IRRI's Environmental Agenda

an approach toward sustainable development





International Rice Research Institute

IRRI's Environmental Agenda—an approach toward sustainable development

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IRRI

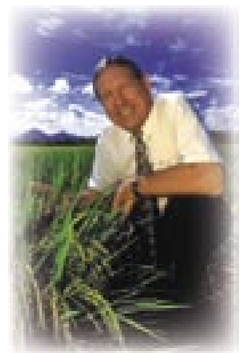
INTERNATIONAL RICE RESEARCH INSTITUTE

Contents

Preface

The environment will always feel the impact of agriculture, not the least of which is rice farming. Rice is the staple food of almost 3 billion people, and rice farms cover around 150 million hectares—more than any other crop. Rice production, much of which takes place in flooded paddies, has unique and profound implications for the environment and the livelihood of the people depending on it. Hence, environmental sustainability is a key component of the sustainable rice ecosystem.

In 2002, an IRRI work group, led by scientists James Hill and Suan Pheng Kam, embarked on the development of a natural resource management strategy to guide our research in all rice-based systems. This effort was uplifted and broadened by Emanuel A.S. Serrão, a respected Brazilian member of our Board of Trustees who suggested that IRRI should take a more holistic view on the sustainability of both rice production and the environment. He encouraged the Institute to establish an environmentally based guiding principle for all the activities we do and the impact we try to achieve. With the full support of our BOT during its September 2002 meeting, IRRI management decided to move forward to pursue Dr. Serrão's recommendation. In January 2003, Ren Wang, our deputy director general for research, established a staff task force to develop IRRI's Environmental Agenda (IEA), which is detailed in this booklet.



I thank the team composed of Sushil Pandey (chair), Gene Hettel (vice chair), Bas Bouman, Darshan Brar, Ruaraidh Sackville Hamilton, Arnold Manza, Casiana Vera Cruz, and Duncan Macintosh (resource person). They have done extensive literature searches and hours and hours of hard work drafting and redrafting this historically significant document and consulting with IRRI staff to crystalize the seven key issues that encompass the IEA.

I also thank two external experts who provided assistance to the IRRI team in conceptualizing and drafting the IEA: Xuan Zengpei of the Chinese Academy of Engineering, who has been involved extensively in China's environmental policy development, and Yueh Kwong Leong of the Socioeconomic and Environmental Research Institute, Malaysia.

Concern for the environment has long been apparent in IRRI's research but, to take the environmental approach in a more holistic way, to consciously commit to conserving the environment and achieving sustainable development, and to package it as a published agenda, I think, is something unique among the Future Harvest Centers of the CGIAR.

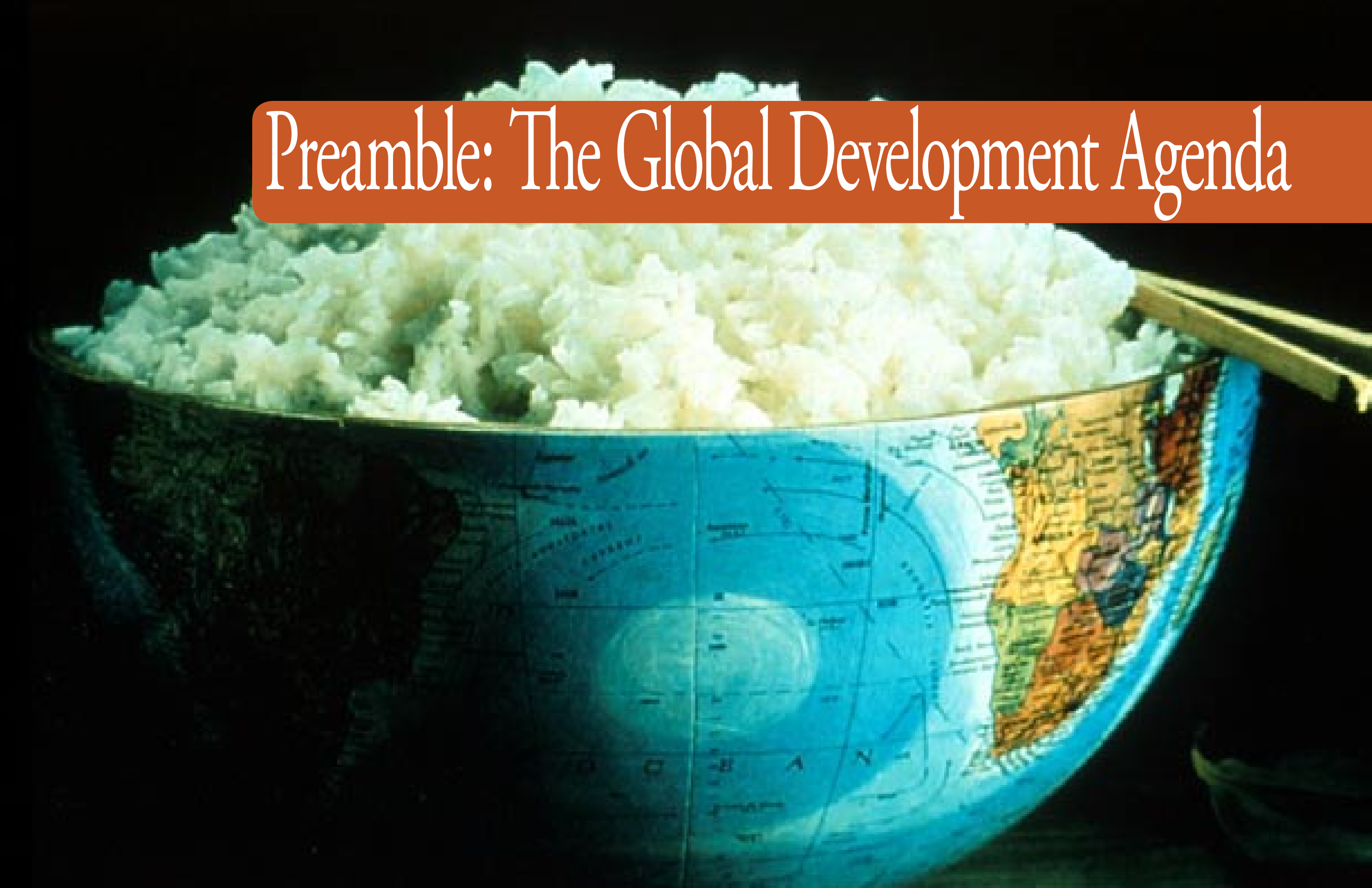
The IEA is an institutional commitment to the effect that we will build environmental principles into the guiding framework of our program activities and extend the benefits to the farthest corners of Asia and beyond.

We decided it would be fitting to launch the IEA at a significant event during the International Year of Rice 2004. So, we selected the World Rice Research Conference in Japan, being the most important—and culminating—scientific event of the IYR, as the most appropriate occasion.

We believe that the IEA will guide IRRI toward achieving a "Doubly Green Revolution," as well as bring the Institute to a higher level of strength and sophistication in producing international public goods for the world.

Ronald P. Cantrell
Director General, IRRI

Preamble: The Global Development Agenda



Four major international events have largely shaped the global development agenda:

- The United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro (1992)
- The World Food Summit in Rome (1996)
- The United Nations Millennium Summit in New York (2000), from which emanated the Millennium Development Goals
- The World Summit on Sustainable Development (WSSD) held in Johannesburg (2002)

United Nations Conference on Environment and Development

The United Nations Conference on Environment and Development (UNCED), also known popularly as the Earth Summit, was the global response to the very serious environmental problems that resulted from economic development. These environmental problems had become global in scope and were very evident by the 1970s. Concern was growing by the 1980s that much of the development taking place was nonsustainable and that development must take the environment into consideration if it were to be sustainable. The Earth Summit firmly established the commitment of the world's nations to protect the environment while striving to achieve social and economic development.

One of the major outcomes of the Earth Summit was the agreement by all countries to adopt Agenda 21, which is the Agenda for Sustainable Development for the 21st century. Eradicating poverty, changing consumption and production patterns, and protecting

and managing the natural resource base for economic and social development were seen as overarching objectives and essential requirements for sustainable development. One of the most important components of sustainable development is the development of sustainable agriculture. The scope of the transition to sustainable agriculture is outlined in chapter 14 of Agenda 21.

Since the Earth Summit, the objectives of sustainable development have become the basis and objectives of many national development plans. This denotes a paradigm shift in the basis of development—from economic development per se to sustainable development as defined in Agenda 21. The three dimensions of sustainable development are economic improvement, social equitability, and environmental sustainability; these are interdependent and must be integrated.

World Food Summit

Despite the considerable achievements made in improving the food situation globally since the 1960s largely as a result of the Green Revolution, food security remains a serious challenge for many parts of the developing world. The World Food Summit of the United Nations highlighted the fact that more than 800 million people throughout the world do not have enough food to meet their basic nutritional needs. Meeting the basic needs for food is therefore an urgent challenge for sustainable development. The World Food Summit in its declaration recognizes that food security is inseparable from poverty eradication and pledges to halve the number of hungry people by 2015. The World Food Summit Plan of Action aims to work toward lasting food security at individual, household, national, regional, and global levels and to achieve this in a sustainable manner.

United Nations Millennium Summit

Although the concept of sustainable development had become widely accepted nationally and internationally, it is now generally accepted that not enough of Agenda 21 was implemented in the years following the Earth Summit for various reasons.

At the United Nations Millennium Summit in September 2000, world leaders placed development at the heart of the global agenda by adopting the Millennium Development Goals (MDGs), which set clear targets for reducing poverty, hunger, disease, illiteracy, environmental degradation, and discrimination against women by 2015.

World Summit on Sustainable Development

The World Summit on Sustainable Development (WSSD) reiterates the objectives and principles of Agenda 21. The Millennium Development Goals were accepted as one of the main themes of the World Summit on Sustainable Development held in 2002. While recognizing that there were shortfalls in the implementation of Agenda 21, the WSSD reiterates its resolve to achieve its objectives as well as the Millennium Development Goals by adopting a detailed Plan of Implementation of the World Summit on Sustainable Development. Another outcome was the WEHAB Agenda (water, energy, health, agriculture, biodiversity) put forward by the UN and this was widely seen as a useful way to concentrate on key policy areas.

The need for agriculture to be productive and environmentally sustainable was emphasized in the Plan of Implementation. Poverty eradication is now seen as an underlying theme in all work of sustainable development. ■

Rice and the Environment

Rice and the Green Revolution

Rice is one of the three most important food crops in the world. It is the staple food for much of Asia's population, an estimated 2.9 billion people out of the world population of 6 billion. Rice as a crop dominates the agricultural landscape over most of monsoon Asia. Rice farming represents the largest single agricultural land use in Asia, covering more than 135 million hectares. The patchwork of rice fields and surrounding areas constitutes a unique agroecological system that is rich in biodiversity and parallels some of the most diverse "natural" systems on Earth.

Rice production to feed the billions of Asians is intricately linked with the land, water, and environment of vast tracts over all of Asia. Careful management of the natural functioning of rice ecosystems is critically important for protecting the environment while raising productivity to meet the growing consumer demand for rice.

The first Green Revolution helped avert predicted famines as Asia's population burgeoned in the 1970s. Given the expediency of the situation then, rice research focused on raising productivity per se to attain production levels apace with population growth. This was done by introducing seeds of high-yielding varieties. This goal has been largely achieved over the past few decades; food production doubled with a mere area expansion of 10–20%. This dramatic increase in productivity became known as the Green Revolution.

However, changing times now place different demands on rice research. First, Asia faces not only continued population growth, albeit at reduced annual rates, but also population shifts, as countries race toward modernization and urbanization. This has resulted in a concomitant increase in the proportion of urban rice consumers who are totally dependent on rural areas for their supply. Second, growing environmental concerns globally over the depletion of natural resources and degradation of the land, soil, and water resonate into the agricultural scenario as well. There is no denying the adverse environmental consequences of agricultural intensification brought about by widespread adoption of the high-yielding varieties

that heralded the Green Revolution of the early days. Nonjudicious use of farm chemicals to attain high yields and in response to heightened disease and pest pressure results in widespread environmental pollution. Heavy demand for water through surface-water and groundwater irrigation affects natural wetlands and water bodies and raises the water table, causing a buildup of salinity and other soil-related problems. Intensified rice cultivation increases the emission of greenhouse gases such as methane, which is an important component of gases contributing to climate change.

The changing social milieu necessitates shifts in the focus of rice research to examine various interrelated issues of rice production, sustainability in the use of natural resources, impacts on the environment, and the impacts of global climate change. The persistence of hunger amid an adequate food supply requires a focus now on access to food and the means of producing food rather than solely its production. This new focus is accompanied by the following challenges to rice research.

1. Rice production is for both attaining national food security and ensuring household food security.
2. With the population shift to urban areas, it is important to produce more rice to feed a growing population, and to keep prices low for urban consumers while allowing for acceptable levels of profitability for producers.
3. Rice production is to be increased using less land and water to ensure sustainability by improving the technology of rice production.
4. The deployment of rice technologies should not compromise environmental and human health. This can be done by
    a. avoiding the overuse of agro-chemicals, and at the same time,
    b. avoiding depletion of the natural resource base and degradation of the land, and
    c. ensuring that the deployment of biotechnology products does not cause other environmental problems.
5. It is also important to anticipate and cope with the impacts of global climate change on the rice environment and crop response.

6. In the face of global changes, changing demands on resources, and opportunities opened up by biotechnological advances, it is prudent to retain as much of the biodiversity of rice and its other ecosystem components for future use as possible.

These considerations form the basis for the seven issues focused upon in IRRI's Environmental Agenda.

Greening the Green Revolution

One of the major efforts in producing more food was the introduction of new high-yielding varieties of the major cereal crops—rice, wheat, and maize—in the 1960s. These modern varieties respond well to fertilizers, and require irrigation as well as pesticides to hold down the pest population. As a result, food production has broadly kept pace with the rising national and regional demand.

The continual and incremental increase in productivity is showing signs of slowing down and appears to be approaching a ceiling. The world's population is expected to grow to 8 billion by 2025, necessitating an increase in productivity as well as planting of crops in less favorable environments. FAO projects world demand for food to increase by 60% by 2030. FAO anticipates that close to 20% of the additional production will come from an expansion of land, 10% from more frequent harvests per year, and 70% from higher yields. Because almost all land suitable for agriculture has already been used, the productivity increase would have to come from less favorable land, such as that in drought- and flood-prone areas, as well as land with other limitations.

With the need to intensify agricultural production in both favorable and unfavorable areas, the issue of agricultural sustainability will have some urgency in the coming decades. Agricultural sustainability depends on environmental sustainability.

Hence, the challenge to agricultural research is to integrate productivity improvement with environmental conservation and protection. What is needed is a new Green Revolution or a "Doubly Green Revolution," in which increased productivity must be accompanied by environmental sustainability. This approach would also have to benefit the poor farmers living in unfavorable environments. These farmers constitute a very large section of the world's people and they were largely neglected in the first Green Revolution. ■

An Environmental Agenda for IRRI

Why an Environmental Agenda for IRRI?

IRRI's main mission since its establishment in 1960 has been to increase rice productivity through its breeding program for high-yielding varieties and to distribute these to the farmers in rice-producing countries. This mission has been quite successful as the productivity of rice as a result of modern varieties has been more rapid than the population growth rate. IRRI was instrumental in the success of this Green Revolution as more than 70% of the rice grown nowadays can be traced to the modern high-yielding varieties that had originated from IRRI.

The high-yielding rice varieties performed best when chemical pesticides and fertilizers were applied in irrigated fields. Excessive and sometimes unnecessary pesticide use resulted in pollution of the environment and adverse effects on the health of farmers and neighboring areas, as well as the ecosystem. Overuse of chemical fertilizers also resulted in runoff from fields into water bodies and contaminated the groundwater, giving rise to health problems. Prolonged use of chemical fertilizers degrades the soil so that increasingly higher amounts of fertilizer are required for the same productivity.

The challenge for the future is to develop improved technologies that not only raise productivity but also protect the environment. Ensuring environmental sustainability is going to be an important objective of agricultural research. New ways need to be found for using agro-chemicals and water in a more efficient manner so that negative effects on the environment are minimized.

Global climate change has emerged as one of the new challenges requiring serious attention as it has many implications for rice production and food security. Although rice cultivation is not the main contributor to the greenhouse gases that cause climate change, it is a contributing factor and any decrease in the production of greenhouse gases and other components of the ecological footprint of rice production would help solve this problem. There is also a need to meet the challenge of the increase in extreme climatic events associated with climate change, such as the increasing severity and frequency of floods and drought, as well as more frequent hurricanes, and their effects on rice production. The increase in temperature, especially that of mean minimum nighttime temperature, has recently been shown to have adverse effects on rice productivity.



The other major environmental concern is the reduction and loss of biodiversity as a result of the introduction of modern rice varieties. Many traditional varieties have been abandoned as farmers found that modern varieties were more profitable. This loss from farmers' fields is serious and would foreclose future use should these varieties become extinct. A loss of biodiversity has also occurred with fish that were traditionally grown during the wet phase of rice cultivation. The widespread use of farm chemicals and the shorter growing season of modern varieties have meant the demise of that practice. Pesticide use has also decreased the diversity of predators of the insect pests that had maintained a balance with traditional cropping practices.

The potential for and the uses of genetic engineering would have some environmental consequences and the potential risks to the ecosystem would need to be assessed. Recent advances in biotechnology offer many opportunities and tools to raise rice productivity as concerns exist that the productivity of traditional breeding tools may be reaching their limit. However, with the use of biotechnological tools, concerns arise about their environmental impact as well as health and safety. An environmental agenda would examine these concerns and help to guide the Institute to properly position itself in pursuing these seemingly conflicting objectives.

Over the years, IRRI has responded to these issues as they were encountered and this is reflected in the Institute's research agenda. Environmental considerations in research are often implicit rather than explicit. With environmental challenges increasing in the coming decades, an articulation of IRRI's concern about the environment would help guide the Institute's priorities.

With the designation by the United Nations of 2004 as the International Year of Rice, this is an opportune time to take stock of the direction of IRRI's research as it pertains to the environment. Having an environmental agenda is one way of focusing attention on various issues related to environmental sustainability and also how IRRI can better respond to global environmental and development goals.

In recent years, several national agricultural research and extension systems (NARES), which are IRRI's partners and research collaborators, have also started examining various environmental issues in agriculture arising out of their countries' adoption of sustainable development policies. The IRRI Environmental Agenda would be a way to synchronize IRRI's research with the environmental concerns of NARES.

Seven Key Issues

In line with the approach and objectives of the new "Doubly Green Revolution" in Asia, IRRI is developing an official environmental agenda to serve as a policy umbrella that would guide its overall research program and operations for environmental protection and sustainable management of natural resources in the coming decade.

A wide range of important issues in the global development agenda are linked to rice research and the environment:

1. Poverty and environment
2. Farm chemicals and residues
3. Land use and degradation
4. Water use and quality
5. Biodiversity
6. Climate change
7. Use of biotechnology

The IRRI Environmental Agenda (IEA) spells out for each issue

- the problem,
- an initiative of the Institute,
- current progress in IRRI's research on the issue concerned, and
- a future strategy and actions.

In addition, the IEA is designed to both heighten awareness of these international issues among the Institute's staff and promote community spirit through environment-friendly initiatives at the local level.

The IEA is the first of its kind developed by the centers of the Consultative Group on International Agricultural Research (CGIAR), though other centers had responded to environmental challenges in their research agendas. By implementing the IEA, IRRI will make the environment a vital priority in its research and operations. IRRI will seek to strengthen its partnership with the NARES as well as with other CGIAR centers in implementing the environmental agenda.

ISSUE 1: Poverty and environment

The problem

The eradication of poverty is the greatest global challenge facing the world today, especially in developing countries. In Asia, the number of people below the poverty line was estimated to be 800 million in 1998. Poverty has many complex social, historic, and political roots. However, environment is an important factor, as the environment is the source of what one needs to survive and the basis of one's livelihood. Unequal access to natural resources for the production of the basic necessities of life, such as land for growing food, materials for shelter, and access to other resources, results in poverty.

As the amount of potentially irrigable land is limited, rice will have to be grown on less favorable land and under rainfed conditions. The poor often are driven to cultivate marginal lands that are not suitable for agriculture and this leads to environmental degradation and unsustainability. These environments are usually too dry, too steep, or too wet, but the poor must still try to make a living out of them. The number of people in these unfavorable areas is very large. Two-thirds of the rural population of developing countries, or about 1.8 billion people, live in the less favored areas. These areas are characterized by low agricultural productivity and land degradation. Thus, poverty is often linked to environmental degradation as the land is overexploited for short-term gains, and this linkage is referred to as the poverty-environment nexus. The downward spiral of poverty leads to overexploitation of natural resources to meet immediate needs, resulting in more environmental degradation. Overexploitation of the environment is often rooted in the absence of sustainable development options.

Continued growth in rice productivity is a key to solving the problem of poverty in Asia as high productivity will benefit the poor directly by increasing production, employment, and income. Low prices resulting from increased supply will also indirectly benefit the millions of poor who are net purchasers of rice. Without adequate productivity growth, the price of rice is bound to increase, affecting the poor and malnourished most. Better management of external inputs in rice production such as chemical fertilizers, pesticides, and irrigation water can contribute to higher productivity while reducing environmental problems that have arisen in many intensively farmed areas.

The challenge for agricultural research now is to make such unfavorable environments productive agriculturally and to do so in a sustainable way. Research is needed to develop appropriate technologies and to develop rice varieties with traits to withstand marginal conditions, such as tolerance of drought, submergence, and problem soils.

IRRI Initiative 1

As a step in alleviating poverty, IRRI recognizes the need to establish household food security for all poor households to ensure that their basic needs are met. This requires continual improvement of farm productivity.

In the favorable rice-growing areas, productivity can be increased by the continued improvement of varieties and by better management of the crop, nutrients, water, pests, diseases, and weeds without incurring environmental problems in the process. The research agenda of IRRI has been examining this issue for many years and places increasing emphasis on minimizing adverse environmental effects.

Research emphasis in the less favorable environments is to increase and stabilize productivity by improving crop performance under stress, so that poor households are food-secure and able to channel more of their limited resources into other income-generating activities.

Progress at IRRI

Increased production and lower prices of rice across Asia have been made possible through rice research and new farming technologies. Around 1,000 modern varieties, which constitute approximately half the number released in 12 countries of South and Southeast Asia over the last 40 years,

are linked to IRRI germplasm. This is indicative of the large impact of IRRI and its crucial role in improving rice productivity in Asia. Modern varieties and the resultant increase in production have increased the overall availability of rice and also helped to reduce world market rice prices by 80% over the last 20 years in dollar terms although real prices in domestic markets did not decline that much. Nevertheless, poor farmers and consumers have benefited directly through production and income growth and indirectly through lower prices. This has brought national food security to the largest countries in Asia (China and India) as well as to Indonesia and other countries. However, further increases in output and even lower prices continue to be needed for the future, although there must be some incentives to ensure that producers will sustain growth in production.

IRRI started CURE (Consortium for Unfavorable Rice Environments) to improve the stability of rice production in unfavorable rainfed environments through research as an integral component of farming systems. The PETRRA (Poverty Eradication Through Rice Research Assistance) project was a 5-year project that IRRI participated in with three other partners: the Bangladesh Rice Research Institute, Bangladesh Ministry of Agriculture, and UK-Department for International Development. Under this umbrella program, various projects have led to environmental improvement, such as a dramatic reduction in the use of pesticides.

Future strategy

We will continue to improve the productivity of rice cropping systems, at least in part, for a reason different from that of the original Green Revolution, which was to achieve national food security. Now, we need a different but sound strategy for attaining individual household food security. Household food security for the millions of poor rice farmers and millions more urban and rural poor families should be a priority of a new "Doubly Green Revolution." We are using cutting-edge research to achieve significant rice yield increases within the framework of conserving the natural resource base upon which the sustainability of future productivity gains depends. Accordingly, our two-pronged strategy is to continue achieving higher productivity in favorable environments by raising the yield ceiling while striving to bridge the yield gap that still exists in unfavorable environments. By raising input-use efficiency through improved technologies, we will attain the required growth in production without an adverse effect on the natural resource base. To meet the needs of poor farmers, various types of low-input agriculture and appropriate technologies for more sustainable forms of agriculture will be looked into.

☛ ISSUE 2: Farm chemicals and residues

The problem

The use of farm chemicals such as pesticides and fertilizer is a part of modern rice cultivation, especially with the introduction of high-yielding varieties. The excessive use of these farm chemicals is widely recognized as a major source of air, water, and soil pollution, and they also have adverse effects on health. FAO and UNEP reported in 1989 one million cases of pesticide poisoning per year from the use of pesticides in agriculture and that 20,000 of these resulted in death.

Research at IRRI and elsewhere has shown the severe environmental and health problems associated with the widespread misuse of pesticides. Many insecticide sprayings by Asian rice farmers are unnecessary because they are often applied at the wrong time and directed at the wrong targets, though rice farming uses fewer pesticides than vegetable farming. The chemicals used, such as methyl parathion, monocrotophos, and metamidophos, are highly hazardous to human health and are banned in the developed world but still used in many developing countries.

Overuse and incorrect spraying of insecticides are due to years of aggressive pesticide advertising, lack of knowledge, and incorrect estimations of crop losses. Even low levels of 28 pesticides in food may be one of the main environmental causes of cancer, posing health risks to farmers and consumers alike.

Despite the success of strategies such as integrated pest management (IPM), the use of chemical pesticides continues at high levels worldwide and is still a problem in rice production. Therefore, ongoing reductions in pesticide use are urgently needed. Not only will such reductions protect the environment, they will also improve human health, boost farming profitability, and conserve important resources such as petroleum used in producing agrochemicals, as well as decrease the greenhouse gases associated with energy used for their production. Better and more effective ways to convince farmers of the advantages of the IPM approach are needed.

Fertilizer, especially nitrogen (N) fertilizer, is often applied in excess of the crop requirement for optimum yield in many intensively irrigated rice systems. Inappropriate timing of N fertilizer application also increases the risk of poor fertilizer capture by crops as less than 35% of applied N is taken up by crops. The excess runoff from fields pollutes water sources in farming areas and beyond. Rice farmers need adequate guidance and follow-up support to apply N fertilizer to rice crops at the right time and in amounts that will supplement the indigenous N supply. IRRI has been promoting an approach that feeds rice as and when needed and this is called "site-specific nutrient management," or SSNM. This would increase efficiency in nutrient use and reduce environmental effects.

Rice straws and husks are rice by-products that are often not disposed of in an environment-friendly manner. Crop residue burning, widespread in some countries of the rice-wheat belt in Asia, emits greenhouse gases and smoke, which in turn contribute to climate change. It is estimated that at least 12 million tons of rice residues are burned annually in Punjab, India, alone. For farmers and other workers exposed to the high amount of gases from the burning of these residues, there is a reported increase in respiratory problems in the local population exposed to such smoke.

IRRI Initiative 2: Farm chemicals and residues

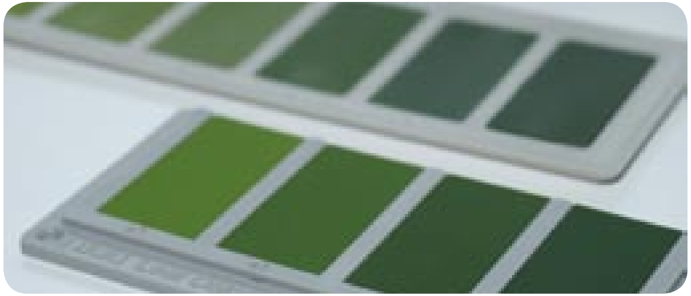
IRRI recognizes that farm chemical misuse, particularly the overuse of pesticides, has become a large problem in many rice-growing countries. We are continuing in our efforts to help farmers reduce pesticide use and, when their use is unavoidable, to use only those that are less toxic. By understanding farmers' decisions and integrating relevant information, we hope to develop mechanisms that will change farmers' attitudes on pesticide use. We also play an essential role as a credible, impartial public-sector source of information to balance information coming from the agrochemical industry.

For fertilizer, IRRI is developing and promoting simple tools and guidelines for site-specific nutrient management (SSNM). With this strategy, we are encouraging farmers to use organic and inorganic fertilizers in a balanced manner to improve crop health and productivity. Optimally fertilized healthy rice crops attract fewer insect pests and diseases, thereby reducing the need for pesticide use.

Progress at IRRI

Over the past decade, several successful projects aimed at reducing inappropriate farm chemical use have been launched:

- Promoting and using crop need-based N management with the leaf color chart (LCC). This simple tool can help farmers to monitor plant N status irrespective of the type of N (organic, biologically fixed, or chemical) applied and to apply N fertilizer only when the crop needs it. More than 400,000 farmers currently use the LCC and they report an average savings of 50 kg of urea per hectare per season, without any yield reduction. For all of Asia, excluding China, the potential savings are 1 million tons of urea annually, if 25% of the irrigated rice farmers use the LCC.
- Incorporating the LCC as an integrated crop management (ICM) component in some countries, because properly fertilized rice crops remain healthy and require less or no pesticide, and combining LCC use with optimum phosphorus and potassium



fertilizer applications based on the omission-plot technique to improve plant health.

- Managing nitrogen through deep-placement in a single dose in the zero-tillage rice-wheat system is proving to be efficient in labor and input use.
- Using local media in an educational campaign in Vietnam that reduced insecticide use in the Mekong Delta by an estimated 72%. In addition, the number of farmers who believed that insecticides would bring higher yields fell from 83% before the campaign to just 13% afterward.
- Breeding disease- and pest-resistant rice varieties.
- Promoting precision farming that improves input-use efficiency.

Future strategy

Our strategy is to develop and deploy pest and nutrient management practices to increase productivity and conserve and enhance the environment by

- Developing suitable approaches for managing herbicide resistance.
- Developing approaches for habitat management by understanding the relationship between habitat biodiversity and pest control.
- Developing genetic diversification approaches that will lower pest populations.
- Using participatory methods to disseminate new information to help improve farmers' decisions.
- Evaluating, in light of the success of the media campaign in Vietnam, a similar use of mass media and other entertainment-education approaches, in partnership with NARES, to motivate farmers to reduce pesticide and fertilizer use in other countries.
- Developing new cultivars with multiple resistance to pests and diseases through the use of molecular biology.
- Developing ecology-based and nonchemical approaches to pests.
- Developing multistakeholder participatory processes to facilitate policy dialogues and policy reforms that encourage more efficient use of farm chemicals.
- Enhancing farmer education on and adoption of balanced and crop need-based nutrient management using the SSNM strategy and the LCC.

- Integrating SSNM with other crop management practices to develop integrated crop management for evaluation in farmers' fields and dissemination of successful ICM options.
- Refining deep-placement of a single application of N in the zero-tillage rice-wheat system.
- Conducting further research on nutrient and pest interactions to understand the mechanisms and to develop mitigation measures to reduce pest incidence through optimal nutrient use.
- Developing efficient methods for energy production through direct combustion of farm residues, and for their recycling and safe incorporation in the soil.
- Developing natural farming systems based on more ecological approaches that need only to decrease the input of chemical fertilizer.
- Integrating rice with fish ponds and vegetable production to improve the livelihood of farmers and their families.
- Using organic farming methods for rice at different scales, on small farms, commercial farms, and industrially.

☛ ISSUE 3: Land use and degradation

The problem

According to the UNDP, about 70% of the world's 1.3 billion poor people who live in Asia often live in the so-called fragile rainfed or sloping upland environments. They are forced to use the limited natural resources that are available to produce the food they need. In these marginal areas, intensification of land use can lead to

- degradation of land resources,
- deforestation,
- loss of biodiversity,
- buildup of pest populations,
- depletion of natural soil fertility, and
- soil erosion.

These changes will ultimately affect the regenerative capacity and functioning of the ecosystems. Deforestation and soil losses from upper catchments have widespread off-site effects through

changed patterns of water flow, leading to increased frequency and intensity of flooding downstream and consequent damage to infrastructure and agriculture. Soil loss through water erosion decreases soil fertility as the topsoil is more prone to erosion.

Land degradation can also occur in favorable areas if excessive irrigation leads to a buildup of salinity in the soil. The depletion of groundwater used in irrigation would also lead to other problems such as sea-water intrusion if the area is close to the sea, and also to subsidence of land.

IRRI Initiative 3: Land use and degradation

IRRI recognizes that scientists must search for ways to produce more rice with less land and water (see water use and quality issue on page 22) while minimizing adverse effects on the natural ecosystems. The key here is to raise the productivity of rice in favorable environments so that there is no need to use fragile environments. The intensification pressure in fragile environments already in use would also decrease.

Farmers who have to grow rice in fragile environments would be assisted with the development of environment-friendly rice production technologies appropriate for fragile environments.

Progress at IRRI

IRRI developed high-yielding varieties and farming technologies for favorable environments, which led to a massive growth in rice production through the Green Revolution. Had rice yield remained at its pre-Green Revolution level of 1.9 tons per hectare, production would have required more than double the current rice area. Such an expansion of rice area would have most certainly incurred high environmental costs.

Yield improvements through rice technologies better suited to fragile areas that are in the pipeline will contribute directly to a decrease in intensification pressure in these environments. Various management methods such as terracing on hill slopes and other soil conservation measures are being developed at various field sites in different countries in Asia.

Future strategy

IRRI's future strategy is to further strengthen the two-pronged approach of increasing productivity in favorable environments while developing rice technologies that have minimal adverse effects on the resource base of fragile environments. We will

- Use new integrative approaches that take into account resource flows, interactions, and trade-offs in the use of land, labor, water, and capital across the landscape for assuring farmer livelihoods and resource conservation.
- Conduct comprehensive analyses of farmers' livelihood strategies in fragile environments and how these interact with the use of land resources to underpin our efforts to develop suitable land-use systems that improve farmer livelihoods.
- Use new planning tools involving community participation and spatial data analysis.
- Bring to bear modern technologies (such as tissue culture, molecular markers, and genomics) to develop rice varieties that

resist or tolerate various stresses such as drought and multiple pests.

- Develop better technologies for managing cropping systems through the efficient use of inputs such as water and farm chemicals so that negative environmental consequences can be avoided.

☛ ISSUE 4: Water use and quality

The problem

About 70% of the water currently withdrawn from all freshwater sources worldwide is used for agriculture and to grow rice requires about two times as much water as other grain crops such as wheat or maize. In Asia, irrigated agriculture accounts for 90% of the total diverted freshwater used, and more than 50% of this is used to irrigate rice. Until recently, this amount of water and future availability had been taken for granted, but this cannot continue as the water demand is expected to outstrip the available supply in the foreseeable future.

The reasons for water shortage are diverse and location-specific, but include

- increased demand from more land brought under agriculture and irrigation;
- deterioration of water quality because of chemical pollution and salinization rendering the water available unsuitable for agriculture;
- depletion of water resources by poor water catchment management and deforestation;
- falling groundwater tables as the rate of use becomes greater than the rate of recharge;
- silting of reservoirs, thereby reducing storage capacity; and
- increased competition from other sectors such as urban and industrial users.

Signs indicate that declining water quality and availability, as well as increased competition and increasing costs, are already affecting the sustainability of irrigated rice production systems. In some countries, the lack of water because of seasonal drought could lead to the inability to grow a rice crop for that season.

By 2025, it is expected that 2 million hectares of Asia's irrigated dry-season rice and 13 million hectares of its irrigated wet-season rice will experience "physical water scarcity," and most of the approximately 22 million hectares of irrigated dry-season rice in South and Southeast Asia will suffer "economic water scarcity."

Moisture stress is one of the main constraints to high yields in rainfed rice production systems in both the lowlands and uplands.

IRRI Initiative 4: Water use and quality

IRRI recognizes that rice producers in many countries already face a crisis over access to enough water to irrigate their crops. This situation is going to intensify as competition for water from other users such as industry and the rising population increases. In the near future, more rice needs to be produced with less water. IRRI's strategy is to reduce water demand and to increase the water-use efficiency of rice in an integrated approach, using genetics, breeding, and integrated resource management.

Several water-saving production technologies are being developed to offer a range of options to farmers in areas that differ in their degree of water scarcity. Proven technologies, such as alternate wetting-and-drying of the soil and dry direct seeding, will be delivered to farmers through our NARES collaborators to achieve immediate impact.

Within the next 5 years, our researchers are committed to developing aerobic rice production systems for the Asian tropics, in which rice is grown the same way as irrigated upland crops such as wheat and maize, instead of being submerged part of the time.

Progress at IRRI

Water use in rice production needs to be decreased and water-use efficiency increased to allow continued rice production in water-short irrigated and rainfed areas. To achieve this, IRRI is exploring using integrated approaches by applying genetics, breeding, and integrated resource management to increase yield and reduce water demand.

Modern IRRI varieties have a threefold greater water productivity than traditional varieties because of their increased yield and reduced crop duration.

Drought-tolerant and drought-escaping rice varieties are being developed for drought-prone rainfed areas.

Management options to increase the efficient use of rainwater such as crop scheduling, diversified cropping, and the construction of small ponds serving as on-farm reservoirs for water harvesting are being developed and tested.

At the field level, water inputs can be lowered dramatically by reducing the relatively large and unproductive losses caused by seepage, percolation, and evaporation.

IRRI has demonstrated the success of, and identified the target domains for, the following soil and land preparation practices: land leveling, crack plowing to reduce bypass flow, and bund maintenance.

Various crop and water management systems are being developed, tested, and disseminated in pilot areas, such as

- Water-saving irrigation techniques such as saturated soil culture.
- Alternate wetting-and-drying of the soil.
- Growing rice with reduced or no tillage either on flat lands or raised beds, especially in the light-textured soils of the Indo-Gangetic plains, can drastically cut unproductive water use.

So far, however, these technologies mostly lead to some yield decline in current lowland rice varieties and would need to be improved.

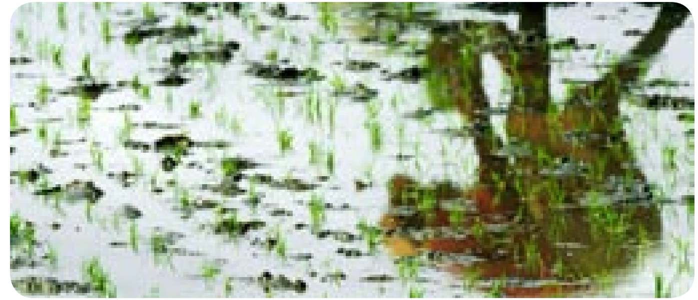
IRRI's socioeconomists are evaluating the viability of these water-saving technologies and are investigating the effect of water policies, such as volumetric pricing, on their adoption.

Other new approaches that IRRI is exploring include

- Incorporating the C_4 photosynthetic pathway of maize into rice to increase rice yield per unit of water transpired,
- Using molecular biology to enhance drought-stress tolerance, and
- Developing aerobic rice to achieve high and sustainable yields in nonflooded soils.

Future strategy

With increasing water scarcity, rice land in the affected areas will likely shift away from being continuously flooded (anaerobic) during



the season to being partly or even completely aerobic. This shift to aerobic rice cultivation will cause profound changes in water conservation, soil organic matter turnover, nutrient dynamics, carbon sequestration, soil productivity, weed ecology, and greenhouse gas emissions. Whereas some of these changes can be perceived as positive (e.g., water conservation and decreased methane emissions), some are perceived as negative (e.g., release of nitrous oxide from the soil, decline in soil organic matter, and reduced availability of micronutrients). The challenge will be to develop effective integrated natural resource management interventions that allow profitable rice cultivation with increased soil aeration while maintaining the productivity, environmental protection, and sustainability of rice-based ecosystems.

One of our new strategies is to establish a team of breeders, physiologists, and water and soil scientists to study the scientific mechanisms underpinning the development of an aerobic rice production system in which rice plants grow the same way as irrigated upland crops such as wheat and maize. With aerobic rice, we hope to realize yields of up to 6 tons per hectare using only half the water used in current lowland practices. In the irrigated rice-wheat belt, growing aerobic rice on unpuddled soils allows the successful use of either flat lands or permanently raised beds to further increase resource-use efficiency of the cropping system.

☛ ISSUE 5: Biodiversity

The problem

The loss of biological diversity is now regarded as one of the most serious environmental problems in the world today, as any biodiversity loss is permanent and irreversible. Estimates of the rate of loss of species diversity in the world vary from about 14 to 30% over the next 20 years depending on the assumptions of habitat loss. A widely cited estimate is that up to 60,000 plant species could be lost by 2025 if the present rate of genetic erosion and extinction does not decrease. FAO estimated that, since 1900, about three-quarters of the genetic diversity of domestic agricultural crops has already been lost.

Globally, more than 20 species of rice exist, but only two are cultivated. It is not known for sure how many varieties and landraces of rice there are, but estimates are as high as 140,000. However, the number of varieties has been declining at an alarming rate in all rice-growing countries, especially after the introduction of modern high-yielding varieties of rice from the 1960s onward. In the Philippines alone, where more than a few thousand varieties were grown in the 1950s, only two varieties now cover 98% of the land for rice.

Genetic diversity is required for the continual improvement of rice crops as cultivars need to be invigorated every 5 to 15 years to better protect them against diseases and pests. With the advances in biotechnology, there is a need for a diversity of genetic material for the potential of these technologies to be fully achieved. Commercial rice production, although sometimes seen as a foe of biodiversity, actually depends heavily on the genetic diversity of rice as a source of material for plant breeding and improvement.

The rice-field ecosystem is a patchwork of terrestrial and aquatic habitats, and is rich in biodiversity, with more than 100 useful species associated with it. Rice fields provide habitats for wildlife species, including fish, amphibians, reptiles, crustaceans, mollusks, and insects, besides various aquatic and free-standing plants. Domesticated species, such as ducks and cattle, also make use of the vegetation for their food. Poor people in rural areas strongly depend on biodiversity for their livelihoods and daily needs. It has been estimated that up to 70% of the protein intake of some rural communities in Cambodia comes from the fish in rice fields and irrigation canals. The great numbers of species of plants and animals in the surrounding areas are a rich source of food, medicine, fiber, construction material, and fuel, and they contribute to food security in rural areas. The rice-field ecosystem has been in existence for thousands of years and it has adapted to different environmental conditions in different countries and regions. As such, it is considered to be ecologically very stable and sustainable. A systems approach should be used when introducing changes to such a time-tested system.

IRRI Initiative 5: Biodiversity

IRRI recognizes that sustainable rice production and poverty alleviation critically depend on the maintenance of biodiversity in balanced ecosystems throughout the rice-farming landscape. IRRI accepts the principles of the 1993 Convention on Biological Diversity and recognizes the importance of regional variation in traditions and practices, and the rights of nations to build on their own culture and biodiversity. IRRI promotes the conservation of biological diversity by encouraging rice cultural diversity. IRRI is committed to protecting the biodiversity of rice and making it and related information available for the enhancement of future rice productivity.

Intensive rice production, which requires the use of chemical pesticides and uniformity of seed material, threatens this rich biodiversity. Pesticides also kill off the natural enemies of rice pests and remove any form of biological control that occurs naturally in a more balanced ecosystem.

Progress at IRRI

Over the past four decades, IRRI has implemented a wide range of projects aimed at maintaining and promoting biodiversity.

Our research spans all aspects of rice-related biodiversity, including

- Genetic diversity within and between rice populations.
- Diversity within and between rice-based communities.

IRRI had notable success in using biodiversity for sustainable pest management. In China's southwestern province of Yunnan, our researchers, in close collaboration with local partners, have found that intercropping rows of different rice varieties can almost completely control the devastating rice blast disease that costs the rice industry millions of dollars annually. The system allows a wide range of high-value but blast-susceptible traditional varieties to be conserved *in situ* and this system reduces the cost of pesticide use so as to increase farmers' profitability.

IRRI has successfully undertaken several in-country projects to promote *in situ* on-farm conservation of traditional varieties together with the associated traditional knowledge. A project currently in progress in the Lao PDR combines *in situ* on-farm conservation with participatory approaches to varietal improvement to instill the ethos of sustainable progress by building on and benefiting from biodiversity.

IRRI has developed advanced methodologies for integrated natural resource management (INRM). This work seeks to enhance ecological sustainability by integrating, at the ecoregional level, biological aspects of the diversity of natural resources with physical and social factors.

IRRI has also conserved rice biodiversity *ex situ* in the world's largest rice genebank, and enriches this huge pool of genetic material through collection and wide crosses. Most of the rice in the genebank at IRRI is held under the auspices of the FAO in trust for the benefit of the international community, as part of a global network of collections. Besides conserving rice genetic diversity, the genebank makes seeds available to farmers and researchers in the public and private sectors to broaden the range of rice biodiversity used in agriculture.

In addition to the rice genebank, IRRI also maintains significant collections of related biota, including *Azolla* and rice-related insect specimens.

Future strategy

IRRI's strategy on biodiversity conservation is based on the principle that biodiversity is an essential prerequisite for sustainable development, as it keeps options for future use available. The preservation of biodiversity is most effective when its positive impact on livelihoods and sustainability is demonstrated. Active community participation is critical to the conservation of the biodiversity in the surrounding rice and natural ecosystems. A good understanding, inventory, and use of agricultural biodiversity at the genetic, species, and ecosystem levels would be the foundation for achieving resilience of the production system against biotic and abiotic stresses. We aim to enhance awareness of its importance at all levels, to improve the quality of, and linkage between, national policy development, local implementation of conservation activities, and the planning and execution of related research and development activities.

The strategy is based on two complementary strands of activities: *in situ* and *ex situ* conservation.

In situ conservation is and must be based on the participatory INRM approach. This approach involves farmers—both men and women—as active participants in research, decision-making, and conservation. We will work with local communities to plan and implement efficient community-led conservation actions. The outcome of these actions will be the dynamic and evolving conservation of entire biological-social landscapes in a way that meets local priorities; builds on existing indigenous knowledge, cultural traditions, and expertise; and contributes to the sustainable improvement of livelihoods. Even with these conservation efforts, concern exists that, with the introduction of modern high-yielding varieties of rice, many traditional varieties may be lost. We will study the rate of loss and erosion of the genetic diversity of rice-growing areas before integrating such information into *in situ* conservation efforts.

Ex situ conservation will continue to focus on individual components of biodiversity in a form in which they are readily available for research. Since we have already assembled probably the world's most complete representation of the primary gene pool of any crop, the urgency of further acquisition of traditional varieties of cultivated rice is low. We plan to add value to the collection by acquiring further knowledge about it, so that we will become better able to target its use for sustainable development. In particular, we shall exploit and further develop high-throughput molecular tools, which are revolutionizing *ex situ* conservation. With these tools, we shall dramatically improve the efficiency of conservation and also, by discovery of valuable new genes and genotypes, the efficiency of use. There was a concern that genetic erosion may be taking place in seed banks because of the nonviability of some seeds and the errors that may occur when seeds are regenerated in the field from time to time. The risks of this occurring will be assessed and strategies developed to reduce the risk of genetic erosion of seed banks.

☛ ISSUE 6: Climate change

The problem

Global climate change has many dimensions and may affect rice production in various ways. Rice production contributes to global climate change and in turn suffers from the consequences.

Rice production has been implicated in the emission of methane when this gas is produced during the flooded phase of rice cultivation. Methane is an active greenhouse gas.

Stratospheric ozone is destroyed by the catalytic reactions of ozone with chlorofluorocarbons and nitrous oxide released into the atmosphere by various manmade processes. Nitrous oxides may result from excessive use of fertilizer, which depletes the ozone layer. This increases the level of biologically harmful UV-B radiation that reaches Earth's surface when ozone is insufficient to filter the radiation. A major source of carbon dioxide into the atmosphere is the practice of farmers of some Asian countries to burn their rice husks and rice stocks, releasing carbon dioxide and smoke into the atmosphere.

Global warming caused by CO_2, CH_4, and other gases may reduce tropical rice yields as a higher temperature increases the respiration rate of the rice plant and reduces food storage. Increasing mean minimum nighttime temperature may be particularly significant in lowering the yield of rice plants. Climate-related stress on wild rice species may aggravate the depletion of the rice gene pool if these wild rice species become extinct locally as a result of changed weather patterns.

In addition to direct effects on rice plants, climate change and global warming may affect other organisms associated with rice and thus alter the occurrence and severity of rice pests, causing the following problems:

- changes in temperature limits of pest/natural enemy species,
- redistribution of pests,
- selection of new strains with varying virulence,
- differential effects on the pest–natural enemy balance, thus causing decoupling of natural control mechanisms,
- changes in food availability resulting in pest shifts, and
- changes in competitive interactions between crops and weeds.

All this may result in the disappearance of some pest species and niches and a potential wider distribution of secondary pests and surviving species.

Progress at IRRI

In rice, wheat, and maize, permanent damage to the reproductive mechanism of the plant reduces grain yield by approximately 10% for every 1 °C increase in temperature from 30 to 40 °C during flowering. IRRI's goal is to produce rice plants

IRRI Initiative 6: Climate change

IRRI views global climate change as a significant environmental threat in the 21st century and recognizes the need to study the interactive relationship between rice production and the global climate.

IRRI seeks to develop rice varieties that will be tolerant of the climates of the future and management systems that do not contribute to greenhouse gas emissions.

that will not suffer yield loss through high-temperature damage caused by global warming.

The original estimates of methane emissions from rice were rather tentative. However, an interregional project conducted by IRRI and its partners showed that rice was responsible for about 12% of global methane emissions. Various mitigation options have been formulated, which largely involve water and residue management. IRRI continues to assess the effects of straw management, carbon sequestration, and soil fertility on methane emissions. Further reduction of methane and nitrous oxide emissions via water-saving technologies, such as alternate wetting-and-drying and aerobic rice cultivation, continues to be an objective of research activities.

Major atmospheric pollutants affecting plant growth are sulfur dioxide (SO_2), nitrogen oxides, and ozone (O_3). Studies at IRRI showed positive effects on yield of elevating CO_2 over a growing season. It is often concluded that projected increases in the partial pressure of atmospheric CO_2 (pCO_2) will result in yield increases. Despite average atmospheric pCO_2 increasing by approximately 4.6 Pa from 1966 to 1998, yields for the same cultivar (IR8) grown on the IRRI farm in 1998 were about 2.6 tons per hectare lower than in 1966 at nitrogen inputs of approximately 150 kg of N per hectare. The cause of the yield decline could be increases in the quantities of atmospheric pollutants such as O_3 or SO_2 and/or toxic phenolic acids formed in soil reduction. IRRI is the first international institute to implement a program of measuring acid rain, O_3, and SO_2 to better understand the effect of pollutants on rice. Such monitoring work provides essential data for understanding the impacts of atmospheric pollutants.

Analyses of climatic parameters for the sites where significant rice and wheat yield stagnation/declines were observed for 1985-2000 showed that solar radiation decreased and average minimum temperature increased over the years at several sites in India. A decrease in radiation reduces photosynthesis and an increase in minimum temperature increases respiration, and shortens vegetative and grain-filling periods.

Future strategy

IRRI recognizes the continuing need to understand the basic physiological, biochemical, and molecular mechanisms involved in crop adaptation to climate change and interactive effects on the crops and cropping systems of the developing world. There is a need to take out “insurance” against weather extremes (El Niño/La Niña) by designing plant types capable of avoiding yield losses as a consequence of stress induced by climate change.

We also advocate using rice residues for energy production by direct combustion or thermal gasification in industrial boilers.

IRRI’s strategy for the future also includes

- Predicting changes in pest abundance and distribution and host-plant interactions as a result of global warming to underpin development of more effective IPM strategies.
- Improving heat tolerance of rice, especially at pollination.

- Managing residues to limit burning and improve C sequestration.
- Developing and disseminating water management strategies that reduce methane emissions.

☛ ISSUE 7: Use of biotechnology

The problem

Recent advances in biotechnology, particularly in genetic engineering, have opened new avenues to produce transgenics, commonly referred to as genetically modified organisms (GMOs). IRRI is aware of the fact that the development and use of plant biotechnology can be a matter of concern in rice-growing countries. One major concern is biosafety, which involves the policies and procedures adopted to ensure the appropriate application of GMOs. Some of these concerns are related to the environmental impact of GM rice. Public awareness of the benefits and risks of GM rice is another issue that needs to be examined. There is a need to have appropriate scientific data to address some of these concerns and to have productive engagement of stakeholders in the decision process regarding the deployment of GM rice by NARES partners.

IRRI Initiative 7: Use of biotechnology

IRRI recognizes the need and potential of modern biotechnology, particularly genetic engineering, to introduce novel genes into rice to extend the options for rice improvement beyond conventional breeding. IRRI is committed to exploring these opportunities and to ensuring that resource-poor farmers and diet-deficient poor consumers, who are unlikely to be reached by the private sector, also benefit from improved technologies. In collaboration with NARES, IRRI is working on developing and sharing transgenic products in the rice-growing countries and also assisting in the establishment of science-based procedures and policies for the biosafety evaluation of these products.

Progress at IRRI

IRRI has long experience in the development and sharing of transgenic rice lines, training in GM technology, and associated biosafety considerations. In collaboration with NARES, IRRI has produced many transgenic *indica* rice lines carrying genes for agronomically important traits such as resistance to pests and improved nutritional quality. IRRI has established a strong record in biosafety of transgenic rice and has facilitated the adoption of biosafety guidelines in the Asian rice-growing countries. IRRI, in collaboration with partner institutes in the Philippines, China, and India, has conducted field tests on transgenic rice carrying the *Bt* gene for stem borer resistance and the *Xa21* gene for bacterial blight resistance. Close working relations with national partners have evolved through several networks such as the Asian Rice Biotechnology Network (ARBN), which enhances the capacity of NARES to employ the techniques of biotechnology in developing improved cultivars, and through sponsored workshops on GM rice.

On the health and nutrition front, IRRI is developing a variety of high-iron, high-zinc, and high-yielding rice types with excellent grain quality as part of the biofortification program, now the HarvestPlus Challenge Program of the CGIAR. Meanwhile, work is under way to produce rice that is also rich in pro-vitamin A. These products will help solve problems such as micronutrient malnutrition, primarily iron and zinc deficiencies, iron-deficiency anemia, and vitamin-A deficiency.

Future strategy

IRRI will continue to engage in research designed to produce improved rice materials appropriate for use by resource-poor farmers. We will continue to monitor research and assess the possible environmental implications of the use of GM rice. In all of our genetic engineering-related research, we observe the highest scientifically accepted standards of safety in the conduct of laboratory and field experiments. We will comply with relevant national or regional biosafety, food, environmental, and policy regulations for the conduct of research on GM rice. IRRI will work with national partners, using the best expertise available, to study potential risks and assure product safety. If a recipient country lacks the expertise to conduct its own risk assessment, IRRI will work with national partners to help develop this capacity, and use appropriate strategies and methodologies.

One environmental concern is that the introduction of GM crops may affect other rice plants because of introgression, including the development of more aggressive weedy rice. This should be monitored and an assessment of the consequences of such outcomes will be undertaken. This situation would be monitored when the GMO plants are released into fields and at the appropriate stage of preproduct development. ■

Our Initiatives to Support the IEA

To support IRRI's Environmental Agenda, we will launch three major initiatives.

IRRI Environmental Council

The first institutional initiative is the establishment of an IRRI Environmental Council (IEC) chaired by the director general. The IEC will set the Institute's environmental guidelines for all activities related to research, operations, and interactions with the local community. The Council will be composed of various stakeholders within IRRI and they will have the responsibility to monitor implementation of the IRRI Environmental Agenda. The Council will meet regularly at least quarterly throughout the year. The executive secretary of the Council will be an internationally recruited staff member who will be responsible to the Council for implementing the agenda. The Council will form working groups for each of the issues identified in the agenda to identify potential issues that require research. The Council will have a budget that would facilitate communication and travel to various meetings with IRRI's NARES partners as well as donor agencies.

Environmental Impact Assessment

The second initiative is the institutionalization of the environmental impact assessment (EIA) as a part of IRRI's research program. IRRI will develop suitable quantitative models and tools that incorporate the relevant biophysical and socioeconomic interactions to permit quantitative assessment of the impact of IRRI's research on the environment and natural resources. Various kinds of environmental and sustainability indicators would be developed as part of the assessment. The EIA would include a social impact assessment, strategic environmental assessment, and life cycle analysis of the implementation of IRRI's agricultural extension programs.

Environmental Audit of IRRI and ISO 14000 Certification

To ensure that IRRI's own activities at the Institute are conducted in an environmentally friendly way, IRRI will conduct an environmental audit of its activities such as on the experimental farms and with operations for and disposal of wastes in its workshops and laboratories. IRRI will develop an environmental management system to guide the conduct of its operations. This could lead to the seeking of some form of environmental certification such as the International Organization for Standardization (ISO) 14000 series. Various environmental awareness programs will be organized for IRRI staff at all levels. IRRI will also consider instituting regular environmental reports on its research programs and activities, in line with the increasingly common practice of institutions and corporations publishing annual environmental reports.

The follow-up to the IEA will be the preparation of a comprehensive implementation plan, which is designed to realize all the objectives of the environmental agenda. This will include a series of activities and action plans over the next few months and years, including an international conference on rice and the environment. ■

Information Sources

Cantrell R, Hettel GP. 2004. New challenges and technological opportunities for rice-based production systems for food security and poverty alleviation. In: Proceedings of FAO Rice Conference, Rome.

Conway G. 1997. The Doubly Green Revolution: food for all in the 21st century. Cornell University Press.

IRRI Rice Knowledge Bank: www.knowledgebank.irri.org

IRRI Rice Web: www.riceweb.org

Millennium Summit Goals 2000

- United Nations Millennium Declaration
- UN Strategy for the Millennium Development Goals

Report of the Fifth External Programme and Management Review of the International Rice Research Institute (IRRI) by Technical Advisory Committee and CGIAR Secretariat, FAO, November 1998.

Serageldin I. 2002. From Green Revolution to Gene Revolution. World Bank.

Shah M, Strong M. 2000. Food in the 21st century: from science to sustainable agriculture. World Bank.

United Nations Conference on Environment and Development (UNCED) 1992

- Rio Declaration on Environment and Development
- Agenda 21, especially chapter 14 on "Sustainable agriculture and rural development"
- Convention on Biological Diversity

United Nations General Assembly, International Year of Rice, 2004

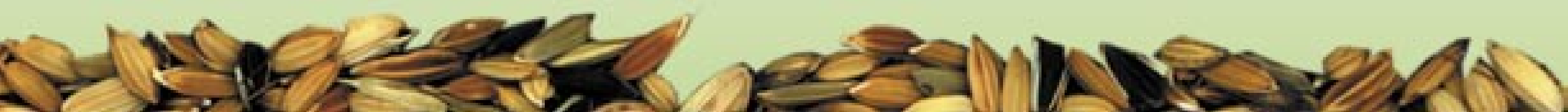
World Development Report. 1992. Development and environment and world development indicators. World Bank and Oxford University Press.

World Food Summit 1996

- Rome Declaration on World Food Security
- Plan of Action

World Summit on Sustainable Development 2002

- Plan of implementation
- WEHAB agenda
- A Framework for Action on Agriculture from WEHAB



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