields for water savings and more even maturing of the crop, was introduced to Myanmar through operator training and field demonstrations. Together, these advances offer options for resource-saving plant establishment and informed decisionmaking for reduced postharvest losses, improved rice quality, and increased profitability.

Output 4: Resource-use efficiency in rice-wheat systems increased

In 2006, we designed integrated crop and weed management options—particularly for minimum-till and direct-seeded systems—that are efficient in labor, water, energy, and agrochemical use. These were evaluated with farmers in four areas in Bangladesh, India, Nepal, and Pakistan. Significant

progress was made in perfecting the double-zero-till system (drill-seeded rice and after zero-tillage wheat) and its benefits in terms of yield, income, and water savings were quantified. A study at Modipuram in the Indian state of Uttar Pradesh has shown that it is possible to cut water use by 35–40% with a double-no-till system while maintaining productivity similar to that of the more commonly used transplanting of rice followed by dry-tilled direct-sown wheat. More than 1,000 on-farm trials and technology demonstrations were conducted in Bangladesh, India, Nepal, and Pakistan for refining resource-conserving technologies' potential to improve productivity, increase income, and minimize adverse environmental impact. The enhanced technologies include zero-till drills, double-disc drills, and rotary-disc drills. These have been modified for multicrop seeding and simultaneous seed and fertilizer application with residue mulch.

Finally, weed management options for direct-seeded rice have been tested in farmers' fields in the Indo-Gangetic

Plains (in the Indian states of Uttaranchal, Uttar Pradesh, and Bihar) in more than 100 farmer field trials over a total of 975 hectares. Direct-seeding options gave yields similar to those of transplanting but achieving good crop establishment and effective weed management requires that farmers acquire new knowledge. Increased efforts will be made to make more information available to farmers.

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PROJECT 5

Enhancing water productivity in rice-based production systems

In many rice-growing regions, supplies of irrigation water are declining. Not only are water quality and availability decreasing, but farmers are also facing increasingly fierce competition from growing industrial, urban, and domestic sectors. Making better, more efficient use of water in irrigated rice production systems is now a crucial issue. Frequent and widespread drought compounds the problem. Further, as supplies diminish, the price of water is rising, either via direct costs or through the power outlay for pumping groundwater.

Asia is highly dependent on irrigated rice for food security. Irrigated agriculture in Asia uses 90% of total diverted fresh water, and about half of that is used for rice. Irrigated rice