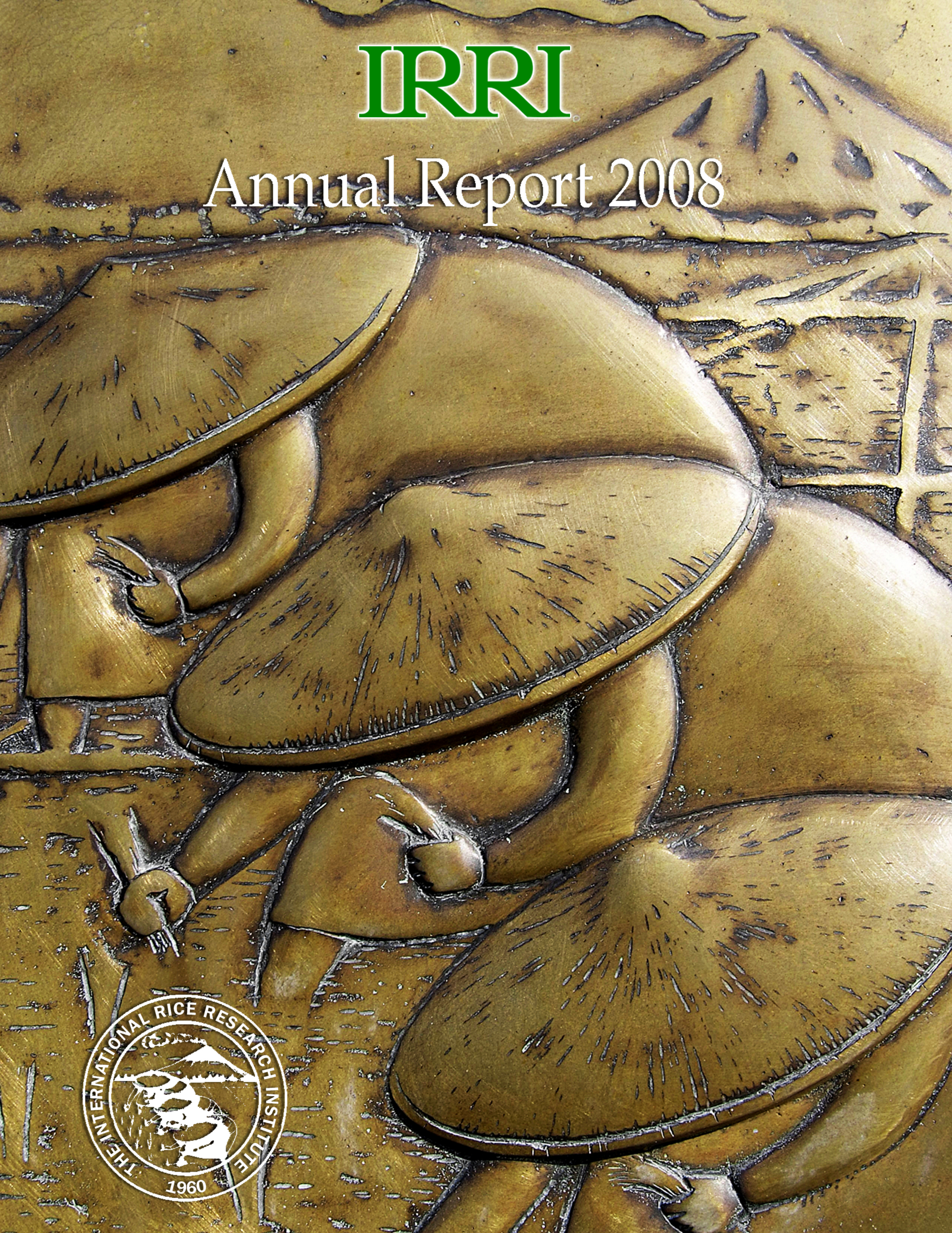
IRRI

Annual Report 2008



An update

from Robert Zeigler

DIRECTOR GENERAL

Welcome to IRRI's 2008 Annual Report, which continues last year's successful experiment using modern digital technology in an interactive DVD format. The material in this report is easy to use and access. I think the best part is this DVD's interactivity, with connections within the publication as well as connections to other relevant Web-based resources. Although you can still read about our progress in 2008, you can also see and hear about our work in a way that I believe will make learning more about our accomplishments an informative and pleasurable experience. Although, like last year, there is no counterpart printed publication, you can easily make printouts if you desire a hard copy of one or more of the various sections. For starters, click on my photo here for my brief video message. And then "click on" into the report and enjoy the exploring!

2008 started out with a bang. Rice prices began to rise in 2007 after widespread concern about general food inflation coincided with a broad-based surge in commodity prices. Key rice-exporting countries restricted exports to ensure that an adequate rice supply at affordable prices was available to their citizens. Prices continued to increase and reached more than $1,000 per ton by mid-2008. This led to an unprecedented amount of media coverage for IRRI. As a result, the Institute has become the primary source of information on food security issues for Asia and the world where rice may be involved. We now see that our press releases are getting far more coverage than they ever had before. Throughout 2008, I talked to the media myself on a number of occasions, including the BBC, CNN, NBC Nightly News, the New York Times, Newsweek, NPR, and Bloomberg, among others.

On 26 February, I was present when IRRI's genebank seed became the first seed of any crop deposited in the Svalbard Seed Vault north of the Arctic Circle in Norway (with 70,000 accessions from 120 countries), with IRRI showcased as the "gold standard" of how to manage a genebank. In 2007, IRRI's genebank had become the first among the CGIAR-supported centers to receive support from the Global Crop Diversity Trust, which funds the operation and management of the vault.

Late February was also when the United States Agency for International Development (USAID) announced that it was likely that most, perhaps all, of its funding might be withdrawn from the CGIAR. Apparently, U.S. congressional earmarks had removed flexibility from the agency. Along with support from the Philippine government and the U.S. Embassy in Manila, we were able to turn that around and actually come out with a modest increase for IRRI. Let's hope this valued and critical support continues well into the future.

Over the last several years, we have made excellent progress in developing a common vision with WARDA, the Africa Rice Center, on how to approach the challenges facing rice producers in sub-Saharan Africa. I am confident that our partnership will grow and that IRRI will make increasing contributions to the rice sector in that region. On 5-7 March, several IRRI scientists attended a meeting in Cotonou, Benin, for the African phase of a major Bill & Melinda Gates Foundation (BMGF) grant in which IRRI and WARDA are partners. STRASA (Stress-Tolerant Rice for Asia and Sub-Saharan Africa) is developing submergence-, drought-, and salt-tolerant rice varieties for difficult environments. On 16-19 March, the Asian phase of this project was inaugurated at the NASC Complex in New Delhi. This was the first direct grant of US$19.9 million over 3 years that IRRI received from BMGF.

On 1 April, Achim Dobermann (photo to below) hit the ground running as the new deputy director general for research. Interim DDG-R, T.P. Tuong, returned to research (thanks, Tuong, you helped us seamlessly manage a major transition!). Dr. Dobermann replaced Ren Wang, former IRRI DDG-R, who had moved on to the World Bank to take over as CGIAR director in July 2007.

An Update for 2008 from the Director General

During the height of the rice price crisis in April, we put together a plan with the Philippine government to make major investments to improve rice productivity across the nation. On 2 May, President Gloria Macapagal-Arroyo visited IRRI to witness the signing of the resulting Memorandum of Agreement (MOA) between IRRI and the Philippine Department of Agriculture on Accelerating Rice Production in the Philippines. The MOA, signed by Secretary of Agriculture Arthur Yap and me, focuses on irrigation, technology, extension services, and credit support for farmers, and is unique in four areas—scope, advances in current rice technology, funding commitment, and management approach. The photo above shows me with President Macapagal-Arroyo and Secretary Yap.

This exercise with the Philippine government also gave us a chance to articulate our vision for what was needed on a global basis, and we put together a nine-point action plan and a two-page summary, which have proven to be quite useful in communicating with donors, both traditional and potential.

Yet another result of crystallizing this vision is that it is now abundantly clear that there will be a need for a public-sector institution like IRRI for the foreseeable future. So, we are now putting serious thought into what we need in infrastructure improvements for the next 50 years. One of the problems facing us is that the funding model for the last 30 years has essentially been one of support for operations only, with the notable exceptions being Japanese and Italian support for construction of the Kenzo Hemmi Laboratory in 1992 and other various grants for biotech upgrades. We feel it is time to thoroughly upgrade our plant growth facilities, completely redo and modernize all of our genetic resources facilities, and create a more efficient central laboratory facility. Some initial architectural estimates come in at around $150 million.

Around mid-year, movements to make a major change in the CGIAR system started to gain momentum. There is not enough space on this DVD to do justice to the range of options that are being considered in this process. Many of the people in positions of influence in the change process have rather limited experience with the system or the centers, so it is critically important that we stay engaged and help guide the process. CGIAR Director Ren Wang arranged for IRRI to host a meeting of around 100 CGIAR stakeholders in September to provide inputs to the change process. This interesting meeting provided a great opportunity for IRRI to showcase for the system what a great center is, what is needed to do serious work on crop improvement and management, and what investments are required in order to make a difference.

Despite our misgivings about some of the ideas being discussed, we believe that there is a need for a major change in the system. IRRI fully supports change that will increase efficiency, reduce the huge administrative and bureaucratic burdens, and allow us to better address our mandate to improve the lives of rice farmers and consumers, while making sure that the rice-producing environments remain healthy for future generations.

A real bright spot was 5 June 2008, when I traveled to Beijing to receive, on behalf of IRRI, the International Science and Technology Award from the government of China. This is the first time an institution has received this prestigious award, so it is testimony to the special relationship that IRRI continues to maintain with China. The photo below shows me with China State Councilor Liu Yangdong. (See elsewhere on this DVD for other awards and honors won in 2008 by the Institute and individual staff members.)

In addition to the $20 million STRASA project already mentioned, throughout the year, we worked with the BMGF to develop a number of other projects. Achim Dobermann led the development of the $20 million Cereal Systems Initiative for South Asia (CSISA) to help 6 million South Asian farmers substantially boost crop yields and their income within 10 years. John Sheehy, head of IRRI's Applied Photosynthesis and Systems Modeling Laboratory, led the development of an ambitious $11 million IRRI-led project to reengineer photosynthesis in rice,

which is involving a consortium of some of the most renowned experts on photosynthesis in the world. Zhikang Li, IRRI's coordinator of the Beijing-based International Network for Molecular Breeding, developed a project ($18 million to the Chinese Academy of Agricultural Sciences, but with IRRI as a major subgrantee) to extend his work to South Asia and Africa. Sam Mohanty, the new head of IRRI's Social Sciences Division, is also a grantee from a BMFG project awarded to ICRISAT to increase the availability of longitudinal district-, household-, individual-, and field-level data. It is clear that the BMGF is now IRRI's largest donor. Considering the rigor with which it vets grantees, this is an enormous vote of confidence in our ability to deliver products of relevance to the world's poorest people.

The 1st phase of IRRI's 7th External Program and Management Review took place 27-31 October. All IRRI staff members were available throughout the week to discuss relevant issues. After its information gathering at headquarters and elsewhere, the review panel returned in early February 2009 to write its final report. On 13 February 2009, Review Panel Chair Greg Edmeades (photo left), in his summary of the final report, pointed out that the changing research environment involves genomics, transgenics, cropping intensification, water, climate change, information and communications, the private sector, and the CGIAR change process. The bottom line of the panel's findings was that IRRI meets high standards in the conduct and management of science, partnerships with NARES and ARIs, financial management, and leadership within and outside, and that overall the Institute does things well. We welcomed and will follow through on 11 specific panel recommendations involving breeding, hybrid rice, Africa, integrated pest management, water, social sciences, managing country partnerships, the BOT Program Committee, career paths at IRRI, research management, and infrastructure renewal. You may be interested in reading both the report of the EPMR7 and the CGIAR Science Council commentary.

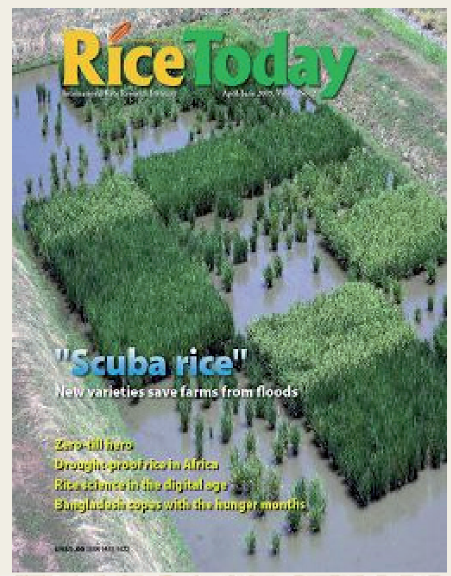
Many advances were made on the research front, certainly too many to summarize here, so I refer you to the research highlight sections of this DVD. However, I do want to mention two highly visible—and successful—projects. It looks as though the effort with Golden Rice (GR) is moving ahead very well despite some problems in the field. We ran the first field test of GR, just in time for it to be hit by a typhoon right before harvest. It never fails, does it? Want rain? Put in a drought trial. Want a typhoon? Put in a critical performance trial! In any event, we'll probably have GR in farmers' fields by 2011 or 2012. This is later than many of us would have liked, but many of the challenges that faced us were completely unforeseen. However, our scientists have done an outstanding job of attacking the many obstacles in a scientific and methodical way, overcoming each one. It will make a tremendous story once it is all put together.

Another great story is the performance of submergence-tolerant or flood-proof rice (photo below). Rice varieties containing the *SUB1* gene developed by Dave Mackill and his team are currently under extensive evaluation all across Asia. The Sub1 varieties' performance in farmers' fields under real-world severe flooding has been nothing short of amazing and I "predict" that, later in 2009, varieties will be officially approved for farmers in India and the Philippines. I can safely say that these will be transformational technologies that will make major improvements in the lives of those living in flood-prone rice-growing regions of the world. Of course, these are the homes to many of the world's poorest people. It is gratifying to see that highly relevant technologies are still coming out of IRRI, even after well over a decade of, frankly, neglect and complacency by some donors.

Plans for IRRI's 50th anniversary celebrations in late 2009 and through 2010 are moving ahead nicely. Festivities begin with the 6th International Rice Genetics Symposium in Manila, 16-19 November, which will be graced by Princess Maha Chakri Sirindhorn of Thailand. Now scheduled for the second weekend of December 2009, near the 50th anniversary (9 December) of the signing of the agreement between the government of the Philippines and the Ford and Rockefeller Foundations, we will hold a party for the Los Baños community. Plans include a concert and fireworks display. Our BOT meeting, 12-17 April 2010, will usher in a homecoming from 18 to 30 April, during which time we hope many IRRI alumni and friends will return for a visit. We welcome suggestions for events we can organize for returning alumni. Festivities will conclude 9-12 November 2010 in Hanoi, Vietnam, with the 3rd International Rice Congress.

Finally, we are changing the way we do business to allow us to focus more of our resources on our main activity: research. Most of you are aware of, and I hope enjoy, IRRI's award-winning flagship communication tool, *Rice Today*. An expensive undertaking, to be sure, but we believe it is an important vehicle to get our important messages out. We have teamed up with The Rice Trader, the world's leading trade publication dedicated to in-depth analysis of the global rice industry, which took over publishing *Rice Today* with the April 2009 issue. They will add advertising so that publishing *Rice Today* will no longer be a cost for IRRI. However, we retain full editorial control. Please provide us with feedback on *Rice Today* as it evolves over the coming years.

In a similar vein, we are following the trend of most scientific societies in engaging private events companies to or-



ganize our conferences. We have several recurring conferences that will benefit from professional organization: the International Rice Genetics Symposium, the International Rice Research Conference, and the International Rice Congress. We intend for these events to grow and become available to many more in the rice community, for IRRI to retain complete control of scientific content, and to make sure that more of our national system colleagues can participate.

There are many other exciting things to report for 2008, but I have gone on far too long already. More details of IRRI's achievements and activities are highlighted in this Annual Report on DVD.

We were encouraged to continue this DVD format after last year's first attempt (IRRI Annual Report 2007) resulted in IRRI winning a Gold Award in the Electronic Publication Class of the 2009 Critique and Awards Program of the Association for Communication Excellence (ACE) in Agriculture, Natural Resources, and Life and Human Sciences. Then, we were informed that this groundbreaking publication had also picked up the Outstanding Professional Skill Award, that is, the Best-of-the-Best across 10 classes in ACE's Publishing Category. One judge's comments say it all about what we were trying to achieve: "This annual report from IRRI is a wonderful example of how a paper publication can be transformed successfully into an electronic communications tool. The DVD is comprehensive, with seven featured programs, an overview with the director, and 15 other supplemental sections (weather, publications, personnel, etc.). Each feature has a spokesperson describing specific work of IRRI and these video clips are interspersed with footage of others involved in rice research and production. All of the material is arranged in an engaging format that is easy to use and access. The best part is that the producers have made the report very interactive, with connections within the publication as well as connections to other resources, primarily web-based. IRRI has done a spectacular job giving information a human face—whether it is the people working for improved rice crops worldwide or the millions who benefit from their good works."

We have striven to do much more of the same in this 2008 DVD with the exception that I have endeavored to be briefer in my comments here and in my video this time. Also, the research highlights are just that–highlights and not all inclusive of every program output. We will rotate to other outputs of our strategic plan next year. Enjoy and let me know your comments and constructive criticisms.

Robert S. Zeigler
Director General

Additional note: In the next sections, we have gleaned some key coverage of 2008 IRRI activities, events, and award announcements from the Institute's excellent and comprehensive weekly *Electronic Bulletin*. If you are a true glutton for IRRI information, go to the *Bulletin's* archive to find much more.

IRRI MILESTONES DURING A REMARKABLE 2008

The following sections chronologically highlight many of the significant events, media coverage, activities, staff changes, and awards during 2008. More details on some can be found elsewhere on this DVD or via links to more comprehensive, all-inclusive details in IRRI's weekly online Bulletin, which has been capturing the corporate memory of the Institute since 2000.

Notable activities, media coverage, and events

Plans developed toward sustainable management of brown planthopper and virus diseases in Vietnam

Vietnam's rice production has suffered losses of about 0.7 million tons from damage caused by brown planthoppers (BPH) and virus diseases. On 8 January in Ho Chi Minh City, Vice Minister Dr. **Bui Ba Bong** emphasized the importance of developing research and implementation strategies that are environmentally sustainable during the *Final Consultation Workshop* of a scoping project sponsored by the Australian Centre for International Agricultural Research (ACIAR) and IRRI (photo 1). The project is designed to review the factors that have contributed to the sudden outbreaks of BPH and virus diseases, the management strategies that were adopted, and their implications. The goal is to develop research and extension opportunities for sustainable management of the problems.

IRRI holds training program on breeding for Myanmar

A 5-day in-country training program on *Breeding for salinity and submergence tolerance in rice* was held in Myanmar in January. Organized by IRRI, upon request from the Department of Agricultural Research (DAR), Yezin, Nay Pyi Taw, Myanmar, the training program aimed to build the capacity of researchers and provide knowledge to boost rice production, especially in rainfed areas of the country, which occupy 80% of the rice lands. Thirty participants from the main station and outstations of Myanma Agriculture Service and one lecturer from Yezin Agricultural University attended (photo 2). **U. John Ba Maw**, DAR deputy director general, inaugurated the event. **Daw Khin Tan Nwe**, director, DAR Rice Division, welcomed the participants.

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Bill & Melinda Gates Foundation gives funds to help poor rice farmers

On 25 January, the Bill & Melinda Gates Foundation (BMGF) announced a grant to IRRI for US$19.9 million over 3 years to initially help place improved rice varieties and related technology into the hands of 400,000 small farmers in South Asia and sub-Saharan Africa. Farmers are expected to achieve a 50% increase in their yields within the next 10 years. The grant to IRRI was part of a package of agricultural development grants announced by **Bill Gates** (photo 3), co-chair of the foundation, at the World Economic Forum in Davos. All of the grants are designed to help small farmers boost their yields and increase their incomes so they can lift themselves out of hunger and poverty.


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IRRI BOT chair on ABC Radio Australia

On 31 January, Prof. **Elizabeth Woods** (photo 4), newly appointed IRRI BOT chair, was interviewed on ABC Radio Australia. She said that a good rice crop means so much more than the simple act of ensuring that people have enough to eat. She added,


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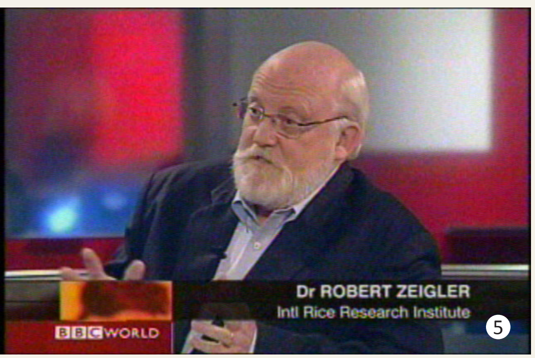
"IRRI's work started off talking about hunger, just to make sure people could actually survive to the end of the year. Now, we're looking at poverty reduction, so ideally a poor family needs to be able to grow enough to feed themselves and also have a little bit left over to sell. That's the money that pays for children to go to school, for health care, and to get on the track to move away from poverty."

Dr. Zeigler on BBC

On 21 February, DG **Robert Zeigler** visited BBC Studios in London and gave this interview about the world's rising rice prices and the implications for the world's poor. Click the photo 5 image to access the 3-minute discussion.



Forum on Rice Policy Research: Key Issues from National Perspectives

Twenty-eight participants from 14 countries in Asia and Africa attended this forum on 18-19 February (photo 6). The socioeconomic and policy research agenda on rice is contained mainly in IRRI's Program 7, *Rice policy support and impact assessment*. In the context of IRRI's strategic plan and the research program evolving from it, consultation with NARES to bring in their perspectives on key policy issues adequately for program design and implementation is critically important. The participants largely agreed that rice is seen by most governments as a "political" commodity, although the national perspectives on rice policy issues varied among countries, depending on national income and the performance of the rice industry. Most countries viewed the world market as "thin and unstable" and preferred to achieve a high degree of self-sufficiency.

Workshop on migration, livelihoods, production, and gender roles

A final workshop of the ACIAR-funded research project on the *Impact of migration and/or off-farm employment on roles of women in Asian and Australian mixed farming systems* was held at IRRI, 21-22 February.

Participants (photo 7) reviewed specific results of four country studies with emphasis on assessing the likely and actual consequences of migration and movement of farm household members from rural areas into other rural areas, into towns, into cities, and even abroad in search of nonfarm work; provided critical comments and suggestions to enhance the quality of the studies and improve the presentation of results in final reports; discussed strategies to communicate/disseminate information to stakeholders; and evaluated the implications of the project findings for institutionalizing gender-sensitive approaches in R&D programs at IRRI and partner institutions.

HZAU and ARRRI representatives visit IRRI to sign MOAs

Professor **Xiuxin Deng** (right, photo 8), with acting DDG-R **T.P. Tuong**), president of the Huazhong Agricultural University (HZAU), China, together with other colleagues; and Dr. **Victor Kovalev**, deputy director for research of the All-Russian Rice Research Institute (ARRRI), together with four other colleagues (photo 9), visited IRRI on 27 and 28 February, respectively. Both parties came for the signing of a Memorandum of Agreement between their organizations and IRRI and work plans of joint research. They also wanted to know about IRRI's recent research agenda and visit the Institute's facilities and new laboratories.

In Benin, scientists meet to launch African component of STRASA project

National and international rice specialists (photos 11 and 12) took part in a meeting, 5-7 March, at the Africa Rice Center (WARDA), in Cotonou, Benin, to launch the African component of the project on *Stress-Tolerant Rice for Poor Farmers in Africa and South Asia* (STRASA). The project, which will be carried out by IRRI and its partners, was approved for funding by the BMGF through a grant to IRRI announced in January.

The African component was developed by IRRI in partnership with the Africa Rice Center, which will be its main partner in implementing this component. The project targets resource-poor rice farmers in Africa and South Asia, who produce their crop under rainfed conditions, in which drought, flooding, and salinity reduce yields and harm their livelihoods.

6th Leadership Course for Asian Women

Twenty participants from China, India, Indonesia, Malaysia, Mongolia, Myanmar, Nepal, Papua New Guinea, the Philippines, Sri Lanka, and Vietnam (photo 10) attended a 2-week training course at IRRI for women researchers, research managers, and other professionals in the agricultural R&D sector, 3-14 March.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The course was designed to enable participants to understand the concept of leadership in general and how it relates to Asian women. It provided strategies for developing both work-related and personality skills to becoming a leader. Moreover, it developed among the participants basic leadership skills that can be applied in their work and personal lives. Upon completion of the course, the participants were expected to become more effective agents of change in the agricultural sector.


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In South Asia: stress relief to uplift rainfed rice farmers

After a successful African launch in Benin, mentioned earlier, the STRASA project, funded by a grant from the BMGF, had a parallel inauguration in South Asia on 16-19 March at the NASC Complex in New Delhi. The meeting was attended by 150 senior scientists, researchers, and representatives of NGOs, private companies, and seed producers from Bangladesh, India, and Nepal (photo 13).

Over a 10-year period, the project aims to reach 18 million farm households, 84% of which would be in South Asia, with improved varieties tolerant of


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drought, submergence, and salinity. This is expected to result in a 50% increase in yield in farmers' fields, translating into an annual increase in income per farm family of at least 15%. In the short term, or within the project period of 2008-10, the project will accelerate the development and delivery of improved rice germplasm to about 300,000 farm households in the major rainfed ecosystems of South Asia. The project is enhancing capacity in NARES and developing a network for seed production and adoption.

BPI and IRRI sign amended MOA

On 18 March, the signing of the amended MOA between the Philippine Bureau of Plant Industry (BPI) and IRRI marked the renewal of IRRI's commitment to safeguard germplasm exchange. BPI Director **Joel S. Rudinas** (right in photo 14 with DG **Robert Zeigler** and Seed Health Unit [SHU] Manager **Patria Gonzales**) was at IRRI to sign on behalf of BPI. Twenty years ago, the first version of this MOA was signed by the then BPI Director **Emiliano P. Gianzon** and then IRRI DG **M.S. Swaminathan**. Under this MOA, IRRI's SHU was deputized to undertake major activities in rice seed health testing for plant quarantine certification. The amendment was made to deal with the changes in international plant quarantine protocols considering the advances in plant breeding technologies and the additional mandate of SHU as a single gateway for incoming and outgoing nonseed biological materials and soil samples in addition to incoming and outgoing rice seeds.


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Water-saving workshop

Thirty participants from various agencies and organizations in the Philippines (photo 15) attended a 3-day workshop and planning meeting on the *Adoption and impact of water savings in rice production* at IRRI, 26-28 March. Co-organized by **Ruben Lampayan** and **Bas Bouman** of IRRI, the workshop was a joint undertaking by the Water-Saving Work Group of the Irrigated Rice Research Consortium and the project *Developing a System of Temperate and Tropical Aerobic Rice (STAR) in Asia* of the CGIAR Challenge Program on Water and Food. The workshop brought together agricultural engineers, irrigation system managers, scientists, and extensionists who are working on the development and dissemination of water-saving technologies in irrigated rice areas in the Philippines.


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Enhancing relations with Japan's private sector

In late March, IRRI DG **Robert Zeigler** (left, photo 16) and Ms. **Fumi Tsuno**, president of Tsuno Food Industrial and Tsuno Fine Chemicals, are joined by Dr. **Mutsuo Iwamoto**, IRRI board member and president of the Society for Techno-Innovation of Agriculture, Forestry, and Fisheries of Japan, in inspecting some Tsuno products. Tsuno is one of Japan's largest processors of rice bran oil. Drs. Zeigler and Iwamoto were invited to visit the company's operations in the Japanese city of Wakayama as part of the efforts to further develop IRRI's relations with the private sector in Japan.


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IRRI and Bangladesh partnership becomes even stronger

IRRI and Bangladesh have shared a significant history of collaboration since the 1960s, which has brought tremendous impact to the agricultural sector of the country, helping it to achieve rice self-sufficiency. After the successful launch of its South Asia component in New Delhi, a project planning workshop on STRASA, funded by the BMGF, was held in Bangladesh, 30-31 March, to map out the strategies and develop the work plans of the project with Bangladeshi partners.

The planning workshop (photo 17) was held at the BRAC Centre in Dhaka, Bangladesh, back to back with the inception and planning meeting of the Generation Challenge Program (GCP)–funded project *Speeding the development of salt-tolerant rice varieties through marker-assisted selection and their dissemination in salt-affected areas of Bangladesh* on 29 March at the IRRI-Dhaka Office.


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IRRI DG back on BBC

On 2 April, IRRI DG **Robert Zeigler** appeared on BBC's *Asia Business Report* to say that there is a need for another Green Revolution. He also discussed the rice shortage in Asia and the tightening of supplies. Click photo 18 to watch.

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New chapter in the history of rice research opens with public- and private-sector partnership

A major new partnership between the public and private sector was made official at IRRI headquarters, 3-4 April, with an aim to increase rice production across Asia via the accelerated development and introduction of hybrid rice technologies. The innovative effort to increase rice production—and support for rice research—comes at a crucial time for Asia as the region struggles to deal with near-record rice prices caused by stagnating yields.


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IRRI convened and hosted this inaugural meeting of the Hybrid Rice Research and Development Consortium (HRDC; participants in photo 19). IRRI DG **Robert Zeigler** said during the opening session that there is no question this meeting represents the first pages of an entirely new chapter in the history of rice research. "Certainly, the success of hybrid rice in China is well known," said Dr. Zeigler, "and the potential for hybrid rice to have an impact across the rest of the rice-growing world is something that we all believe is real."

IRRI BOT meeting, April

During the annual meeting of the Board of Trustees, 9-11 April, IRRI called on the international community—with particular emphasis on donors—to start focusing on solutions to what's being described as a "rice price crisis" in Asia and elsewhere.

On 10 April, the BOTs of IRRI (foreground, photo 20) and CIMMYT (photo 20 inset) met jointly for 1 hour in the refurbished ITS video conference room. Joint board member **Mutsuo Iwamoto** (Japan) had the distinction of attending both meetings in person in Mexico earlier in the week and at IRRI later in the same week.


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Following the BOT meeting, DG **Robert Zeigler**; BOT Chair **Elizabeth Woods**; Philippine Secretary of Agriculture (and IRRI BOT member) **Arthur Yap;** BOT members **Mutsuo Iwamoto**, **Ruth Oniang'o** (Kenya), **Seong-Hee Lee** (Korea), **Achmad Suryana** (Indonesia), and **M. Syeduzzaman** (Bangladesh); and PhilRice Executive Director **Leo Sebastian** held a press conference on the rice price and availability with the major Philippine media, which came down from Manila for the specially arranged event.

Rice crisis featured in Time

On 10 April, IRRI DG **Robert Zeigler** was quoted in *Time* magazine's cover story (photo 21) on Asia's rice crisis, *No grain, no pain.* "Rice isn't just another commodity," Dr. Zeigler said. "In Asia, rice has cultural, social, and, in many places, even a religious role, so it carries much more psychological weight." On the same day, Dr. Zeigler talked about the rise in fertilizer prices and the blocking of rice exports on NPR's *Morning Edition***.** Click on the NPR logo to listen to the 5-minute program.

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5th International Crop Science Congress

On 14 April at the 5th International Crop Science Congress (ICSC) in Jeju, Korea, with the theme *Recognizing Past Achievements, Meeting Future Needs*, a 24-member IRRI delegation was in attendance, headed by DG **Robert Zeigler**. He gave a keynote presentation, Rice Science: Key to Food Security and Environmental Health in a Changing World. He prefaced his remarks with the developing crisis on rising rice prices and shortages that were sparking concerns across Asia and the world at the time. Click here to view Dr. Zeigler's PowerPoint.

The Temperate Rice Research Consortium (TRRC) held its first Steering Committee meeting on 17-18 April 2008 in Jeju, Korea, as part of the ICSC. Participants (photo 22) reviewed research proposals of the four working groups for 2008 and discussed future funding scenarios for the smooth operation of the TRRC.

Library and CPS undergo external review

Throughout the week of 14-18 April, an external review of Library and Documentation Services (LDS) and Communication and Publications Services (CPS) took place (photo 23 combined group with reviewers). The review team helped explore how both units should evolve over the next few years, which technologies to adopt, and how to maintain the communication services they currently provide to the Institute.

Global food crisis

On 17 April, Prof. **Elizabeth Woods**, chair of the IRRI BOT, was featured on ABC *Radio Australia* to discuss the causes of the rapidly increasing price of grains and rice and related food security, and the issue of increasing hectares of land in Indonesia being used to grow palm oil for fuel, instead of food. Click here to access the archived program on the Web site of *ABC Radio Australia*.

Water-saving Technologies Project

The second annual review and planning meeting for the project *Development and dissemination of water-saving rice technologies in South Asia*, supported by the Asian Development Bank (ADB), was conducted at the Central Rice Research Institute (CRRI), Cuttack, India, on 19-21 April. Forty-one participants (photo 24) from Bangladesh, India, Nepal, Pakistan, USA, IRRI, and ADB attended. Progress made in the previous year in Bangladesh, India, Nepal, and Pakistan, and at IRRI was presented by each participating institution. The work plan for the third year for each country was discussed and finalized.


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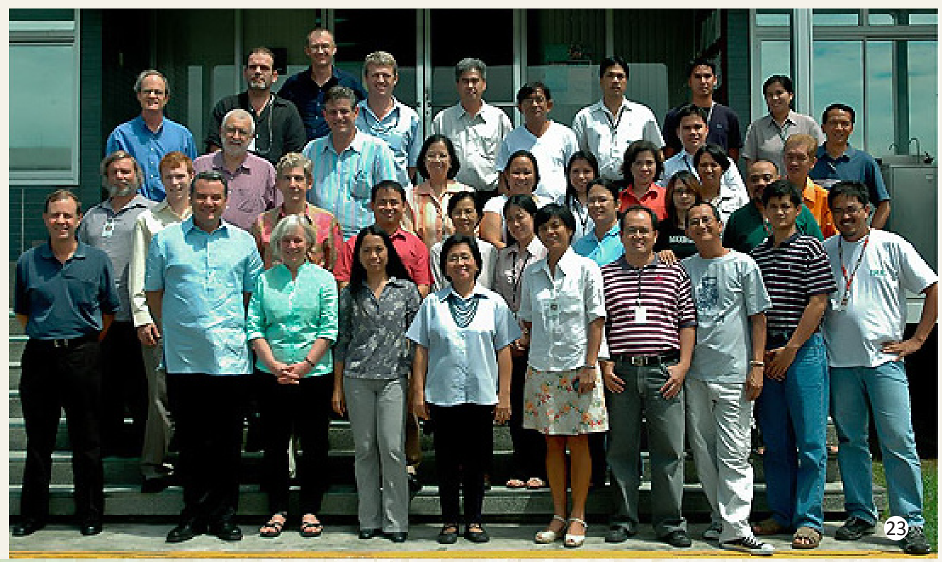
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Dr. **Jiangfeng Zhang**, ADB project economist, expressed his high appreciation of the progress of the ongoing project. In his inaugural address as chief guest, Dr. **D.P. Ray**, vice chancellor of Orissa University of Agriculture and Technology, Bhubaneswar, emphasized that developing technologies to increase water-use efficiency in rice production is the key to sustainable water and food security and that farmers must learn how to grow more rice with less water.

The silent tsunami

In the 19-25 April issue of *The Economist* (photo 25), in which the feature was *The food crisis and how to solve it*, IRRI DG **Robert Zeigler** is quoted: "Yields cannot be switched on and off like a tap. Spreading extra fertilizer or buying new machinery helps. But higher yields also need better irrigation and fancier

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seeds. The time lag between dreaming up a new seed and growing it commercially in the field is 10–15 years, Even if a farmer wanted to plant something more productive this year, and could afford to, he could not—unless research work had been going on for years. It has not."

CGIAR audio press briefing on the world food crisis

On 29 April, the CGIAR in Washington, D.C., coordinated a 1-hour world press briefing via a conference call on the current world food crisis. Giving opening remarks and then answering questions were IRRI DG **Robert Zeigler**, IFPRI DG **Joachim von Braun**, and ILRI DG **Carlos Seré**. **Ellen Wilson** of Burness Communications was the moderator. Questioners represented *Reuters*, *Associated Press*, *AFP*, *Climate Wire*, *New Scientist*, Discovery Channel, *The Chicago Tribune*, and others.

IRRC focuses on Phase 4 that will identify gaps

Following the strong recommendation of external reviewers in January for a fourth phase of the Irrigated Rice Research Consortium (IRRC), an internal IRRI planning meeting was held, 29-30 April, at the Training Center (TC). The meeting aimed to determine the key outcomes of the IRRC for Phase 4, review the structure of the IRRC, and identify potential stakeholders. **Urs Scheidegger** from the Swiss College of Agriculture, representing the donor Swiss Agency for Development and Cooperation, facilitated the meeting with TC Head **Noel Magor**. Dr. Scheidegger was pleased with the ownership and engagement shown by the IRRI members of the IRRC.

IRRI staff discuss rice crisis and climate change on ANC and CNN


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On 8 May, on a segment of ANC's Prime News (Philippine television), CESD Head **Bas Bouman** discussed the Institute's collaborative plan with the Philippines' Department of Agriculture to look for ways to meet the future rice needs of the country (click photo 26). On the role of technology versus political will in solving the crisis, he stated, "Right now, there is a rice crisis, and we need to get more food out there. So, part of the program is in getting technologies out that we've invested in the past several years ... by rolling out these technologies, making sure they get into the hands of farmers, we can already do a lot in the short term."

On 10 May, IRRI DG **Robert Zeigler** and Program 1 leader **David Mackill** discussed IRRI's work on rice that thrives despite climate change on a segment of CNN's *Spirit of Survival* series (click photo 27).

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Dr. Zeigler said that the biggest challenges that face us are sustaining the high productivity that is going to be needed to feed a population that is still growing. "We fully expect that storms will be more severe, there will be more severe flooding, there'll be more severe droughts, and the modern tools that we have at our disposal will allow us to develop varieties that will be tolerant of these stresses that we predict in the future. A lot of the criticism against genetically modified food is mixed up in a tangle of ideology, philosophy, and fear ... of change."

RDA and IRRI hold collaborative work plan meeting at IRRI

Scientists from the Rural Development Administration (RDA), Korea, visited IRRI, 8-9 May, to conduct their collaborative work plan meeting with IRRI scientists. Participants (photo 28) in this biennial meeting reviewed and assessed the progress of the collaborative projects done in 2006-07 and developed the 2008-09 RDA-IRRI collaborative work plan. The meeting focused on the presentation of IRRI's research and development program and the assessment of the recent collaborative projects of RDA and IRRI.

Dr. Zeigler appears on Bloomberg Television with other experts to discuss the rise in food prices

On 15 May, in a special 45-minute program on Bloomberg Television, IRRI DG **Robert Zeigler** talked with Bloomberg's **Michael McKee** (right and left, respectively, photo 29; click to view video) about the rise in food prices and its impact on the global economy. Click on the image to link to the video on Bloomberg. Others appearing on the program included **Daniel Gustafson,** director of the Washington office of the United Nations Food and Agriculture Organization, and **Timothy Searchinger**, a professor at Princeton University.

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Regional plant breeder workshop in East and Southern Africa

IRRI conducted its first regional plant breeder workshop in Mozambique, 12-16 May. Eighteen plant breeders (photo 30) from Burundi, Tanzania, Rwanda, Kenya, Uganda, and Mozambique came together at Chokwe in southern Mozambique to make selections from more than 1,000 advanced breeding lines being grown at the Institute for Investigation of Agriculture Mozambique (IIAM) research station.

The workshop was led by **Surapong Sarkarung** (at right in photo wearing the big hat) from IRRI and **Marcos Langa** from IIAM. Each breeder selected from 60 to 120 lines to take home for testing in their own rice breeding program. Most of the participants said that they had never had this type of opportunity before. **Jimmy Lamo** from Uganda best summed it up by saying: "With this amount of material available to us, we should have new lowland varieties being grown in farmers' fields within 3 years."

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Special course: Rice Research to Production

Over 3 weeks, 19 May-6 June, 28 participants from around the world attended the second Rice Research to Production training course (photo 31). This course began as an idea of **Susan McCouch** of Cornell University and IRRI's **Bob Zeigler** and **Hei Leung**. It is funded by the National Science Foundation USA, the United Kingdom's Gatsby Foundation, and IRRI.

This was an exciting time for IRRI—an event in which IRRI staff members were all contributing to building the next generation of rice scientists. Participants got their feet wet in the rice fields of Asia and got to know how rice is connected to the international community. The 3-week course aimed to help create a new generation of plant scientists who are well networked into the international community and understand the importance of innovative plant science in addressing global problems.

ICW 2008 participants discuss dealing with the media, creative commons, and Web 2.0

The 14th Interinstitutional Communication Workshop (ICW) was held 21 May at IRRI, attended by more than 50 communication specialists from Philippine institutions in the region and IRRI (photo 32). Hosted by IRRI and ACE Philippines, the ICW provided a forum for the exchange and discussion of ideas on current and relevant topics and promoted interaction and sharing of information among communication professionals.

Speakers were **Adam Barclay**, managing editor of *Rice Today* and IRRI's interim media relations specialist, who discussed dealing with the media during the ongoing rice price crisis; **Atty. Michael Vernon M. Guerrero**, deputy director of the e-Law Center and the IT Center, Arellano University School of Law, who discussed applying Creative Commons in Web publishing; and **Kristin Mandigma**, editorial director, Vibal Foundation—a nonstock, nonprofit organization that serves as the sociocultural development arm of Vibal Publishing House, Inc.—who discussed disseminating knowledge using Web 2.0 tools. Click on the name to view the PowerPoint presentations of Barclay, Guerrero, and Mandigma.

BMGF-funded STRASA project training courses on participatory varietal selection conducted in eastern India

One of the major activities of the BMGF-funded STRASA project is to enhance the capacity of NARES researchers in conducting participatory varietal selection (PVS) and using participatory rural appraisal (PRA) tools in site characterization, including socioeconomics and gender analysis.

Thelma R. Paris, IRRI socioeconomist-gender specialist, and **Umesh Singh**, regional coordinator of the BMGF in South Asia, together with SSD staff members **Amelia delos Reyes-Cueno**, associate scientist, and **Donald Villanueva**, researcher, conducted activities at Narendra Deva University of Agricultural Technology, Kumarganj, Faizabad, eastern Uttar Pradesh, India, 21-24 May (photo 33), and at the Central Rice Research Institute, Cuttack, Orissa, 26-28 May. These training courses were conducted to enhance the capacity of NARES partners in effectively involving men and women farmers in selecting suitable varieties that fit their agroecological, social, and cultural circumstances.

IRRI MILESTONES DURING A REMARKABLE 2008

Dr. Jackson meets with Thai prime minister

Acting Director General **Michael Jackson** (left, photo 34) met with the prime minister of Thailand, **H.E. Samak Sundaravej**, 23 May, at the Dusit Thani Hotel in Manila. Among many issues they discussed were new technologies for rice production, including varieties and hybrids that IRRI can share with Thailand.

Mr. Samak paid tribute to IRRI's valuable contributions to Thailand's rice research and development and in building human capacity of its rice scientists (calling them IRRI alumni) that led to the accelerated development of Thailand's rice industry to its current position. He was also very grateful to IRRI for its recognition of the work of His Majesty the King of Thailand in helping poor rice farmers, and by making him IRRI's Royal Patron and giving him an International Rice Award on 5 June 1996. He added that he looks forward to Thailand being part of IRRI's 50th anniversary celebrations in 2010 and he will visit IRRI the next time he comes to the Philippines.

IRRI Experiment Station maintains ISO 14001:2004 certification

On 27 May, an external surveillance audit team, led by Ms. **Rubilyn L. Osila**, awarded the ISO 14001:2004 to the IRRI Experiment Station (ES) in recognition of its commitment to environmental, safety, and health standards (photo 35). The audit team concluded that the ES has established and maintained its management system corresponding to the requirements of the ISO 14001:2004. The team also found out that the ES has demonstrated the ability to systematically achieve predetermined requirements for products and services. Based on the results of the audit and the system's demonstrated state of development and maturity, the audit team recommended that management system certification be continued.

IRRI and IIAM hold first farm mechanization field day in Mozambique

IRRI and the Institute for Investigation of Agriculture Mozambique (IIAM) conducted their first farm mechanization field day in Umbuluzi, southern Mozambique, on 13 June (photo 36).

More than 40 people, including local equipment manufacturers and dealers, agricultural extension officers, IIAM research staff, and farmers, experienced first-hand the operation of small-scale equipment for rice production. The equipment demonstrated included two-wheel tractors, threshers, cleaners, a drum seeder, cone weeders, IRRI Super Bags, and the IRRI moisture meter.

Conference evaluates major threat to Asian rice production

Rice planthoppers, small insects that have devastated millions of hectares of rice in southern China and Vietnam over the past few years and caused the loss of thousands of tons of the grain at a crucial time for global production, were the focus of a critical and timely conference, 23-25 June, at IRRI (photo 37). Planthoppers are normally kept in check by naturally occurring biological phenomena, such as other animals that prey on the pest. In the 1970s and 1980s, planthoppers threatened rice intensification programs in Indonesia, Thailand, India, the Solomon Islands, and the Philippines.

IRRI organized the first brown planthopper (BPH) international conference in 1977, bringing together scientists from all rice-producing countries. Activities triggered by this meeting—including integrated pest management, reducing unnecessary insecticide use, and breeding BPH-resistant rice varieties—helped keep BPH under control for the next 20 years. However, in the last 5 years, planthopper problems have worsened in several countries, including China, Korea, Japan, and Vietnam. Increasing insecticide resistance is also a concern. One of the key problems is the overuse of pesticides.

Regional plant breeder workshop in Tanzania

IRRI conducted a regional plant breeder workshop in Tanzania, 7-9 July. Twenty-one plant breeders from Burundi, Tanzania, Rwanda, Kenya, Uganda, and Mozambique (photo 38) gathered to make selections from more than 600 advanced breeding lines being grown at the Dakawa Agricultural Research Station in Tanzania. In opening the workshop, D**r. Jeremiah Haka**, director of research for the Ministry of Agriculture in Tanzania, said, “This was a most opportune time for the subregion to have such a workshop, given the growing importance of rice in East and Southern Africa.” He said rice had the potential to become the number-one cereal crop in Tanzania, with very good potential for export. He also highlighted the necessity to build human capacity and provide infrastructure for rice research across the region as an important driving force in the rice industry.

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Reinventing rice to feed the world

Science magazine featured the importance of rice research and IRRI’s work in its 18 July issue with the story Reinventing rice to feed the world. “To balance production and consumption, IRRI forecasts that by 2015 the world must grow 50 million tons more rice per year than the 631.5 million tons grown in 2005,” stated IRRI DDG-R **Achim Dobermann**. This will require boosting global average yields by more than 1.2% per year, or about 12% over the decade. Other IRRI staff members quoted in the feature are senior plant breeder **David Mackill**, senior entomologist **K.L. Heong**, and **John Sheehy**, head of the Applied Photosynthesis Laboratory.

IRRI delegation visits Brunei to discuss rice production issues and cooperation

IRRI DG **Robert Zeigler** (right in photo 39), together with Development Director **Duncan Macintosh** and **Mahyuddin Syam**, IRRI representative to Brunei, Indonesia, and Malaysia, visited Brunei on 28 July and met with officials from the Department of Agriculture to discuss IRRI-Brunei Darussalam cooperation and important rice production issues for Brunei. The IRRI delegation was welcomed by **Hajah Normah S.H. Jamil**, acting director of agriculture; **Hajah Aidah Binti Haji Mohd Hanifah**, acting deputy director of agriculture; and **Muda Yusran Bin Abdullah**, head of the Rice & Field Crop Develop-

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ment Unit. During their visit to the Wasan Rice Project, they learned about the acid sulfate in the soil, which could cause toxicity to the rice crop. Dr. Syam suggested that IRRI soil scientists study the soil conditions and recommend a plan of action to prevent toxicity. He also suggested that Brunei should grow available improved varieties through varietal testing in some locations, which would jump-start the improvement of their local varieties in yield and maturity.

DDG-R participates in SDC’s Annual Conference in Fribourg

On 22 August in Fribourg, Switzerland, the 2008 Annual Development Cooperation Conference of the Swiss Agency for Development and Cooperation (SDC) focused on the Mekong Region. Participants examined the complementary nature of bilateral and multilateral development cooperation. Discussions revolved around two current themes: food security and sustainable globalization. A professional program included speeches (ministers from Switzerland and Laos, and Vietnam’s representative at the WTO), videos showing practical examples of development work (including IRRI’s production of the IRRI-Laos video Celebrating the Land), interviews with experts, two Vietnamese musicians, and a short panel discussion.

Guest speakers such as IRRI DDG-R **Achim Dobermann**; **Khempeng Pholsena**, minister to the Lao Prime Minister’s Office and head of the Water Resources and Environment Administration; **Dang Ngoc Minh** from Vietnam’s Permanent Mission to the WTO in Geneva; and **Thomas Crouch** from the Asian Development Bank took an in-depth look at decisive development aspects of a region that is as complex as it is dynamic.

According to Dr. Dobermann (left in photo 40 with a drum seeder), IRRI had an excellent exhibit, including all kinds of materials from IRRC work, some real tools (drum seeder, grain quality kit, the Super Bag, leaf color chart, and water pipe for alternate wetting and drying),

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a new IRRI video made just for this event running nonstop on a large TV, and a nice collection of diverse rice varieties put together by the Genetic Resources Center. He explained to the audience that these are the fruits of 15 years of research in a regional effort of many countries. Dr. Dobermann also did three radio interviews and was busy for hours answering many questions in really good discussions with the local Swiss people.

IRRI helps Myanmar recover from Cyclone Nargis

On 26 and 28 August, in Yangon, Myanmar, IRRI scientists **T.P. Tuong**, **David Johnson** (center in photo 41), **Abdelbagi Ismail**, **Ruben Lampayan** (3rd from right), and **Grant Singleton** met with representatives from the United Nations Development Programme, the Food and Agriculture Organization of the United Nations, and the Myanma Agriculture Service (MAS) to discuss how IRRI could assist with developing plans for increasing rice production during the next dry-season crop and the 2009 wet-season crop. The delegation also made a field trip to Nargis-affected areas in two townships (Kun Yangon of Yangon Division and Daedaye of Ayeyarwaddy Division) on 27 August.

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The price of survival: IRRI DG reacts to ADB's new Asian poverty line

In a *Newsweek* article on 30 August, The price of survival, IRRI DG **Robert Zeigler** reacted to the Manila-based Asian Development Bank (ADB)'s new Asian poverty line**.** The revised poverty line does not reflect a sudden drop in conditions. Instead, it represents an attempt by development economists to, as Dr. Zeigler puts it, get their "arms around the definition of poverty and articulate it in a way that [policymakers] can use effectively." To accomplish that, ADB proposed scrapping the $1-per-day poverty measure popularized by the World Bank in 1990 as an estimate of the per-person cost of procuring the 2,100 calories a day deemed necessary for human health.

IRRI participates in 6th Asian Society of Agricultural Economists conference

The Asian Society of Agricultural Economists (ASAE) held its 6th international conference with the theme *The Asian Economic Renaissance: What's in It for Agriculture?* at the Asian Institute of Management, Makati City, Philippines, 28-30 August (photo 42). During the conference, IRRI convened a session on *Income dynamics and farmers' livelihoods in Asia*, chaired by **Sushil Pandey**, IRRI senior agricultural economist. A number of distinguished global and Asian experts on food and agriculture, including Prof. **Keijiro Otsuka** (former chair of the IRRI Board of Trustees), Dr. **Prabhu Pingali** (Bill & Melinda Gates Foundation), Dr. **Mark Rosegrant** (International Food Policy Research Institute), Prof. **Peter Timmer** (Stanford University), and Prof. **James Roumasset** (University of Hawaii at Manoa), among others, delivered keynote presentations on critical agricultural development topics such as rural poverty, the global food crisis and food security, food policy, and climate change.

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IFAD Facility Grant coordinated by IRRI for World Bank; ICAR collaborates with NRCWA

Thelma Paris, IRRI senior scientist, socioeconomist, and gender specialist, and Dr. **Krishna Srinath**, director, National Research Centre for Women in Agriculture (NRCWA) of the Indian Council of Agricultural Research (ICAR), organized a collaborative training workshop on Gender Analysis and Its Application in Sustainable Rural Livelihood Security of the World Bank–funded National Agricultural Innovations Project (NAIP) under ICAR, 5-7 September, at NRCWA, Bhubaneswar, India (photo 43).

The training course enhanced the capacity of NARES partners on gender analysis and aimed to identify measures to examine gender issues in the projects under Sustainable Livelihood Security (component 3) funded by WB-NAIP (ICAR) in India. The focus of IFAD's Facility Grant to the project, *Accelerating agricultural*

technology adoption to enhance rural livelihoods in disadvantaged districts in India, is to facilitate access to international experience and best practices to accelerate the adoption and transfer of technologies to improve the livelihoods of the poor.

CGIAR "change" meetings conducted at IRRI

The CGIAR Independent Review, Stakeholders' Consultation, and Change Management Workshop was held 6-10 September at IRRI headquarters (photo 44). Under discussion were the future of partnerships in the CGIAR, rethinking CGIAR governance and structure, and funding mechanisms. In attendance were members of the Independent Review Panel, center DGs and board chairs, and representatives from the CG Secretariat, NARES, regional organizations, universities, NGOs, the private sector, and advanced research institutes.

5th Hybrid Rice Symposium held in China

The 5th International Hybrid Rice Symposium was held in Changsha, China, 12-14 September, jointly organized by IRRI, the China National Hybrid Rice Research and Development Center, the China National Rice Research Institute, and the People's Government of Hunan Province, China.

The symposium brought together around 500 leading researchers (photo 45), representing 24 countries, from various disciplines and industry experts to review current knowledge on hybrid rice development, seed production, molecular applications, crop and resource management, and economics. They also discussed future research strategies. The program included a combination of paper presentations, field visits, and hybrid rice technology exhibits. The event was also cosponsored by 23 national/public, international, and private institutions.

BOT message: Global food situation at a crossroad; world can avert major problems, but must act now

Declining agricultural productivity and continued growing demand have brought the world food situation to a crossroad. Failure to act now through a wholesale

reinvestment in agriculture—including research into improved technologies, infrastructure development, and training and education of agricultural scientists and trainers—could lead to a long-term crisis that would make the price spikes of 2008 seem a mere blip.

This stark warning, in line with calls from organizations such as the World Bank, the World Food Program, and Asian Development Bank (ADB), was issued by members of the IRRI Board of Trustees (BOT; photo 46) in a press release following its meeting on 16-19 September. The photo shows (L-R) **Robert Zeigler** (USA), **Mutsuo Iwamoto** (Japan), **Ruth K. Oniang'o** (Kenya), **M. Syeduzzaman** (Bangladesh), **Emerlinda R. Roman** (Philippines), **Mangala Rai** (India), **Elizabeth Jean Woods** (Australia), **Arthur C. Yap** (Philippines), **Seong-Hee Lee** (Korea), **Ralph Anthony Fischer** (Australia), **Jillian Lenné** (UK), **Martha ter Kuile** (EPMR panel member), **Achmad Suryana** (Indonesia), **Usha Barwale Zehr** (India), **Fatoumi D. Seyni** (WARDA BOT member), and **Ronald L. Phillips** (USA). Not in photo, **Baowen Zhang** (China).

IRRC prepares for Phase 4 with Research to Impact Workshop

A significant sharing of cross-country learning among Asian countries was captured at the Research to Impact Workshop of the Irrigated Rice Research Consortium (IRRC), 23-24 September. Around 70 participants gathered at the Philippine Rice Research Institute, Nueva Ecija, Philippines, to present their case studies on natural resource management (NRM) of irrigated rice in Asia. The workshop documented the learning during IRRC's Phase 3 on NRM dissemination and evaluated the dissemination methods in preparation for IRRC's Phase 4 (2009-12). DDG-R **Achim Dobermann** said that many mature technologies have improved over the years, and there are still many possibilities. "There is no single recipe for disseminating these technologies," he said. He advised that the IRRC must look ahead, not only in the coming 2–3 years, but 10–15 years from now as well.

IRRI and WARDA: working to improve African rice production

In a special joint seminar on 7 October, **Achim Dobermann** and **Marco Wopereis**, DDG-R for IRRI and the Africa Rice Center (WARDA), respectively, discussed how the two centers are working together to improve rice production in sub-Saharan Africa (SSA). After their presentations, WARDA DG **Papa Seck** and IRRI DG **Robert Zeigler** joined them in a panel discussion and answered questions from the audience in the packed Havener Auditorium (photo 47, from left, Drs. Wopereis, Zeigler, Seck, and Dobermann; click photo to view discussion).

Dr. Wopereis mentioned that rice is important to the livelihoods of 100 million people in the SSA, but still between 40% and 50% of all rice consumed is imported. He added that, by 2015, around 10 million tons of rice annually will be needed to meet demand. Ultimately, the lowlands will be the key to producing more rice in the SSA. Dr. Dobermann described the four programs of the IRRI-WARDA joint rice research effort in East and Southern Africa.

Training workshop on rice diseases

A training workshop on *Biology of Rice Diseases: Diagnosis and Identification* was held at IRRI, 6-17 October (photo 48). Supported by the International Fund for Agricultural Development (IFAD) through the joint WARDA-IRRI project *Alleviating rural poverty through improving rice production in East and Southern Africa*, which is coordinated by **Joe Rickman,** Program 3 leader, it aimed to improve the food security and living standards of the extreme poor in East and Southern Africa. Twelve participants from Burundi, Kenya, Mozambique, Rwanda, Tanzania, and Uganda attended.

IRRI and the National Taiwan University agree to cooperate on rice research

On 9 October, IRRI and the National Taiwan University (NTU) signed a research cooperation agreement that establishes a partnership in rice-related research to boost global rice production. The agreement, signed by NTU President **Lee Si-chen** (center in photo 49) and IRRI DG

Robert Zeigler (left), comes at a time when global rice stocks are at their lowest in a quarter of a century. "Many countries are facing severe food shortages because rice production has fallen as a result of global climate change and the extensive use of land for biofuel production," said Dr. Lee. "The problem is particularly serious because rice is the staple for more than half the world's population."

IRRI and WARDA hold field day, give free improved rice varieties to farmers

IRRI and WARDA distributed improved rice varieties to about 65 farmers from across Nigeria as part of their joint Rice Farmers' Day on 15 October (photo 50). These varieties with better grain quality were the farmers' top choice during the previous farmers' day, with potential to improve yield due to their tolerance for iron toxicity, salinity, and other soil-related stresses.

Southeast Asian nations endorse IRRI's Rice Action Plan

On 21 October, the world's biggest rice-exporting and -importing nations collectively endorsed IRRI's new Rice Action Plan that targets many of the problems that triggered the 2008 rice price crisis. At a meeting of the 10-nation Association of Southeast Asian Nations (ASEAN) in the Vietnamese capital of Hanoi, ministers of agriculture unanimously endorsed the seven-point plan presented by IRRI Development Director Duncan Macintosh (photo 51). ASEAN includes two of the world's largest rice exporters, Thailand and Vietnam, and several importing nations as well.

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A global voice for the global grain

Rice Today magazine—the voice of rice (the grain that feeds half the world)—became even stronger with *a new partnership* announced in Thailand on 21 October between IRRI and The Rice Trader, Inc. (TRT), publisher of the world's premier publication on rice trade issues. **Jeremy Zwinger**, president of TRT, and IRRI DDG-R **Achim Dobermann** kicked off the new partnership at a signing ceremony at World Rice Commerce 2008 in Chiang Mai.

CORRA and IRRI join hands to tackle current rice research and production challenges in Asia

About 30 participants comprising member-country representatives, IRRI and JIRCAS staff members, and observers attended the 12th CORRA (Council for Partnerships on Rice Research in Asia) meeting at the Japan International Research Center for Agricultural Sciences (JIRCAS), Tsukuba, Japan, 23-24 October (photo 52). This annual meeting brought together the senior research representatives of 16 major rice-producing and -consuming nations to assess and discuss the main issues and challenges facing the Asian rice industry.

Dr. **Kenji Iiyama**, president of JIRCAS and current CORRA chair, welcomed the participants and mentioned the importance of rice in Japanese households and agriculture and challenged the members to focus more on increasing productivity by working on the biotic and abiotic stresses brought about by the effect of global climate change. He also encouraged the member nations to find options that should improve collaboration among them in increasing rice production in Asia.

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IRRI joins Second International Symposium on Rice and Disease Prevention

IRRI DDG-R **Achim Dobermann** delivered a keynote lecture, *Rice Research for the Future*, at the Second International Symposium on Rice and Disease Prevention, 26-27 October, in Wakayama City, Japan. Acting chair during his presentation was Dr. **Mutsuo Iwamoto**, IRRI board member and president of the Society for Techno-Innovation of Agriculture, Forestry, and Fisheries of Japan. GQNPC Head **Melissa Fitzgerald** also delivered a lecture, *Searching for Structures of Starch in Rice to Mitigate the Consequences of Nutritional Diseases*.

Phase one of IRRI's 7th EPMR takes place in late October

The 1st phase of IRRI's EPMR7 was conducted at headquarters 27-31 October. Panel Chair **Greg Edmeades** and other panel members, in consultation with IRRI management, developed the agenda. All IRRI staff members were available during the period.

Rice modelers meet at IRRI

Seven international scientists from Australia, France, Japan, and The Netherlands and 17 IRRI staff members attended the *Second International Rice Model Workshop* at IRRI, 3-6 November. Participants discussed progress made since the first 2007 Rice Model Workshop, and planned next steps on collaboration on modeling of rice and rice-based systems in terms of scientific developments, software development, model application, and collaboration mechanisms.

IRRI, CIMMYT, and BRRI organize workshop

A kickoff workshop on *Sustainable intensification of rice-maize systems in Bangladesh* was jointly organized by IRRI, CIMMYT, and the *Bangladesh Rice Research Institute (BRRI)*, 9-10 November, at BRRI in Gazipur. The IRRI-CIMMYT joint project, to be led by IRRI-CIMMYT scientist Dr. Jagadish Timsina, and supported by the ACIAR for 5 years, involves multiple partnerships for strategic and adaptive research and technology transfer on rice-maize systems in four districts in Bangladesh. The national partners in the project include government organizations (BRRI, the Bangladesh Agricultural Research Institute, and the Bangladesh Academy for Rural Development) and nongovernment organizations (Bangladesh Rural Advancement Committee and Rangpur-Dinajpur Rural Services).

From genes to farmers' fields: waterproof rice set to make waves in South Asia

An early-November tour of research stations and farms in Bangladesh and India led by **David Mackill**, IRRI senior rice breeder, marked the successful completion of a project, *From genes to farmers' fields: enhancing and stabilizing productivity of rice in submergence-prone environments*, funded for the past 5 years by Germany's Federal Ministry for Economic Cooperation and Development (BMZ). The tour culminated with a 1-day wrap-up workshop at the Central Rice Research Institute (CRRI) in Cuttack, India, 7 November (photo 53). (See more information on this project in the Program 1 report on this DVD.)

India-Africa conference tackles sustainable food security

The India-Africa Conference on Cooperation for Sustainable Food Security, jointly organized by the government of India, the Indian Council for Agricultural Research (ICAR), and the Indian Farmers Fertilizer Cooperative (IFFCO), was held on 10-12 November at the NASC Complex, Pusa, New Delhi.

The participants included ministers, policymakers, farmers, scientists, and private-sector representatives from India and selected African countries. To mark the occasion, an exhibit highlighted developments in Indian agriculture, focusing on India-Africa collaborative efforts in the food sector. The IRRI-India Office put up a booth showcasing IRRI-Africa collaboration in the fight against hunger and poverty (photo 54).

Rice in the Philippines: promise and neglect

The U.S. television network NBC featured a series on the global food situation around the world, *Against the Grain*. In the first story aired on 24 November in the U.S., the work of IRRI and the challenges facing the Philippines were featured. Said **Ian Williams,** NBC News correspondent, "IRRI DG **Robert Zeigler** was a terrific host, bubbling with enthusiasm, as he told me about the new varieties of rice that could bring enormous relief to the world's poor." Dr. Zeigler said, "This is a transformational technology. It gives me goose bumps," pointing at clusters of rice stems emerging from a flooded paddy field. "These are tailored for floods. They basically hold their breath under water."

Clinton Global Initiative

On 2-3 December, DG **Robert Zeigler** attended the first meeting of the Clinton Global Initiative (CGI) to be held outside the United States in Hong Kong. He was on hand to witness the announcement of an IRRI commitment, *Rice power: using rice residues for bioenergy and climate change mitigation.* Photo 55 shows Bill Clinton making the announcement and congratulating Dr. Zeigler. The CGI meeting was similar in format to the annual meeting in New York. Former U.S. President Clinton engaged a distinguished group of leaders for two days of panel discussions and interactive working ses-


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sions, each of which examined specific challenges and opportunities for action. The meeting focused on three primary areas of discussion: education, energy and climate change, and public health.

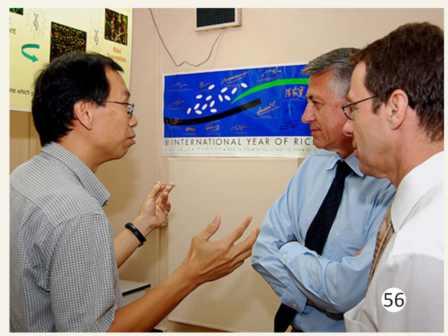
Robert Zeigler accepts second 5-year term as IRRI's director general

Rounding out an incredible year of achievements and activities at IRRI, Elizabeth Woods, BOT chair, announced in her Christmas message to the Institute that the Board offered Robert Zeigler a second 5-year contract beginning in 2010 as director general, and that he has accepted the offer. Prof. Woods stated: "I believe that we can now be confident of a strong leadership to take IRRI forward into what will be both exciting and possibly turbulent times. Bob has a wealth of experience in IRRI and in other parts of the CG system as well as outside the system."

Ambassadors, ministers, officials visit IRRI to get research orientations and overviews

On 26 February, H.E. **Dr. Peter Sutter** (at center in photo 56), ambassador of Switzerland to the Philippines, and Dr. **Felix Gmünder** (right), representative, Basler and Hofmann/Elchrom Scientific, Switzerland, visited IRRI, here discussing rice genetic diversity with IRRI senior scientist Hei Leung.

H.E. **Kristie Kenney** (in black coat in photo 57 touring the GRC storage facility), ambassador of the United States of America to the Philippines, and her party of nine visited IRRI on 10 March to talk about collaboration with the U.S. Ambassador Kenney also had lunch with IRRI's American community.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On 25 March, Hon. **Gabriel Kapris**, minister for Commerce and Industry of the Independent State of Papua New Guinea and party, including Hon. **Damien Gamiandu**, ambassador of Papua New Guinea to the Philippines, visited IRRI.


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Dr. **Jungchaee Kang**, president of Chonnam National University (CNU), South Korea, and party visited IRRI on 17-19 March. Dr. Kang signed a memorandum of understanding with IRRI and got updates on the recent research agenda of the Institute and its collaboration with Korea.

On 28 April, H.E. **Jorge Rey Jiménez**, Cuban ambassador to the Philippines (right in photo 58), came to IRRI headquarters to sign a memorandum of understanding with DG **Robert Zeigler**. The MOU calls for scientific-technical relations between the Instituto de Investigaciones del Arroz (Havana) and IRRI that will involve technology, germplasm, and information exchange and the arrangement of scientific meetings. The rice crop in Cuba is wholly represented by modern IRRI varieties and, over the last 40 years, IRRI has been the host to more than 40 Cuban rice workers and researchers.

On 29 April, the Honorable Dr. **George Chan Hong Nam**, deputy chief minister of Sarawak, state minister of modernization of agriculture, and state minister of industrial development, Malaysia, visited IRRI.

Ten directors of different rice research and rice seed centers of the Rice Department of Thailand visited IRRI, 5-6 May, to familiarize themselves with the Institute's research and development program and discuss collaborative opportunities to strengthen the partnership between Thailand and IRRI.

H.E. **Alcides G.R. Prates**, ambassador of the Federal Republic of Brazil to the Philippines, visited IRRI on 10 June.

Messrs. **Jesus Zorilla** and **Constantino Petrides** (center and right, respectively, in photo 59 with DDG-OSS **William Padolina**), two officials from the Agriculture and Rural Development Unit of the European Commission based in Brussels, visited IRRI on 24 June to discuss the developments in rice research and IRRI's latest research agenda. They were also very much interested in the recent rice crisis and got an overview of IRRI's involvement and opinion.

The Royal Government of Bhutan and IRRI have had a long-standing partnership since 1984 when the first IRRI-Bhutan project was launched and the project was continued until 2004 with visible impacts in building a strong national research system and generating technologies that have increased food production at the national level. To further strengthen ties, eight senior officials from the Royal Government of Bhutan, led by Dr. **Tashi Samdup**, director, Council for Renewable Natural Resources of Bhutan, visited IRRI on 4 July.

C. Lawrence Greenwood, vice president for Operations, and Mrs. **Schäfer-Preuss**, vice president, ADB, visited IRRI to discuss ongoing IRRI-ADB projects and other opportunities to further strengthen the relationship between the two organizations.

H.E. **Ali Mojtaba Rouzbehani**, the newly assigned ambassador of the Islamic Republic of Iran to the Philippines, visited IRRI on 29 July.

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H.E. **President Pascal Couchepin and Madame Brigitte Couchepin** of the Swiss Confederation visited IRRI on 12 August. The president and his party were formally received and welcomed by DG **Robert Zeigler**, **Crissan Zeigler**, Los Baños Mayor **Caesar Perez**, Laguna Vice Governor **Ramil Hernandez**, DDG-OSS **William Padolina**, DDG-R **Achim Dobermann**, and DPPC **Mike Jackson**. During the president's visit, Dr. Zeigler gave a formal briefing about IRRI and its collaboration with Switzerland. The group also visited the International Rice Genebank and the Long-term Continuous Cropping Experiment. Switzerland has been a long-time supporter of IRRI's research through its Swiss Agency for Development and Cooperation (SDC). Photo 60 shows **Ruaraidh Sackville Hamilton** (left) and Dr. Zeigler (right) with President Couchepin and his wife.

H.E. **Rod Smith**, ambassador of Australia to the Philippines, visited IRRI on 14 August to get an overview of the Institute's research agenda and its collaboration with Australia.

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On 23 August, U.S. House of Representatives staff members **Craig Higgins**, **Steve Marchese**, and **Dottie Rayburn**; accompanied by **Michael Pignatello**, political officer, U.S. Embassy Manila; **Daniel Moore**, chief, USAID/Philippines Office of Energy and Environment (OEE); and **Oliver Agoncillo**, natural resource advisor, USAID, made a surprise visit to IRRI. Photo 61 shows the party observing activities at the International Rice Genebank with **Ruaraidh Sackville Hamilton**, **David Mackill**, **Samarendu Mohanty**, and **Duncan Macintosh**.

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Kenzo Oshima, senior vice president of the Japan International Cooperation Agency (JICA), together with three other colleagues, visited IRRI on 20 August to get a general overview of the Institute's latest research agenda. In photo 62, IRRI DG **Robert Zeigler** explains daily activities that happen inside the International Rice Genebank to Mr. Oshima, together with **Keijiro Otsuka** (former IRRI board chair, 3rd from left) and guests.

M.S. Swaminathan (8th from left in photo 63), former IRRI director general (1982–88), made a surprise visit to IRRI, 31 August–1 September. During breakfast at the Guesthouse, he discussed the Asian food crisis with the IRRI staff welcoming delegation.

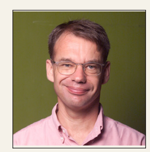
Dr. **Nguyen Danh** (right in photo 64, with GRC staff member **Ato Reaño**), parliament member and deputy head of the parliament delegation from Gia Lai Province of Vietnam, together with eight other Vietnamese policymakers, visited IRRI on 11 September. Their visit was coordinated by Asia BioBusiness, which is currently conducting a major project on behalf of the APEC High-level Policy Dialogue on Agbiotechnology.

Dr. **Abas Shahdi Kumleh** (2nd from right in photo 65, with two colleagues and IRRI scientist **Abdel Ismail**, right), director general of the Rice Research Institute of Iran, and three other colleagues, visited IRRI on 8 October to get a general overview of the Institute's recent research agenda and to specifically know more about our hybrid rice program. Iran recently launched a hybrid rice program and would like to accelerate this technology.

African scientists from the Africa Rice Center (WARDA) and NARES in Tanzania, Mali, and Madagascar visited IRRI for a week beginning 24 November. Dr. **Baboucarr Manneh**, Africa coordinator for the BMGF-funded STRASA project, Dr. **Negussie Zenna**, and Dr. **Khady Nani Drame**, both postdoctoral fellows for cold tolerance and iron toxicity tolerance, respectively, were from WARDA. NARES scientists were Dr. **Raymond Rabeson**, head of the Rice Program, and Dr. **Fousseyni Cisse**, rice breeder from FOFIFA (Centre National de la Recherche Appliquée au Développement Rural), Madagascar. They met with IRRI scientists involved in the STRASA project and attended the marker-assisted selection training workshop on 24-28 November. Photo 66 above shows (from left) **David Mackill**, IRRI senior scientist/plant breeding and STRASA program leader; Drs. Zenna, Manneh, Cisse, Drame, and Rabeson; and **Glenn Gregorio**, senior scientist/rice breeder for Africa and IRRI liaison scientist for WARDA.

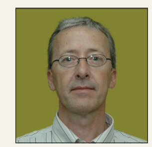
IRRI staff updates

Effective 1 June, **Bas Bouman** was appointed leader for Program 2. Parallel to this, Dr. Bouman will remain as head of the Crop and Environmental Sciences Division (CESD). Also effective 1 June 2008, **David Johnson** (right) was appointed as coordinator of the Consortium for Unfavorable Rice Environments (CURE). In addition, he continues his current activities as weed scientist. New international staff arrivals in 2008 were **U.S. Singh**, IRRI's South Asia regional project coordinator for developing abiotic stress tolerance; **Serge Savary**, senior scientist, PBGB; **Laetitia Willocquet**, scientist, PBGB; **Samarendu Mohanty**, head, SSD; **Digna Manzanilla**, postdoctoral fellow, SSD; **Deepinder Grewal**, postdoctoral fellow, PBGB; **Krishna Jagadish**, postdoctoral fellow, PBGB; **Matthieu Conte**, postdoctoral fellow, CRIL; **Xiangqian Zhao**, postdoctoral fellow, GQNPC; **Sarah Covshoff**, postdoctoral fellow, PBGB; **Xin'ai Zhao**, postdoctoral fellow, PBGB; **Nobuko Katayanagi**, visiting research fel-


B. Bouman


D. Johnson


U.S. Singh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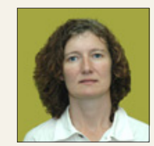
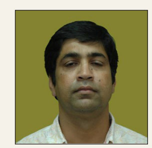
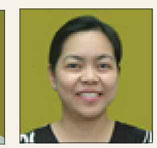
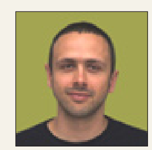

L. Willocquet


S. Mohanty

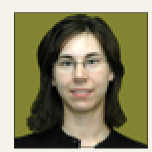

D. Manzanilla


D. Grewal


K. Jagadish


M. Conte


X. Zhao


S. Covshoff


Xin'ai Zhao


N. Katayanagi

low, CESD; **Yohei Koide**, visiting research fellow, PBGB; **Devendra Gauchan** and **H.N. Singh**, postdoctoral fellows under the BMGF-funded project on stress-tolerant rice; **Inez Slamet-Loedin**, scientist, plant biotechnology, PBGB; **Kyung-Ho Kang**, senior scientist, plant breeding, PBGB; **Ajay Kohli**, senior scientist, molecular biology, PBGB; **Finbarr Horgan**, scientist, entomology, CESD; **Fiona Farrell**, head, HRS; **Michael Thomson**, international research fellow, molecular genetics, PBGB; and **Kay Sumfleth**, visiting research fellow, CESD.

Departing international staff in 2008 were **Deborah Templeton**, social scientist/economist (impact assessment specialist), SSD; **Philippe Hervé**, molecular biologist, PBGB; **Christine Kreye**, international research fellow, CESD; **Hector Hernandez**, head, HRS; **Gary Jahn**, coordinator, Greater Mekong Subregion; **Yuichiro Furukawa**, project scientist, CESD; **Graham McLaren**, head, CRIL, and leader, Program 6; **Susana Poletti**, postdoctoral fellow, PBGB; **Ramaiah Venuprasad**, postdoctoral fellow, PBGB; **Paramjit Sachdeva**, consultant and interim head, HRS; and **Madonna Casimero**, project scientist, IRRC.

For a complete listing of staff arrivals and departures, click here.


Y. Koide


D. Gauchan

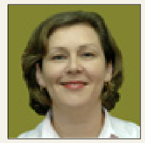

H.N.Singh


I. Slamet-Loedin


K-H. Kang


A. Kohli

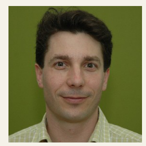

F. Horgan


F. Farrell


M. Thomson


K. Sumfleth


D. J. Templeton

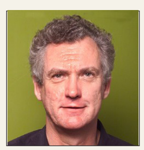

P. Hervé

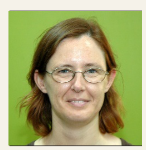

C. Kreye

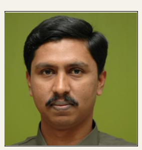

H. Hernandez

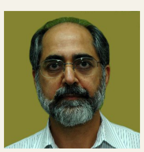

G. Jahn

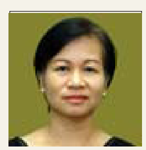

Y. Furukawa


G. McLaren


S. Poletti


R. Venuprasad

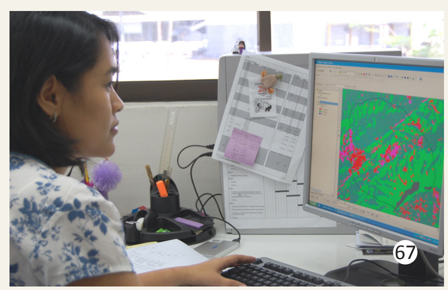

P. Sachdeva


M. Casimero

Staff recognition in 2008

2008 was another outstanding year of international recognition for rice research during which many IRRI staff members were recognized for their recent achievements. Below is an accounting of some of them. Click here for a complete listing.

In the ongoing effort to acknowledge the contributions of outstanding performers and role models among the nationally recruited staff (NRS) and to recognize those who have shown extraordinary involvement in activities that contribute to the overall improvement in effectiveness and efficiency of the Institute, the 2007 NRS awardees were announced in advance of the April BOT meeting. They were **Alice Laborte** (photo 67), associate scientist in SSD, IRRI Award for Outstanding Scientific Achievement; **Norberto T. Quilloy** (photo 68), research technician III in PBGB, IRRI Award for Outstanding Research Support; and the *Rice Today* Production and Distribution Team in Communication and Publications Services, IRRI Award for Outstanding Administrative Support.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Romeo Cabangon (photo 69), associate scientist in CESD, was the 2008 Outstanding Filipino Agricultural Engineer in the field of soil and water management. The award was given during the 58th PSAE Annual National Convention and the 6th International Agricultural Engineering Conference and Exhibition held at the University of the Philippines Los Baños, Laguna, 21-25 April. He was recognized for his significant contribution to the advancement of science in the field of soil and water conservation, specifically on the development of water-saving technologies in rice production systems in Asia.


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During the 39th Annual Conference of the Pest Management Council of the Philippines held in Puerto Princesa, Palawan, 6-9 May, **Joel D. Janiya** (CESD; right in photo 70) received the Pest Management Award in Research from the Pest Management Council of the Philippines,

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Inc., in recognition of his outstanding achievements in crop protection research. The citation states that his work on ecologically based weed science options allows less reliance on chemical control and expensive labor, thus reducing costs of weed control inputs and increasing farmers' profits, while at the same time minimizing environmental and human health hazards. Also at the conference, **Rolly G. Fuentes**, CESD, won the Best Paper Award in Weed Science for his *Biochemical study on the ecotypic variation of upland and lowland purple nutsedge* (Cyperus rotundus *L.*) and **Teodoro R. Migo**, CESD, was elected president of the Weed Science Society of the Philippines (WSSP) for 2008-09.

Sant Virmani, former IRRI principal scientist (PBGB), was given the Padma Shri Award on 10 May. Photo 71 shows Dr. Virmani receiving the award from Her Excellency, the President of India, Mrs. Pratibha Devisingh Patil, at the President House in New Delhi, 10 May. The award was given in recognition of his lifetime contributions made at IRRI in the development and dissemination of hybrid rice technology in tropical countries, including India. India is currently growing hybrid rice on about 1.3 million ha, which helps to increase its paddy production by 1.5 million tons. Encouraged by this achievement, the government of India has allocated $125 million during the next 5 years to promote hybrid rice technology in the country under the National Food Security Mission.

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On 20 May, DDG-R **Achim Dobermann** (photo 72) was the recipient of the 2008 IFA International Crop Nutrition Award. The award recognized his pioneering research on the fine-tuning of fertilizer and crop management practices in order to promote the ecological intensification of rice, maize, and soybean production systems in many countries. He received the award during the opening session of the IFA Annual Conference in Vienna, Austria.

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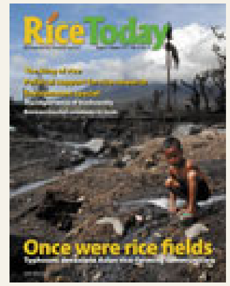

In the 2008 Critique & Awards Program of the Association for Communication Excellence (ACE), *Rice Today* staff members in CPS won three Gold Awards and one Silver Award for the content in the four issues of the magazine published in 2007 (covers and links above).

Accumulating 98 out of a possible 100 points in the overall Magazines and Periodicals Category, the judges commented that the *Rice Today* team took often difficult and sometimes technical subjects and made them interesting to the reader. The outstanding photography highlighted a good balance between text and graphics. The *Rice Today* team includes CPS staff members **Adam Barclay** (managing editor), **George Reyes**, **Ariel Javellana**, **Gene Hettel**, **Meg Mondoñedo**, **Juan Lazaro IV**, **Bill Hardy**, **Jose Raymond Panaligan**, **Emmanuel Panisales**, and **Chris Quintana**.

IRRI staff members garnered several awards during the 38th Crop Science Society of the Philippines (CSSP) Annual Conference, 12-16 May in Iloilo City, Philippines. With the theme "Environmental Sustainability for Global Competitiveness through Crop Science," the conference gathered around 250 crop scientists, extension specialists, and professors from all over the country. The 2008 CSSP Achievement Award for Technology Development went to **Alvaro M. Pamplona** (center, photo 73) associate scientist, PBGB, in recognition of his significant contribution to the development of improved rice varieties for unfavorable rice-growing environments in the Philippines. He helped develop many varieties released for the rainfed lowland, mostly for dry seeding. One of these is PSBRc 68, which has very good yield and is tolerant of both drought and submergence. He took the responsibility of handling the new plant type lines of PBGB.

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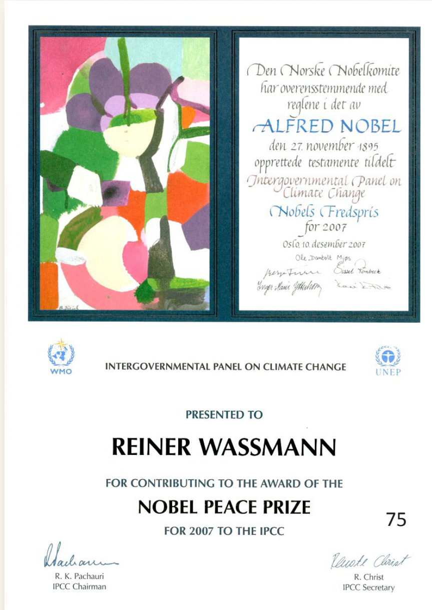
Eugenio ("Eugene") C. Castro, Jr. (photo 74), associate scientist in IRRI's Training Center, was named the Outstanding Professional of the Year in the field of agricultural engineering by the Professional Regulation Commission (PRC) during the 2008 PRC Awards Night on 20 June at the Manila Hotel. The award was given for his demonstrated professional competence and expertise as an agricultural engineer, manifested through his involvement in the design, development, testing, and improvement of different technologies in small-, medium-, and large-scale farming.

74

Reiner Wassmann, coordinator of IRRI's Rice and Climate Change Consortium, was formally recognized in July by the United Nations Intergovernmental Panel on Climate Change (IPCC) for having made substantial contributions to the IPCC's Nobel Peace Prize award (photo 75). The IPCC and former U.S. Vice President Al Gore were awarded the Nobel Peace Prize for 2007 "for their efforts to build up and disseminate greater



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knowledge about man-made climate change, and to lay the foundations for the measures that are needed to counteract such change." In his acceptance speech, IPCC Chairman **R.K. Pachauri** stated, "The IPCC produces key scientific material that is of the highest relevance to policymaking, and is agreed word-by-word by all governments, from the most skeptical to the most confident."

On 28 October, a team from IRRI's Rice Biotechnology Laboratory won the Best Poster Award from the Philippine Association for Plant Tissue Culture and Biotechnology (PAPTCB). The poster, *Enhancing nutrition in rice through biotechnology*, presented during the 6th PAPTCB Scientific Conference, Los Baños, Laguna, Philippines, was coauthored by PBGB staff members **N. Oliva**, **E. Abrigo**, **J. Lescano**, **G. Atienza**, **S. Poletti**, **M. Manzanilla**, **C. Dueñas**, **R. Garcia**, **P. Hervé**, **G. Barry**, and **I. Slamet-Loedin**.

For their landmark research leading to the development of flood-tolerant rice that can benefit farmers in flood-prone areas worldwide, **Julia Bailey-Serres** of UC Riverside, **Pamela Ronald** of UC Davis, and IRRI's **David Mackill** (right to left in photo 76) were honored by the U.S. Department of Agriculture (USDA) with the 2008 USDA National Research Initiative Discovery Award. The three scientists are, or have been, principal investigators on grants the USDA has awarded them for rice research. Their research achievements were celebrated at a ceremony at UC Riverside on 5 December.


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The International Network for Genetic Evaluation of Rice (INGER) in PBGB was the 2008 winner of the CGIAR Science Award for Outstanding Scientific Support Team. This was one of nine Science Awards given at the CGIAR Annual General Meeting on 2 December in Maputo, Mozambique. This award recognized a team that has made an outstanding contribution to a CGIAR research program through cooperative efforts. The collective contributions can be in any research field, should be important in enhancing the work of a research program, and should demonstrate high standards of excellence in performance. The recognition came with a $10,000 cash prize and a scroll. The team (photo 77) consists of **Edilberto Redoña**, **Connie Toledo, Cel Laza, Franco Nazareno, Glenn Alejar, Virgilio Ancheta, Jose Angeles, Fe Danglay, Cenon Lanao, Nestor Leron, Virgilio Magat, Jose Marasigan, Honorio Oboza, Renato Pizon, Allan Salabsabin, Ernesto Sumague,** and **Joseph Vicente**.


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Farewell to old friends

L. Dale Haws, 81, former crop production specialist at IRRI (1974-85), passed away on 4 January (photo 78). Click here to read in his memoirs his recollections of IRRI and click here to read a story about his work in Egypt during the early 1980s.


78

Dr. **Rosendo K. Pali**s (at left in photo 79), who served as IRRI's agronomist and liaison scientist in Burma (now Myanmar) from 1980 until his retirement in 1993, died of a heart attack in California on 21 February.


79

Federico V. Ramos, (photo 80) former superintendent of the IRRI Farm (now the Experiment Station) from 1961 to 1985, and father of U.P. President **Emerlinda Roman** (ex officio BOT member), died on 13 May. In his recent pioneer interview, IRRI's first rice breeder, **Peter Jennings**, mentioned Mr. Ramos's role in the distribution of IR8 to Filipino farmers in 1965.


80

Urbito ("Bito") Tanjutco Ongleo, 74, former CPS photographer and supervisor (1961-89), passed away on 6 September. Mr. Ongleo (photo 81) took many historic photos of activities and events at IRRI during the early days, including the famous image (photo 82) of U.S. President Lyndon Johnson in a plot of IR8 with DG **Robert Chandler**, Philippine President **Ferdinand Marcos**, and IRRI breeders **Peter Jennings** and **Hank Beachell**.


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Dr. **Sukumar Mallik**, 52, rice breeder at the Rice Experiment Station in Chinsurah, West Bengal, India, died of a heart attack on 17 November. Dr. Mallik (photo 83) was a very close colleague and friend of many IRRI staff, having been involved in many collaborative activities. He had contributed significantly to the development of varieties for flood-prone areas. He had recently played a leadership role in the seed multiplication, evaluation, and dissemination of Sub1 varieties in West Bengal and other Indian states.


83

Raising productivity in rainfed environments: attacking the roots of poverty

David Mackill
Leader, Program 1

Rainfed rice accounts for approximately half of the rice area of tropical Asia, where productivity is low and variable because of uncertain rainfall and infertile and toxic soils. This area is home to millions of the world's poorest farmers. Although the program has emphasized the vast rainfed areas of South and Southeast Asia, we have begun to engage with Africa, where about four-fifths of the total rice area is rainfed.

In rainfed lowland and upland environments, abiotic stresses are a major constraint, and most of the highly popular varieties are susceptible to these stresses. A major objective of the program is to develop improved tolerant varieties, along with complementary management practices and improved cropping systems.

This year's theme, from lab to field, reflects the broad range of activities in the program, extending from identifying and manipulating genes for stress tolerance to dissemination to farmers of the products of laboratory and field-based breeding. Exciting progress has been made on developing rice varieties with tolerance of drought, submergence, and salinity. The submergence-tolerant Sub1 varieties, developed by marker-assisted backcrossing of the *SUB1* gene into mega-varieties, are now undergoing intensive seed multiplication to meet heavy demand from farmers. Similar products for salt tolerance are nearing the testing phase. Quantitative trait loci (QTLs) conferring tolerance of drought are now being discovered, but varieties developed by standard breeding practices have performed well under drought. The drought-tolerant variety Sahbhagi dhan (R74371-70-1-1) was released in India following its promising performance in farmers' fields.

The work of program scientists has attracted significant funding from donors such as the Generation Challenge Program, the German government (BMZ), the International Fund for Agricultural Development, and the Japanese government. The large project Stress-Tolerant Rice for Poor Farmers in Africa and South Asia (STRASA), funded by the Bill & Melinda Gates Foundation, passed its first year and has made noteworthy progress. This project ties together stress-tolerance

breeding with participatory varietal selection with farmers and seed dissemination and uptake. With strong support from national and regional

governments, farmers' organizations, and nongovernment organizations, we have been able to take the best products to the farm. This represents a significant expansion of our collaboration beyond public research institutions to new partners.

Some additional highlights of the program research include the expansion of drought-screening activities, the identification of drought-tolerance QTLs in Asian mega-varieties, development of a decision support system for nutrient management of rainfed lowland rice, the identification of root-rotting fungus and nematodes as a cause of yield decline in aerobic rice, development of improved nursery and field management practices for submergence-prone and salt-affected conditions, new cultivars and cropping/aquaculture systems for salt-affected coastal areas, and the development of guidelines for integrated crop management that increased yields in the rainfed lowland conditions of Cambodia.

Even with more than three decades of intensive research on rainfed rice, most of the cultivars grown in rainfed lowland areas are high-yielding varieties developed for irrigated systems. This is expected to change soon, with stress-tolerant varieties becoming widely available to farmers in rainfed areas. These varieties, coupled with improved management methods, will extend the benefits of the Green Revolution to the farmers in these unfavorable environments.

Technology-powered breeding plants rice farmers in the future

While it may not be obvious in a muddy rice paddy, today's rice farmers are at the cutting edge of science, taking advantage of sophisticated technologies by choosing to grow new rice varieties that are the result of technology-powered plant breeding at the IRRI.

Plant breeding and the development of new crop varieties are a foundation of agriculture. New crop varieties are bred for all sorts of reasons such as to increase their yield, produce higher quality grain, cope with challenging environments, reduce pesticide use, or improve fertilizer-use efficiency.

Traditional plant breeding has evolved well beyond farmers simply selecting the best performing individuals in their rice fields and using them to parent the next generation. Over the years, the aim of plant breeding has remained the same—to improve the crop in some way—but the tools have changed and the results are being delivered to farmers with astonishing speed to give them more choices on what varieties to plant to suit them and their farms best.

One outstanding example of this delivered in 2008 by an IRRI team and its partners is submergence-tolerant rice—rice that can survive up to 2 weeks under water. Although rice enjoys standing in water, it does not take well to being completely covered with water and will usually die or be knocked back so badly that its yield declines significantly. This is a major problem as flooding is a common occurrence in many rice-growing areas.

The discovery

Scientists had long known of an Indian rice variety that could handle a week or more of complete submergence and recover sufficiently to offer a reasonable harvest. Even with its remarkable submergence-tolerance property, it was never expected to make a big impact on a wide scale because it was otherwise a low-yielding variety that was grown only in limited areas in India.

Nevertheless, rice breeders at IRRI saw the potential to breed the sought-after submergence-tolerance trait into some of the modern high-yielding rice varieties planted over vast flood-prone areas of Asia.

Although the team and its partners had some early successes creating higher-yielding rice plants that could handle major floods, they never got close to releasing them to farmers. During the breeding process, which transferred to the modern varieties whichever genes were responsible for the flood tolerance, too many unwanted genes moved across as well. The result was poor-tasting, flood-tolerant rice that yielded no more than existing varieties.

More advanced breeding technologies were needed.

Gene identification

Teaming up with the University of California (UC) at Davis, researchers eventually pinpointed the precise stretch of DNA that made the original Indian variety so interesting, and named the assumed gene *SUB1*. Further research identified and isolated the exact gene responsible for most of the flood tolerance, and it was named *SUB1A*.

Gene identification is critical to most plant breeding programs these days and is used in a whole suite of other rice breeding research activities at IRRI. In 2008, projects under way at IRRI sought to identify the genes involved in traits such as disease resistance, drought tolerance, phosphorus-use efficiency, and salt tolerance.

Precision breeding

With the *SUB1A* gene identified, breeders used a “precision breeding” method, known as marker-assisted selection, to move *SUB1* into modern rice varieties without affecting other characteristics.

Dr. David Mackill explains, “Marker-assisted selection is the process where we find a piece of DNA that flags the presence of the gene of interest. This piece of DNA is easy to find; so, if we find it in a rice plant, we know the gene of interest has been moved across.

“We still use traditional breeding techniques of crossing two plants together, but, through the use of marker-assisted breeding, we can determine quickly and accurately how successful that cross has been at incorporating only the traits we want and none that we don’t.

”Basically, we try to recover all the markers of the original parental variety and none from the donor except the *SUB1* gene. In this way, we keep the donor introduction to just the chromosome area around *SUB1*, usually less than 1% of the genome.”

IRRI is also using marker-assisted breeding to help incorporate traits related to salt tolerance, phosphorus-use efficiency, drought tolerance, and increased vitamin A.

Field testing

In 2006, submergence-tolerant versions of several popular rice varieties along with the original varieties were field-tested at IRRI's experiment station in the Philippines, where they were subjected to 15 days of complete submergence. When the water was drained, muddy plots of limp, flattened, deathly looking plants were revealed.

Then, a remarkable thing happened. Within 2 weeks of the flood, almost all of the submergence-tolerant plants recovered. A few scattered clumps of the original versions made a comeback, but there was no comparison. At harvest, the submergence-tolerant rice yielded more than twice as much as its original counterpart.

National testing

With submergence-tolerant rice proven at the experiment station, it was time to test the rice in other countries. Seeds were sent for testing and refinement to national organizations in South Asia,

including the Bangladesh Rice Research Institute (BRRI) and, in India, the Central Rice Research Institute (CRRI) and Narendra Dev University of Agriculture and Technology. The trial results there were also extremely promising.

"In those areas where flooding occurs once or twice and recedes within 12–14 days," says BRRI Principal Scientific Officer M.A. Mazid, who has overseen the rice trials on submergence tolerance at BRRI's Rangpur station, "the Sub1 varieties could survive and improve yields by up to 3 tons per hectare."

More than 1 million hectares, or 20%, of Bangladesh's rice lands are flood-prone and, given that Bangladesh is forced to import around 2 million tons of rice each year, BRRI Director General Mohammad Firoze Shah Shikder says that successful flood-tolerant rice could substantially reduce, if not eliminate, the country's imports.

"Sub1 varieties will add to the total production of the country," he says. "They will save a lot of money that would otherwise be used for importing rice."

Farmer testing

Following its success in the tightly controlled environment of experiment stations, it was time to test submergence-tolerant rice on a real farm and, throughout 2007 and 2008, submergence-tolerant rice was tested in farmers' fields. In this setting, there was no way of controlling when flooding would occur, how long it would last, or whether it would even happen at all.

Mostafa Kamal is one of the farmers BRRI recruited to test the Sub1 varieties in his field. He and his brothers have a 6-hectare farm—large by Bangladeshi standards—that needs to produce enough rice each year to feed 22 members of the Kamal family. The farm suffers heavy losses because of flooding every 4 out of 5 years.

"In the past, many of my plots became fallow because they were flooded too often," says Mr. Kamal, referring to the lowest-lying 2 hectares of the farm. "If we can cultivate on these plots, it will help us produce rice to sell on the market. Two extra hectares is a big jump."

Twenty-three days after the 8 July transplanting of the 2008 wet-season crop, the farm was hit by a 15-day flood. When the waters receded, Mr. Kamal witnessed a wonderful thing. In his Sub1 plots, 95–98% of the plants recovered. In the non-Sub1 plots, the figure was 10–12%. Many of his neighboring farmers, who were not involved in the trial, lost their entire crops. So encouraged was Mr. Kamal, he planned to give away, not sell, a kilogram of flood-tolerant seeds to each of his neighbors.

Making a difference

In 2008, farmers were already planting submergence-tolerant rice and the varieties themselves are likely to be officially released over the next 2 years. The key to their success will be dissemination to smallholder farmers in flood-prone areas. IRRI is leading this initiative through the project Stress-Tolerant Rice for Poor Farmers in Africa and South Asia, funded by the Bill & Melinda Gates Foundation. IRRI is also collaborating with national organizations to test Sub1 varieties in Southeast Asian countries (Laos, Thailand, Cambodia, Indonesia, Vietnam, and the Philippines) through a project funded by Japan's Ministry of Foreign Affairs.

The story of the *SUB1* research underscores the capacity of science to improve people's lives, as well as the power inherent in a gene. It seems a long and unlikely journey from experimental plots and laboratory benches in the Philippines and California to a small farm in Bangladesh, but it demonstrates how harnessing the latest scientific power from all over the world can make a big difference in people's lives.

Improving food security in less favorable areas

The global rice crisis of 2008 threatened many lives, and the year will be well remembered for the soaring prices, the long lines in the market, the panic, the blame game, and the social unrest in different countries. Dr. Gelia T. Castillo wrote that a sense of alarm grew when rice, known to be the most "affordable" food for the poor, suddenly became "unaffordable." (See *Can less favorable areas obtain food security?* on page 46 of *Rice Today* Vol. 8, No. 2.) It reminded the world of rice's crucial role in human existence. It also revived interest in agriculture. Researchers often focus on farming on irrigated, favorable, and accessible farms. But we may fail to realize that many farmers contend with unfavorable areas just so their families can have enough rice to eat and survive.

Rice science has not always favored investing in unfavorable areas as they were too diverse, complicated, and difficult. Compared with irrigated farms, these topographically, ecologically, and climatically challenged areas provided meager harvests. When the international development community adopted poverty as its flagship challenge, the opportunity came to establish the Consortium for Unfavorable Rice Environments (CURE). Fostering cooperation between the national agricultural research and extension systems and the International Rice Research Institute, this initiative involves 10 countries: Bangladesh, Cambodia, India, Indonesia, Lao PDR, Myanmar, Nepal, the Philippines, Thailand, and Vietnam.

As CURE focuses its research on the development of less favorable areas, the goal is to provide more food security for the poor families in the marginal and diverse rainfed environments in monsoon South and Southeast Asia, through more sustainable and resilient rice-based production systems. CURE uses a common approach to examine eight generic themes (germplasm improvement, rice varietal diversity, seeds and seedling management, crop establishment, cropping system enhancement, upscaling activities, patterns of labor use, and food security) across the different sites, but the resulting technologies are specific to each ecosystem.

Among the CURE technologies, the primacy of seeds is the most recurrent. For the Filipino farmers in the Arakan Valley, for example, rice seed security is food security. When they run out of food, the people start to eat their seeds. Hence, they set up a community seed bank. Through participatory varietal selection, farmers chose seeds among different varieties that performed well in the field compared with the traditional ones. CURE also introduced the concept of clean and healthy seeds, lower seeding rates, and quality seedlings. Direct-seeding technologies resulted in earlier crop establishment and harvest, less labor, and better weed control. With shorter-duration varieties and time-saving crop establishment, it also became possible to grow nonrice crops for cash and employment.

Anthropologist Stephen Zolvinski observed some of the technologies that resulted from the process. The submergence-tolerance gene known as *SUB1A* was transferred to Swarna, a popular variety in South Asia (see *Scuba rice, stemming the tide in flood-prone South Asia* on pages 26-31 of *Rice Today* Vol. 8, No 2). The development of this variety is an example of how modern scientific tools are combined with locally popular varieties to produce improved varieties that are stress tolerant and acceptable to farmers. Using science in combination with local practices to meet the challenges of diverse rice environments through a common approach, CURE found the common denominators and made rice security in less favorable areas a realizable goal.

Rice science has now demonstrated that it can greatly contribute to the unfavorable rice environments by incorporating stress tolerance in local plant types. This entry point allows farmers in the less favored areas to improve yields with reduced risk, and it has created more opportunities to improve productivity. The International Fund for Agricultural Development has recognized the contribution that rice science can make to improving livelihoods of the rural poor in Asia, and it is hoped that collaboration with CURE will be established soon.

From lab to farmers' fields: overcoming drought stress in rice

Since the dawn of agriculture, drought has been the bane of farmers, especially those who grow rice, a crop that has special water requirements.

Most rainfed areas receive a reasonable amount of rainfall during the growing season but "its erratic distribution and shortage, particularly at flowering and again at grain-filling, can seriously curtail productivity," says Arvind Kumar, a plant breeder at the IRRI. In Asia alone, 23 million hectares (20% of the total rice area) are prone to drought. Climate change is likely to worsen water scarcity in these areas.

Most farmers in drought-prone rainfed areas grow varieties bred for irrigated conditions such as IR36, IR64, Swarna, Lalat, and Sambha Mahsuri, just to name a few. Since irrigated varieties are highly susceptible to drought, farmers are lucky to harvest even half a ton per hectare when droughts occur.

To help farmers cope with water scarcity, IRRI has been focusing its efforts, for many years, on combating drought through rice research and developing breeding lines that can give good yield under drought conditions.

"IRRI has intensified its efforts to develop drought-tolerant and aerobic cultivars to cope with the looming water shortage," says David Mackill, leader of IRRI's rainfed program. (Aerobic rice is grown like an upland crop such as wheat and maize, in soil that is not puddled or flooded.)

New breeding lines

IRRI has bred several new lines that are as high-yielding as any normal varieties with sufficient water. They have a 0.8 to 1 ton per hectare yield advantage whenever drought occurs. These lines can withstand drought at any stage of the crop cycle, even at the reproductive stage, when the plant suffers more loss from drought.

Two of these drought-tolerant breeding lines are

expected to be recommended for official release: IR74371-70-1-1 in India and its sister line IR74371-54-1-1 in the Philippines.

These breeding lines are products of sustained research for 40 years; Dr. Brigitte Courtois attempted the crosses, which had led to the development of these two lines. And it was Dr. Gary Atlin who introduced the concept and initiated and conducted experiments on direct selection for grain yield under drought stress. He combined high yield potential under irrigated situations with good yield under drought.

What turning point along the way led to high-yielding drought-tolerant rice? In 2004, IRRI scientists started working in a different way: working directly on improving grain yield in rice under drought.

In the years before that, scientists had been working on improving the traits thought to be related to drought tolerance such as leaf rolling, rooting depth, and other traits. They had thought that yield under drought could be increased by improving these secondary traits.

Rachid Serraj, a drought physiologist involved in dissecting the mechanisms of drought tolerance and its genetic variation in rice, says that combining high yield potential and drought tolerance through direct selection for grain yield is one of the right approaches for developing drought-tolerant lines, in addition to marker-assisted selection (see *On your mark, get set, select* on pages 28-29 of *Rice Today* Vol. 3, No. 3) and genetic modification (GM) approaches (see *Overcoming the toughest stress in rice: drought* on pages 30-32 of *Rice Today* Vol. 8, No. 3).

"Developing drought-tolerant cultivars is the most efficient way to stabilize rice production in drought-prone areas," affirms Dr. Kumar.

As the scientist now responsible for developing drought-tolerant varieties, Dr. Kumar says that he is very lucky to witness the success of this teamwork.

Participatory varietal selection

"Drought-tolerant lines have received high farmers' preference scores in both normal and drought trials and farmers look convinced of adopting such superior varieties," says Dr. Stephan Haefele, IRRI soil scientist and agronomist who is responsible for testing the lines in farmers' fields under participatory varietal selection (PVS) in India.

And even if IR74371-54-1-1 is not yet officially released in the Philippines, it has made farmers happy and is already popular among them as "5411." In the province of Bulacan alone, farmer cooperators increased from 13 in 2004 to more than 100 in 2008.

The breeding network approach

Breeding networks and working closely with national agricultural research and extension systems (NARES) are some of the reasons many IRRI breeding lines are advancing in South and Southeast Asia.

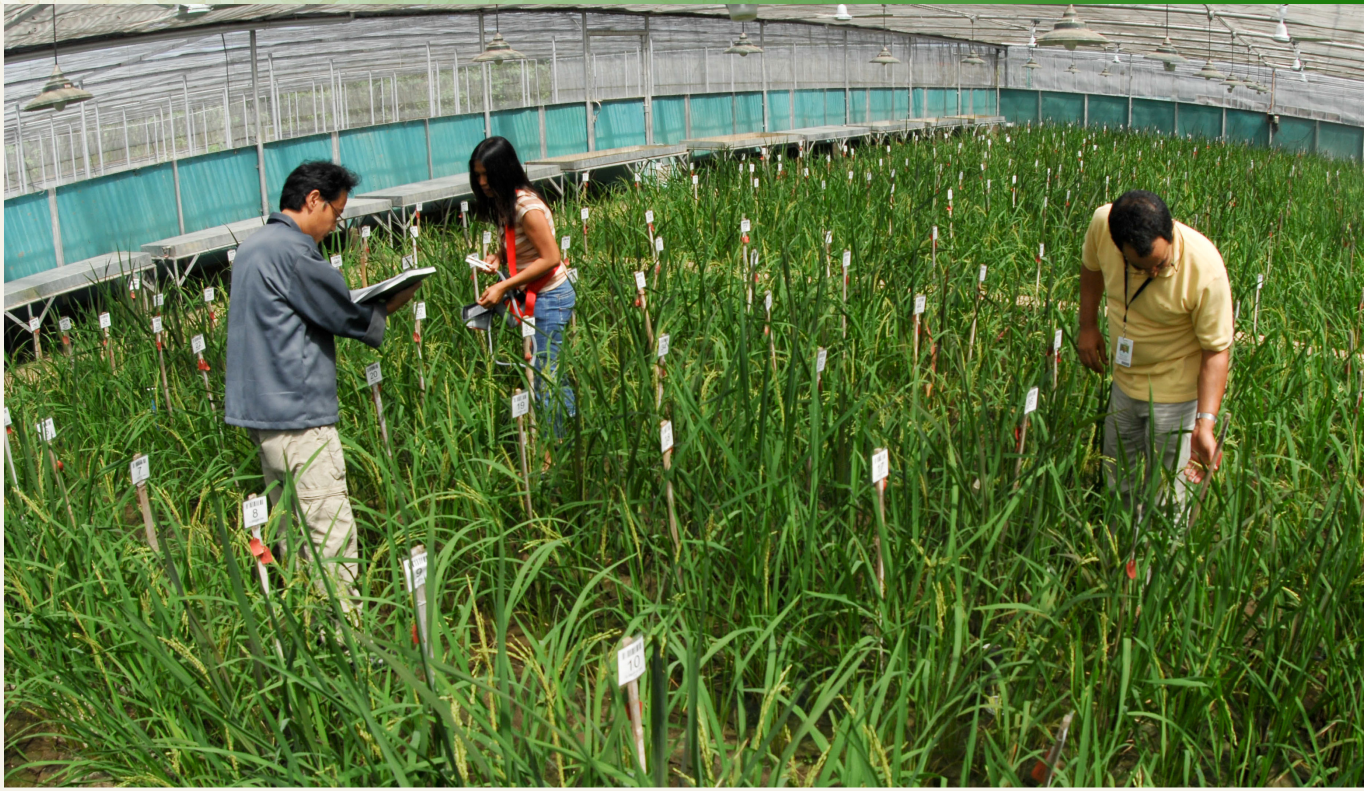
A drought-tolerant breeding line, IR74371-70-1-1, which IRRI introduced in eastern India, has an interesting story. It was tested under an India-IRRI collaborative project, the Drought Breeding Network (DBN), whose partners are the Central Rainfed Upland Rice Research Station (CRURRS) in Hazaribag; Indira Gandhi Krishi Vishwa Vidyalaya, Raipur; Birsa Agricultural University, Ranchi; Narendra Dev University of Agriculture and Technology, Faizabad; Tamil Nadu Agricultural University, Coimbatore; University of Agricultural Sciences, Bangalore; and Barwale Foundation, Hyderabad, India. Courtesy of the DBN, researchers have identified this entry as promising for the drought-prone ecosystem.

As a product of a joint endeavor, this line was named *Sahbhagi dhan*, which means, in Hindi, “rice developed through collaboration.”

Sahbhagi dhan is only one of the products of this network approach, which Dr. Surapong Sarkarung started way back in 1992-95 under the Rainfed Lowland Shuttle Breeding Network. Later on, Dr. Atlin and Dr. Mackill continued and sustained this shuttle breeding effort for many years.

“I am amazed to see the success of the shuttle breeding approach after so many years and I personally feel that this is the way to move, if we really want to have an impact in the long run,” says Dr. Kumar.

Moreover, hundreds of new rice breeding lines have been recently screened for drought tolerance in multilocation trials in India. Dozens of promising cultivars are being tested in large-scale PVS trials with farmers and in the national varietal testing programs



in India, Bangladesh, Nepal, and the Philippines under projects supported by the Bill & Melinda Gates Foundation, Rockefeller Foundation, Generation Challenge Program, and Asian Development Bank.

Seed multiplication and distribution

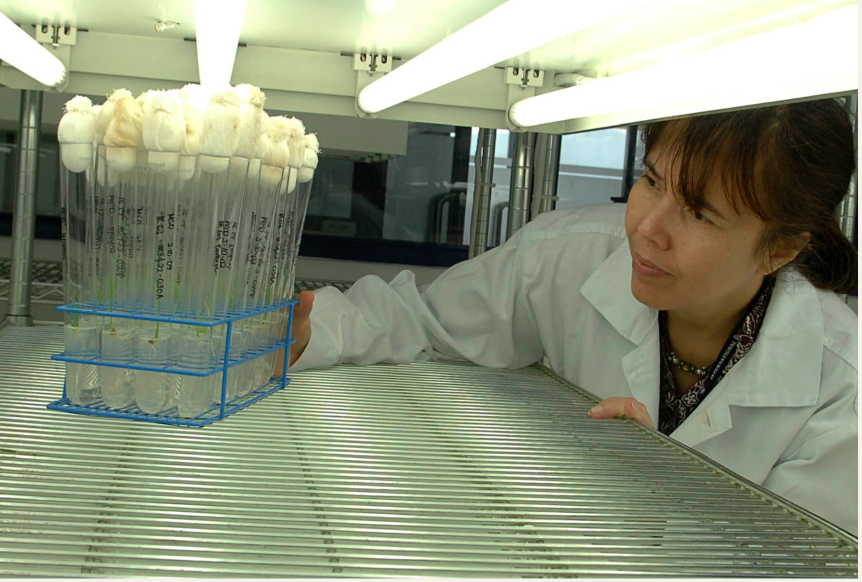
To get these breeding lines to farmers’ fields, IRRI has put in place seed multiplication and distribution channels. Seed is produced by national authorities in South Asia, private-sector companies, and NGOs for large-scale dissemination in the target drought-prone areas.

U.S. Singh, the IRRI regional coordinator for South Asia of the Bill & Melinda Gates Foundation–supported project on *Stress-Tolerant Rice for Poor Farmers in Africa and South Asia* (STRASA) and responsible for seed production and dissemination of Sahbhagi dhan, plans to have large-scale seed multiplication of this line in 2009 and produce 100 tons of seed to distribute to as many farmers as possible by the next wet season in India.

The National Food Security Mission of India, National Seed Corporation, various public- and private-sector seed corporations and companies, research organizations, and NGOs are interested in reproducing and disseminating Sahbhagi dhan seeds. “Our purpose is to take this variety to the maximum number of farmers in the shortest possible time,” says Dr. Singh.

Applying new genetic technology

The main goal of IRRI's strategic research on drought is to scale up gene detection and delivery for use in marker-aided breeding in rice. This involves the development of high-throughput phenotyping and genotyping systems to allow genes for drought tolerance components to be efficiently mapped, and their effects assessed, moving the most promising into widely grown rice mega-varieties. The drought research team at IRRI involves breeders, molecular geneticists, agronomists, and social scientists.



Research groups at IRRI, led by Drs. Serraj and Inez H. Slamet-Loedin, cell biologist, are currently working on drought-tolerant varieties using genetic modification (GM). "Current GM technologies at IRRI are very efficient for both indica and japonica rice cultivars, and there is no major technical bottleneck in producing a large number of 'events' (independent plants generated from a GM cell) as long as there is space to plant and characterize them," said Dr. Slamet-Loedin.

To support and expand scientists' development of drought-tolerant rice varieties using GM modification, IRRI established a drought-screening facility and a protocol that mimics drought conditions in lowland rice fields. In the past, genetically modified drought-tolerant breeding lines were tested mostly under artificial conditions using pots, as field trials would violate biosafety requirements. The drought-screening facility allows scientists to better predict the yield these lines would have in the field.

During the dry season of 2007, the first drought-screening experiment using the facility was carried out to test the effects of a gene for drought tolerance provided by the Japan International Research Center for Agricultural Sciences. Scientists were pleased to observe that the data on yield under irrigated and drought conditions inside the drought-screening facility were similar to those obtained from nontransgenic field experiments at IRRI. The drought-screening facility was thus found to succeed in creating realistic drought conditions.

"We are making progress and we have already identified a few promising lines," Dr. Serraj confidently stated. "These, however, will need further testing and validation. The drought-screening facility greatly helped in our transgenic research, so we plan to establish a similar and bigger facility in the future. This will allow us to test more gene candidates."

Marker-assisted backcrossing

Another important factor that led to the success of these breeding lines is the diverse and appropriate genetic resources that IRRI uses in its breeding program. IRRI scientists have identified major quantitative trait loci (QTLs, or genomic regions) conferring grain yield under drought. Now, these QTLs are being introgressed in the background of mega-varieties such as IR64 and Swarna, among other varieties using marker-assisted backcrossing to improve their drought tolerance.

The STRASA project

It was also in 2008 that IRRI established a drought consortium involving international scientists for the development and evaluation of drought-tolerant rice. With the Bill & Melinda Gates Foundation-funded STRASA project, IRRI is working with the Africa Rice Center and 59 national agricultural research and extension system partners in South Asia to develop drought-tolerant varieties, and to deliver these varieties to large areas in South Asia and sub-Saharan Africa (http://strasa.irri.org). The intensive network efforts that IRRI is putting into the rainfed program (not just in drought, but also in submergence and in salinity) are now being supported by STRASA.

With all these concerted and sustained efforts to improve productivity in unfavorable rainfed environments, there is hope for increasing food security and improving the lives of the mostly poor farm families living in these areas.

Sustaining productivity in intensive rice-based systems: rice and the environment

Bas Bouman
Leader, Program 2

Highlights in developing high-yielding rice varieties include the first-ever release of an IRRI-bred semidwarf high-yielding aromatic line (Punjab Mehak 1) in the Indian state of Punjab. We developed pyramid lines with three bacterial blight resistance genes (*Xa4*, *Xa7*, and *Xa21*). To improve maintainer and restorer lines when developing hybrid rice, resistance to bacterial blight was introgressed through marker-assisted selection (MAS) in parental lines of Mestizo hybrids. A sequence tagged site (STS) marker tightly linked with brown planthopper resistance conferred by the *Bph18* gene was MAS-validated in advanced backcross japonica breeding lines. We fine-mapped a tungro resistance gene, and found DNA markers closely linked to the gene.

For crop management options, findings on crop-weed interactions have been incorporated into management recommendations. A computer-based decision support tool for nutrient management (Nutrient Manager for Rice) was released in the Philippines, while specific versions were developed for Vietnam, Bangladesh, and one state in India. A large number of national agricultural research and extension systems (NARES) in Asia tested aerobic rice germplasm, and adopted research, development, and dissemination activities on the aerobic rice production system. A strategic assessment of rice-maize production systems for 29 locations across Asia was completed, highlighting the yield potential for each crop and the opportunities for optimizing the cropping systems' outputs.

At the landscape level, we showed that surrounding grasses are useful habitats for natural enemies of insect pests. We identified sites in Thailand, Vietnam, and China for trials on ecological engineering (modifying landscape components to increase ecosystem resilience against pest outbreaks). Surveys in Thailand show that farmers actively manage landscapes to support functions such as the provision of food, medicine, and pest and weed control. Specific ecosystem services of paddy landscapes 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; and regulating temperature/climate.

In our research on climate change, geographic regions with high risk for high-temperature damage to rice were mapped. Promising germplasm is being identified from areas with current high risk for high temperatures to enter breeding programs for genetic improvement. High heat tolerance was found for the aus-type variety N22. A germplasm screening for heat avoidance (early morning flowering) has been finalized. Using a hydraulic model, we assessed the impact of sea-level rise on water levels in the Vietnamese Mekong Delta. Rice production will be affected through excessive flooding in the tidally inundated areas and by longer flooding periods in the central part of the Delta. Preventive measures must therefore be taken.

The Irrigated Rice Research Consortium (IRRC) successfully implemented "Country Outreach Programs" to integrate participatory research and development. The consortium undertook development, adaptation, and delivery of water-saving technologies in the Philippines, Bangladesh, and Vietnam. We worked with the fertilizer industry to develop site-specific nutrient management options in the Philippines, Indonesia, and Vietnam. Millers and manufacturers were involved in the development of postharvest technologies such as the Super Bag for grain storage, dryers, and grain moisture meters in Vietnam, Laos, Cambodia, and Myanmar. We calculated a 2%, 1.4%, and 2% increase in gross present values (GPVs) for farmers using IRRC-developed technologies for direct-seeded rice in the Indian states of Uttaranchal, Uttar Pradesh, and Bihar, respectively. The GPVs in these rice-producing areas are estimated at US$12.6 million, $165 million, and $80 million, respectively.

The harvest isn't over yet: reducing grain loss postharvest

Being a rice farmer is tough. It's not easy waking up at the crack of dawn every day—including weekends—doing backbreaking work in the mud under the scorching sun. You have to constantly think about planting clean, healthy seeds, and getting rid of pests such as insects, rodents, and weeds.

Water is crucial. The right amount of nutrients must be supplied at the right time. But don't think that the work is done when you've harvested all your grains. To get a good price, you have to make sure your grains are healthy from the field until they reach the market.

This is not an easy task as 15–20% of grains are lost because of delays in harvest, labor shortage, delayed drying, spoilage, pests, and poor milling facilities. Farmers suffer 30–50% in financial losses from harvest to market.

For more than 15 years, the IRRI has been working with partners in national research institutions and the private sector to develop and test harvest and postharvest technologies that are designed to reduce yield losses and improve grain and seed quality. These key technologies are a low-cost paddy moisture meter, quality assessment toolkits, mechanized harvesting technologies, mechanical rice dryers, and hermetic or airtight storage systems that provide insect control without using pesticides.

One of the most important achievements of IRRI's postharvest team is the successful partnership with the public and private sector over the years, which has made technology transfer across countries and collaboration for adaptation and extension easier.

Success in seed storage

An efficient storage system is crucial to protecting seeds for the next planting season. In humid tropical conditions, seed and grain quality quickly deteriorate within 3–4 months of storage because rice grains absorb water from the surrounding air and storage pests, mostly insects, accumulate.

In 2000, IRRI evaluated airtight storage cocoons with a 5-ton capacity with the Cambodian Agricultural Research and Development Institute. Results showed that airtight storage extends germination from a few months to 9–12 months. However, upon evaluation,

the cocoons were found to be too expensive and farmers preferred individual storage rather than group storage.

IRRI then started working with Grainpro (a manufacturer of airtight storage systems) in 2004 to develop the Super Bag. Created specifically for farmers with small amounts of land, it can store up to 50 kilograms of seeds or grains and it costs less than US$2 each.

The Super Bag and larger airtight storage systems (with 5- to 200-ton capacity) have been extensively tested and verified with farmers and seed processors in Vietnam, Cambodia, Lao PDR, Indonesia, and Myanmar. Results showed that farmers can reduce their seed rate by up to one-third by using the Super Bag.

Commercial seed producers and more than 4,000 farmers in Cambodia and Vietnam are now using Super Bags to store their seeds safely for 6–9 months, maintaining germination rates above 90%. And, farmers can now sell more grain in the market since higher germination rates mean they need less grain for seed.

Transfer of drying technologies across countries

The main reason for deterioration of seeds is delayed, incomplete, or ineffective drying. Traditionally, millions of Asian farmers dry their grain by spreading it under the sun.

Mechanical flat-bed dryers were developed to help farmers dry grain more evenly than with traditional sun-drying, thus preventing spoilage and producing better quality grain.

In 2006, the Postproduction Work Group (PPWG) of IRRI's Irrigated Rice Research Consortium (IRRC) and the postharvest group of Dr. Phan Hieu Hien of Nong Lam University, Vietnam, conducted training activities on dryers for manufacturers and research technicians from Cambodia, Lao PDR, and Myanmar. When they returned to their countries, the dryer manufacturers built prototypes for demonstration and subsequently released models for commercial use. Now, more than 48 dryers are installed in rice mills and used by farmers' groups in Myanmar, along with 22 in Laos and 7 in Cambodia. Construction of flat-bed dryers and training of farmer groups have led to more than 5,000 farmers having better quality rice in Myanmar and Laos, which in turn means they can sell their rice to millers at higher prices.

Dr. Myo Aung Kyaw, secretary general of the Myanmar Rice and Paddy Traders' Association (MRPTA), participated in the dryer training in Vietnam. When he returned to Myanmar, he led MRPTA's impressive campaign on postharvest losses and stressed the importance of increasing rice quality as a basis for improved milling yields; capacity building for farmers, millers, and extension workers on postharvest management; and promotion of newly introduced dryers. Most of MRPTA's activities were done with public-sector institutions such as the Plant Protection Division of the Myanma Agriculture Service. Theirs is a good partnership between the public and private sector that is reaping rewards for many farmers.

In Indonesia, collaborative research led to the design of more efficient fans for grain dryers. In 2007, this led to milling quality 12–40% higher than that of sun-dried rice.

A low-cost moisture meter

Moisture determination is the most critical factor when drying, storing, and processing rice seed and grain. In 2008, the team developed the new IRRI Moisture Tester Mark II, designed for easy testing of paddy moisture content. The IRRI Paddy Moisture Indicator is a decision-making tool for postharvest operations and was not designed for trading. Locally produced by two manufacturers in Los Baños, Laguna, Philippines it is available at IRRI's RiceWorld Bookstore for US$55, excluding shipping costs.

Empowering farmers

In eight villages in Cambodia and four villages in Vietnam, market boards have been set up to keep farmers up to date on market information. In Cambodia, rice prices from village, provincial, and Phnom Penh markets are collected every 3 days from extension workers and villagers using mobile phones. These updated prices benefit 1,840 farmers—empowering them to make wise decisions on what to produce, where to sell, and how high the quality of produce should be for them to earn higher returns from their harvests.

Building capacity of partners

In 2008, IRRI's postharvest team continued to build capacity of partners through hands-on training activities in their countries. These involved training on laser-leveling equipment, seed and grain quality, combine harvesting, and mechanical drying.

Key fact sheets and videos on postharvest technologies are also being translated into Myanmar and Khmer languages.

Learning alliances and impact pathways

The IRRC's PPWG is also eager to know how farmers respond to and use these postharvest technologies, and thus conducted qualitative and economic impact assessment activities in the first half of 2008. In May, a 3-day workshop on "Research to Impact in Postharvest: Lessons Learned" was held in Ho Chi Minh City, Vietnam, gathering 37 participants from partner countries. Based on the encouraging results, donor Swiss Agency for Development and Cooperation has agreed to fund postharvest research and development in Cambodia, Lao PDR, Myanmar, Vietnam, and Indonesia through the PPWG for another 4 years in Phase IV of the IRRC. In December, a participatory impact pathway analysis workshop was conducted in Cambodia.

During the December workshop, a new project with a 5-year time frame, "Bringing about a Sustainable Agronomic Revolution in Rice Production in Asia by Reducing Preventable Pre- and Postharvest Losses," was launched. Funded by the Asian Development Bank (ADB) for implementation in Cambodia, Vietnam, and the Philippines, the new project builds on pilot activities of the recently concluded ADB/Japan Fund for Poverty Reduction project "Improving Poor Farmers' Livelihood through Improved Rice Postharvest Management."

IRRI's postharvest team will continue to strengthen partnerships and forge new ones with the public and private sector, building on success stories and lessons learned, to be able to develop and test promising technologies that will benefit hundreds of thousands of farmers across Asia.

Responding to water scarcity

As the world's population keeps on increasing, the nagging question is, Can Earth produce enough food to feed the growing population? From more than 6.5 billion people today, Can Earth still feed 8 billion in 2025?

Producing food requires water. To produce a kilogram of unmilled rice alone requires about 2,500 liters of water (see *How much water does rice use?* on pages 28-29 of *Rice Today*, Vol. 8, No. 1). Around 1,400 liters of water are used in transpiration and evaporation. In transpiration, the plant uses water to cool itself and carry essential nutrients from roots to shoots before it is released to the atmosphere. In evaporation, water in the soil or rice paddies turns to vapor and goes to the atmosphere. The remaining 1,100 liters are lost from the field by seepage and percolation.

Unfortunately, water for agriculture, specifically in rice-growing areas, is dwindling. It has been estimated that, by 2025, 15 to 20 million hectares of irrigated rice will suffer from some degree of water scarcity (see *Every drop counts* on pages 16-18 of *Rice Today*, Vol. 8, No. 3). This scarcity could be caused by falling groundwater tables, silting of reservoirs, chemical pollution, salinization, malfunctioning of irrigation systems, and increased competition from other sectors such as urban and industrial sectors.

Conscious of the increasing pressure on limited water resources, IRRI has pro-actively responded in many ways to determine how to use water more efficiently, that is, getting more crop per drop. The way to deal with reduced irrigation or rainwater inflows to rice fields is to reduce nonproductive outflows by seepage, percolation, or evaporation, while maintaining transpiration flows as these contribute to crop growth. This can be done through technologies such as alternate wetting and drying (AWD) and aerobic rice.

Responding through AWD technology

IRRI mitigates water scarcity through an innovative water-saving technology dubbed as alternate wetting and drying, or AWD (also known as controlled irrigation). In AWD, rice does not need to be flooded all the time. Using a perforated or punctured field water tube, the depth of the water in the field is monitored. This field water tube helps farmers see the "hidden" source of water. If the water level (as measured in the tube) is 15 cm below the surface of the soil, then it is time to irrigate and re-flood the field up to 5 cm. The threshold of 15 cm is called "safe AWD" as this will not cause any yield decline since the roots of the rice plants will still be able to take up water from the saturated soil and the perched water in the root zone. This 5-cm water level should be kept from a week before until a week after the peak of flowering to avoid severe yield loss (see *Saving water: alternate wetting and drying* on page 17 of *Rice Today*, Vol. 8, No. 3). With AWD technology, farmers can produce rice using less water, and hence save money. Also *see AWD technology creates impact in Bangladesh* on page 15 and *Promising varieties for water-saving conditions* on page 19.

In the Philippines, farmers who practice AWD use 15–30% less water, saving fuel where pumps are used and reducing labor while maintaining yield. AWD reduces costs by 20–25% and increases production because the saved water can be used to irrigate more rice lands or other crops. AWD is not only innovative but also environment-friendly. Under AWD, methane emissions could be reduced by around 70% (see *Reducing GHGs through AWD*). AWD as a water management strategy is widely used in China, and is rapidly being adopted by farmers in the Philippines, Vietnam, Bangladesh, Myanmar, and Indonesia.

The Water-Saving Work Group of the Irrigated Rice Research Consortium (IRRC) has shared AWD with many farmers in different countries. In Bangladesh alone, the AWD technology is helping farmers save at least two irrigations during the boro rice-growing season. Indeed, AWD has made a positive impact, so much so that Bangladesh's Ministry of Agriculture has endorsed AWD as a national program and directed concerned agencies to widely disseminate the technology to farmers. Syngenta, a private company, also embraced and supported the technology by distributing 50,000 water-measuring tubes and leaflets to farmers in 2008.

In the Philippines, validation and promotion of AWD with the national agricultural research and extension systems and partners started in 2001 in pump irrigation systems in Tarlac Province. Since 2005, the technology has now spread to gravity irrigation systems. Big national irrigation systems such as the Upper Pampanga River Integrated Irrigation System and the Magat River Integrated Irrigation System have started implementing AWD as an irrigation water management scheme in selected service areas of the systems. From the combined 160,000 farmers getting irrigation water from these two systems, 20% are already using the technology. More than 20,000 farmers have also implemented AWD in a number of smaller national irrigation systems in the country.

In Vietnam, the dissemination of AWD started in 2005 in the Mekong Delta in collaboration with Vietnam's Plant Protection Department. AWD was integrated in the successful "Three Reductions, Three Gains" program (*Ba Giam, Ba Tang*), an integrated crop management approach that is a national policy for Vietnam. Farmers who tried and adopted the technology confirmed that AWD reduced water use and pumping costs, with savings of around 200,000 Vietnamese dong ($13) per hectare, and yields were relatively higher with AWD than with the regular practice. AWD was introduced to other parts of Vietnam where water is scarcer than in the Mekong Delta. More than 5,000 farmers are estimated to have adopted the technology in Vietnam.

In other countries, AWD technology is still at the "techno-demo" stage. Myanmar and Indonesia are piloting the technology in water-scarce irrigated areas, which serve as a "lighthouse" to disseminate AWD to the wider community. With positive and encouraging feedback from farmers who use the technology, IRRI is working with partners for the respective countries to certify or endorse AWD as an approved technology for nationwide dissemination.

Aerobic rice

In a situation where water is really scarce and not sufficient to even intermittently flood the field such as in AWD, IRRI offers another water-saving option—

aerobic rice (see *High and dry* on pages 28-33 of *Rice Today*, Vol. 7, No. 2). This system grows “aerobic rice” varieties that need less water than lowland rice. Aerobic rice is grown like an upland crop such as wheat and maize, in soil that is not puddled, flooded, or saturated. The soil is therefore “aerobic” or with oxygen throughout the growing season, as compared to traditional flooded fields, which are “anaerobic.”

In temperate countries, aerobic rice can be considered a mature technology. It is used on 80,000 hectares in northern China and 250,000 hectares in Brazil. Han Dao 277, Han Dao 297, and Han Dao 502 are some of the varieties planted in northern China, with demonstrated potential yield of 6 tons per hectare with about 50% less water input than with flooded lowland rice.

For the tropics, the IRRI has developed aerobic varieties since 2001. The first generation of tropical aerobic rice varieties consists of IR55423-01 (Apo) and UPLRI-5 from the Philippines, with 6 tons per hectare of potential yield. However, these varieties have a relatively lower tolerance of dry soil conditions than the Chinese varieties. Other varieties such as B6144-MR-6-0-0 from Indonesia and CT6510-24-1-2 from Colombia were also identified as suitable for aerobic conditions.

For IRRI, improving the performance of aerobic rice is a work in progress. In the Philippines, farmers are testing aerobic rice in the provinces of La Union, Tarlac, Bataan, Nueva Ecija, Aurora, Bulacan, Palawan, and Bohol. Farmers have positively reviewed the technology.

Farmers in India are also trying out aerobic rice on their farms with varieties such as Pusa Rice Hybrid 10, Proagro 6111, and Pusa 834, which were highly tolerant of aerobic conditions. As a result, farmers were able to save 30–40% of water for production of 4–4.5 tons per hectare.

Various activities are being done to extend aerobic rice to farmers. Demonstrations are being held for farmers, researchers, and other stakeholders at most experimental sites in China, the Philippines, India, and Thailand. In the Philippines, the technology is included in a number of training packages on water-saving technologies in rice production. Training courses for farmers and irrigation engineers have been organized by the Philippine Rice Research Institute in several provinces.

In China, aerobic rice concepts are circulated through two national extension networks. Seminars have been organized targeting farming communities. The China Central Television Network, a major TV network in the country, is coordinating with China Agricultural University to produce a video on aerobic rice to show nationwide.

Capacity building

As always, IRRI is ready to share the technology with all. For example, when leaders from An Giang, Vietnam, sought the assistance of IRRI on the latest production technologies, IRRI quickly responded by

spearheading a trainer's training on water savings and AWD technology in An Giang on 17-21 November 2008. Seventy people from different districts and provinces attended this successful activity. In the Philippines, the expanding impact-pathway network, for both scaling up (influencing policymakers) and scaling out (wider dissemination of technologies to end users), is driven by training. The participants in these courses were staff from institutes, universities, extension agencies, and irrigation system administrators with a mandate for applied research, water management, or extension.

This kind of training activity creates a snowball effect as trainers will train more people in their respective districts and provinces.

Thinking together and working together

On 26-28 March 2008, a workshop on adoption and impact of water savings in the Philippines was held to understand the status of extension and adoption of these technologies, identify how to address research gaps to further improve these technologies, and learn how to promote AWD at the policy level. With the technical support of IRRI, NARES partners from the Philippine Department of Agriculture (DA) and attached agencies drafted a policy guideline in the form of an Administrative Order from the DA secretary to institutionalize AWD for countrywide dissemination.

Stakeholders from Bulacan Agricultural State College; Philippine Rice Research Institute; Bureau of Soils and Water Management; National Irrigation Administration (including representatives from its offices in Quezon City, Bohol, Region VII-VIII, Bulacan, Tarlac, Tacloban City, UPRIIS-Cabanatuan City, and Ilocos Norte); Provincial Irrigation Administration-Bohol; Central Luzon State University; Philippine Council for Agriculture, Forestry, and Natural Resources Research and Development; and the Casecnan Project in Nueva Ecija have all participated.

Integrated field water management

For farmers to cope with water scarcity, IRRI's approach has never been piecemeal. It adopts an integrated field water management approach, which always seeks to find appropriate technologies and water management practices specifically suited to local conditions.

As a research center, IRRI will continue to develop technologies that will benefit farmers worldwide. As an effective facilitator of communication at district, provincial, national, and international levels, IRRI will continue to promote appropriate water-saving technologies by scaling up and scaling out. IRRI will also help to strengthen the capacity of national extension systems, NGOs, and the public and private sector.

As climate change poses new threats and as rainfall becomes more erratic, aerobic rice, AWD, and adapted varieties are appropriate technologies for farmers to cope with water scarcity where it happens and when it happens.

Site-specific nutrient management for rice

The largest expense for rice farming after labor is typically fertilizer. Fortunately, a partnership of scientists coordinated by IRRI across Asia beginning in the mid-1990s developed an improved site-specific nutrient management (SSNM) approach for rice. This approach, after more than a decade of research, enables farmers to optimally apply nitrogen, phosphorus, and potassium as and when needed by their rice crop. The use of SSNM in on-farm research across Asia increased yield and profit as compared with current farmers' practices and existing fertilizer recommendations.

The SSNM approach is a relatively knowledge-intensive technology, in which optimum fertilizer management for a rice field is tailored to specific local conditions for crop yield, growth duration of the rice variety, crop residue management, past fertilizer use, and input of nutrients from organic materials. This knowledge intensity of SSNM has slowed its wide-scale promotion and uptake by farmers. Uptake by farmers has also been constrained by confusion arising from contrasting recommendations for nutrient management received by farmers and extension workers from different sources.

IRRI has therefore collaborated with partners in the public and private sector to consolidate knowledge on SSNM and current recommendations on nutrient management for rice into concise principles and guidelines widely accepted and promoted across multiple research and extension organizations. In 2008, the consolidation of knowledge and consensus building among organizations providing fertilizer recommendations to extension workers and farmers led to the development of easy-to-use decision tools that enable extension workers, crop advisors, and rice producers to rapidly determine the optimal rates and timing of fertilizer for specific rice fields (see *Management made easy* on pages *32-33 of Rice Today,* Vol. 7, No. 4).

The decision tools include computer-based software with about 10 to 15 questions, easily answered within a few minutes by an extension worker, crop advisor, or farmer. Based on responses to the questions, a fertilizer guideline with amounts of fertilizer by crop growth stage is provided. Each guideline is tailored to farmers' cropping practices, accommodates farmers' use of organic sources of nutrients, and enables the selection of the most cost-effective combination of available fertilizers. These guidelines accommodate rice varieties with a range of growth durations and establishment practices. This decision tool for the Philippines is available on the Internet at www.irri.org/nmrice.

Indonesia

In Indonesia, IRRI and partner organizations within the Indonesian Agency for Agricultural Research and Development (IAARD) consolidated soil testing, soil mapping, and plant-based approaches into one concise national nutrient management guideline for rice. This guideline is consistent with the scientific principles of SSNM for rice based on years of research across Asia. The SSNM principles are available in the book *Rice: A Practical Guide to Nutrient Management*, which was released in 2008 in Bahasa Indonesia and is now being released across Asia in other local languages.

In 2008, IRRI and partners in IAARD developed interactive computer-based software that enables extension workers and farmers to rapidly use this national nutrient management guideline to determine the optimal rates and timing of fertilizer for specific rice fields. The software, named *Pemupukan Padi Sawah Spesifik Lokasi* (*Rice Fertilization for Specific*

Locations), or PuPS for short, asks about 15 questions in Bahasa Indonesia that an extension worker or farmer can answer with readily available information in about 15 minutes for a specific rice field or rice-growing area. It then provides a one-page guideline illustrating the optimal timing and rates of fertilizer based on the rice variety, rice yield, crop residue management, fertilizer sources, and use of organic materials specified by the user. It uses soil test and soil map information when available. When this is not available, it uses information on historical fertilizer use to estimate soil nutrient-supplying capacity and the field-specific need for fertilizer.

The PuPS decision tool was ceremonially released on a CD along with an associated training module by President Susilo Bambang Yudhoyono during the Indonesian National Rice Week in July 2008. The PuPS CD was distributed to extension workers across the country through Indonesia's Assessment Institutes for Agricultural Technology, and it is part of the technologies promoted nationally for rice production.

The Philippines

In the Philippines, IRRI scientists in partnership with public- and private-sector organizations developed a similar decision tool tailored to rice-growing conditions in the country. This decision tool, named *Nutrient Manager for Rice*, was released in English by Secretary of Agriculture Authur Yap in August 2008. Starting in October 2008, the Philippine Department of Agriculture (DA) distributed *Nutrient Manager* on a CD in five dialects as well as English to local extension agencies throughout the country. It is used by the DA, agricultural universities and colleges, provincial and local governments, and a fertilizer company.

Through a partnership with West Visayas State University, DA, and provincial and local governments in Iloilo Province, the *Nutrient Manager for Rice* software was used to develop a province-wide quick guide with the most salient nutrient management guidelines for rice farmers in Iloilo. The quick guide for fertilizing rice in Iloilo illustrates on one page for either direct-seeded or transplanted rice the optimal rates and timing of fertilizer for common yields, rice varieties, and crop residue management practices in the province.

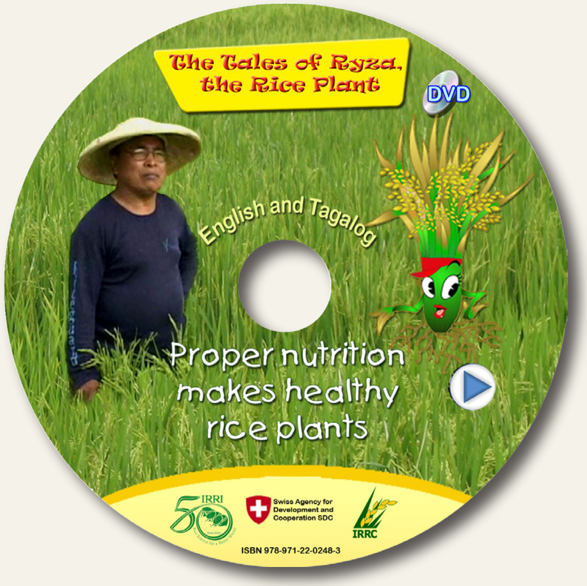
Evaluation of the quick guide in Iloilo indicated that it was an effective tool for accelerating the rate at which guidelines developed with *Nutrient Manager for Rice* can reach farmers. The *Nutrient Manager for Rice* software requires a computer, and it can be rather time consuming to reach hundreds of thousands of farmers when fertilizer guidelines are developed independently for rice fields and farmers. One-page quick guides, on the other hand, can rapidly reach many farmers through banners and printed materials illustrating fertilizer guidelines for the 5 to 20 most common combinations of crop establishment method, growth duration of a rice variety, crop residue management, and rice yield in a province.

Rice-growing conditions that influence fertilizer needs for rice vary among provinces, and hence a quick guide developed for one province might not be appropriate for other provinces. Therefore, based on the experiences of Iloilo, the DA and other organizations are working together to develop quick

guides based on *Nutrient Manager for Rice* for release to Filipino farmers in each rice-growing province of the country in 2009.

A video, *The tales of Ryza the rice plant: proper nutrition makes healthy rice plants*, was developed for farmers and extension workers in the Philippines. In the video, Mang Lando, a rice farmer, gets the surprise of his life when a talking rice plant pops up out of his rice field and tells him what rice plants need. Ryza, the talking rice plant, gives Mang Lando first-hand information on rice and nutrients. By going through the growth stages of rice, Mang Lando finds out how to manage nutrients in order to get high yields. The video is now available on the Internet, in English and in Tagalog.

Rice farmers often face the challenge of selecting the least costly source of nutrients for their rice crop. IRRI, in partnership with several state agricultural universities and colleges in the Philippines, therefore developed a computer-based teaching tool, *Nutrient Optimizer for Rice*, which enables users to enter the current cost of inorganic and organic nutrient sources and then select the most cost-effective source of nutrients. A beta version was released in the Philippines in 2008 for evaluation in agricultural universities and colleges as a teaching tool in introductory soil, agronomy, and crop science courses.



The experiences in Indonesia and the Philippines illustrate the potential of decision tools for accelerating the uptake by researchers, extension workers, and farmers of improved nutrient management based on SSNM principles. The decision support software combines SSNM principles with the unique rice-growing conditions for a country or rice-growing region to illustrate on one page the optimal nutrient management for a specific rice field. The software also enables the development of location-specific quick guides, such as at the provincial or district level, tailored to the most common local rice-growing conditions. Videos and teaching tools facilitate the exposure of more persons to improved nutrient management practices. IRRI is actively working with partners in the public and private sector to develop decision support software together with accompanying quick guides, videos, and teaching tools for additional countries and rice-growing regions.

Breeding BPH-resistant and high-yielding lines

In recent years, elite rice cultivars that were once resistant to brown planthopper (BPH) have become susceptible to the insect in many countries. Kshirod Kumar Jena, plant breeder and IRRI country representative for Korea, mentioned two reasons for this change. First, resistance genes that were previously incorporated into the plant no longer function. Second, the BPH biotypes have changed. In other words, BPH has evolved to survive and damage previously resistant varieties.

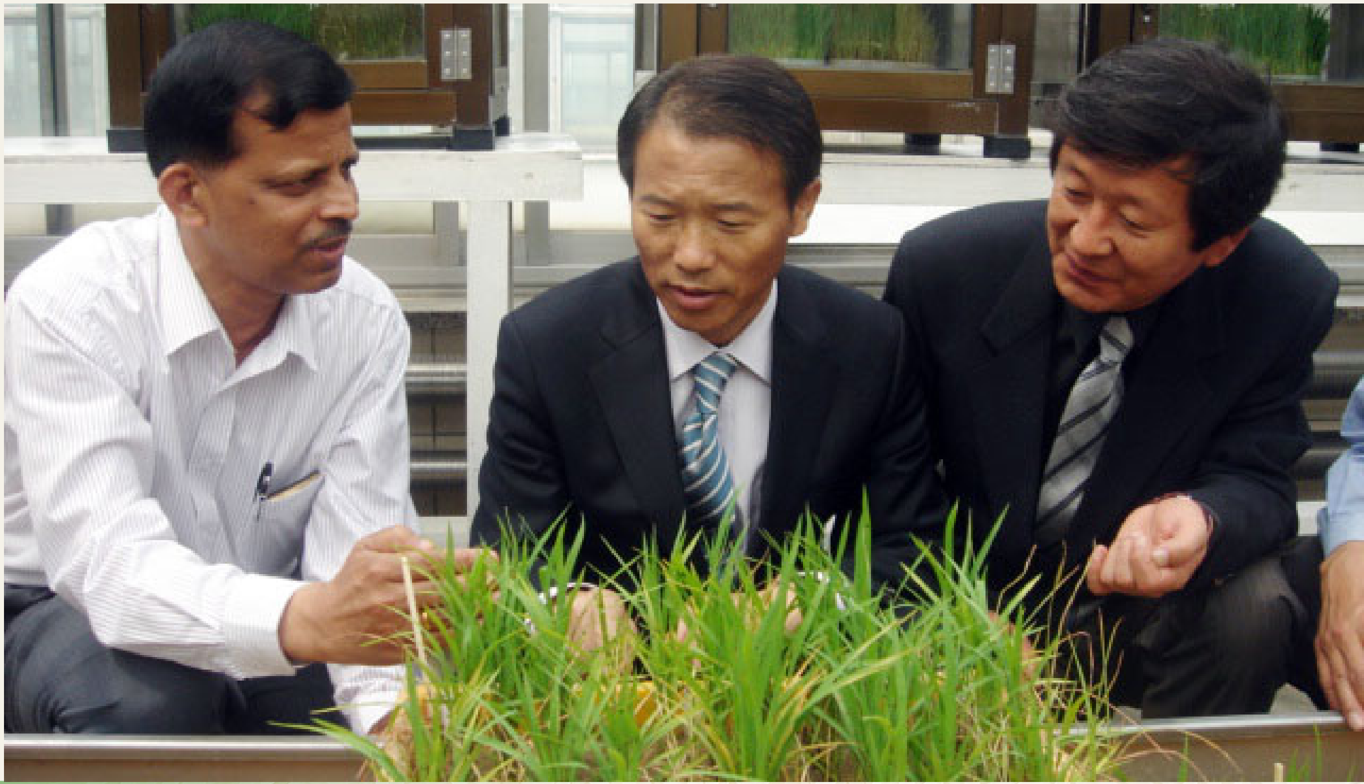
BPH cannot overwinter on the Korean peninsula. It migrates into Korea from Vietnam and China, causing a significant yield loss in rice production annually.

The good news is that Dr. Jena identified a new source of BPH resistance in the breeding line IR65482-7-216-1-2 and fine-mapped a novel gene, *Bph18*, which confers strong BPH resistance using the tools of genetics, plant breeding, and genomics. The *Bph18* gene was incorporated into a BPH-susceptible Korean elite cultivar, Junambyeo, by backcrossing and marker-assisted selection (MAS). With two to three successive backcrosses followed by selfing and MAS, the *Bph18* gene was integrated into Junambyeo without disturbing its major and desirable agronomic traits. The presence of the resistance gene was validated by its associated DNA marker (7312.T4A) and resistant phenotypes of the progenies were detected by greenhouse bioassay. Several advanced breeding lines were produced and evaluated for agronomic traits such as plant height, days to heading, panicle number, spikelet fertility, 1,000-grain weight, amylose content, and yield potential.

Now, five promising breeding lines already have BPH resistance (controlled by the *Bph18* gene). They are similar to the recurrent parent, especially in quality traits. And their yield? They can potentially yield from 9 to 10 tons per hectare.

These BPH-resistant lines are now being tested in different locations in Korea. The seeds of these lines were also shared with the national agricultural research and extension systems (NARES) in some rice-growing countries in South and Southeast Asia. In fact, breeders in Vietnam and China are introducing the *Bph18* gene into their elite local cultivars for developing BPH-resistant cultivars.

Thus, IRRI has developed valuable genetic resources for BPH resistance through successful collaboration with the Rural Development Administration (RDA) of Korea. Surely, these will also benefit other countries, such as China, Japan, and Vietnam, with which IRRI shares genetic resources, for them to improve BPH resistance in rice cultivars.



Breeding lines for cold tolerance

Rice production in countries located in high-latitude and high-altitude areas is seriously affected by environmental stresses such as low temperature or cold during the reproductive stage. Rice production in these regions is about 20% of global production and rice is primarily consumed and exported from these regions to other countries to maintain food security.

Genetic improvement of cold-sensitive cultivars using modern breeding technologies is an important option to reduce yield loss. Kshirod Kumar Jena, plant breeder and IRRI country representative for Korea, and his team identified a new source of cold tolerance in the breeding line IR66160-121-4-4-2, which inherited cold-tolerance genes from Indonesian cultivar Jimbrug and Chinese cultivar Shen-Nung89-389. Recombinant inbred lines (RILs) were produced from a cross combination of cold-tolerant and intolerant cultivars. Dr. Jena evaluated RIL progenies under cold-water stress in the field and cool air temperature in the greenhouse (18 °C) and selected some promising cold-tolerant lines with desirable seed fertility. Then, he was able to identify and validate effective quantitative trait loci (QTLs or genomic regions) that confer cold tolerance at the reproductive stage in the selected cold-tolerant lines. The selected breeding lines had desirable plant type, early maturity, high fertility, and cold tolerance. These promising cold-tolerant lines were shared with NARES for the improvement of cultivars with cold tolerance.

In a nutshell, these promising cold-tolerant lines will economically benefit the rice industry by increasing rice production and making the food supply more stable, which will secure current and future markets.

AWD technology creates impact in Bangladesh

"An incredible clock for irrigation scheduling." This is how Bangladeshi farmers describe alternate wetting and drying (AWD) technology. AWD, a simple-to-follow water-saving technology, is having a profound impact on farmers in Bangladesh. It espouses irrigating the field only when needed by observing the level of water inside a plastic tube. If the water level is 15 centimeters below the surface of the soil, it is time to irrigate and re-flood the field up to 5 cm (see *Saving water: alternate wetting and drying* on page 17 of *Rice Today*, Vol. 8, No. 3).

More and more farmers are benefiting from the technology because it is now officially promoted by the Bangladeshi government. It all started in 2005 when the International Rice Research Institute introduced AWD to the Bangladesh Rice Research Institute (BRRI), through projects funded by the Swiss Agency for Development and Cooperation and Asian Development Bank. This was subsequently supplemented by the Challenge Program on Water and Food.

BRRI tested the AWD technology at Gazipur and the Rural Development Academy (RDA) at Bogra. After seeing the success of AWD as a water-saving technology, Hamid Miah, IRRI liaison scientist

for Bangladesh, took the initiative to validate the technology at Madhupur Farm of Bangladesh Agricultural Development Corporation (BADC) in 2006-07, which included the dry (boro)-season crop (November to May).

During the crop-cutting ceremony on 14 May 2007, a group of high-level officials, policymakers, and farmers were able to witness the performance of the crop under AWD. Present also was the secretary of the Ministry of Agriculture, Md. Abdul Aziz, who was convinced and gave a directive to BRRI, BADC, the Barendra Multipurpose Development Authority (BMDA), and the Department of Agricultural Extension (DAE) to work together in validating and promoting the technology (see *AWD gains momentum in Bangladesh* on page 3 of *Ripple* Vol. 2, No. 3).

BRRI, which was directed to check whether AWD is profitable and acceptable to farmers, validated the technology at its seven regional stations of more than 900 farmers' fields. BRRI's records show that yield was higher by around half a ton per hectare and water-savings ranged from 15% to 25%. Other private companies and nongovernment organizations such as Syngenta, Petrochem, and Practical Action became interested and also tried the technology. Each organization played an important role in the widespread adoption of AWD technology. This started the large-scale adaptation of AWD technology, which has involved thousands of farms and farmers.

More than just through word of mouth, the acceptability of AWD as a technology to farmers in Bangladesh is well documented by BRRI based on a survey conducted among 100 farmers in each of the seven districts.

BADC, which is the largest public-sector seed-producing agency in Bangladesh, conducted AWD demonstrations on more than 12 hectares, which are distributed on 22 farms.

BMDA, a government organization, was asked to adopt AWD more intensively because its clients are farmers who have to pay for water. Covering 16 districts in the northwestern part of the country, it established 26 demonstration farms.

DAE, the largest public-sector extension organization, became the lead agency in promoting

the technology to farmers. DAE trained 150 of its staff members on AWD and established 460 demonstration farms in 25 districts as suggested by BRRI and IRRI.

Even the private seed-producing company Syngenta oriented its own 1,200 employees on AWD. Syngenta also distributed 50,000 plastic tubes to farmers.

Petrochem, another seed-producing company, tried AWD technology on more than 160 hectares of land. The result? The technology saved one-third of the electricity cost and the normal requirement of 24 irrigations declined to 12.

Practical Action, an NGO working as a partner of the IRRI Food Security for Sustainable Household Livelihoods (FoSHoL) project in Bangladesh, conducted a demonstration with 120 farmers.

The information derived from all these validations was consistent among the agencies. They agreed that, with AWD, water and fuel were saved because irrigation frequency declined, production costs decreased, and yields increased. Though there were a few more weeds requiring one extra hand weeding compared with the farmers' practice, the extra cost of weeding was compensated for by savings on fuel cost and extra yield. According to the data from BRRI, when water savings and the yield increase are factored in, less the cost of extra labor, a farmer can have an overall benefit of US$67–97 per hectare.

Environmentally speaking, given the shortages in diesel fuel and groundwater depletion, large-scale adoption of AWD will surely have a positive impact nationally.

AWD technology has clearly revealed positive results based on validation from both the public and private sector in Bangladesh.

Its widespread adoption has been possible because of upscaling efforts and constant facilitation by dedicated persons and organizations—resulting in the support of policymakers and different organizations from both the public and private sector.

Reducing greenhouse gases through AWD

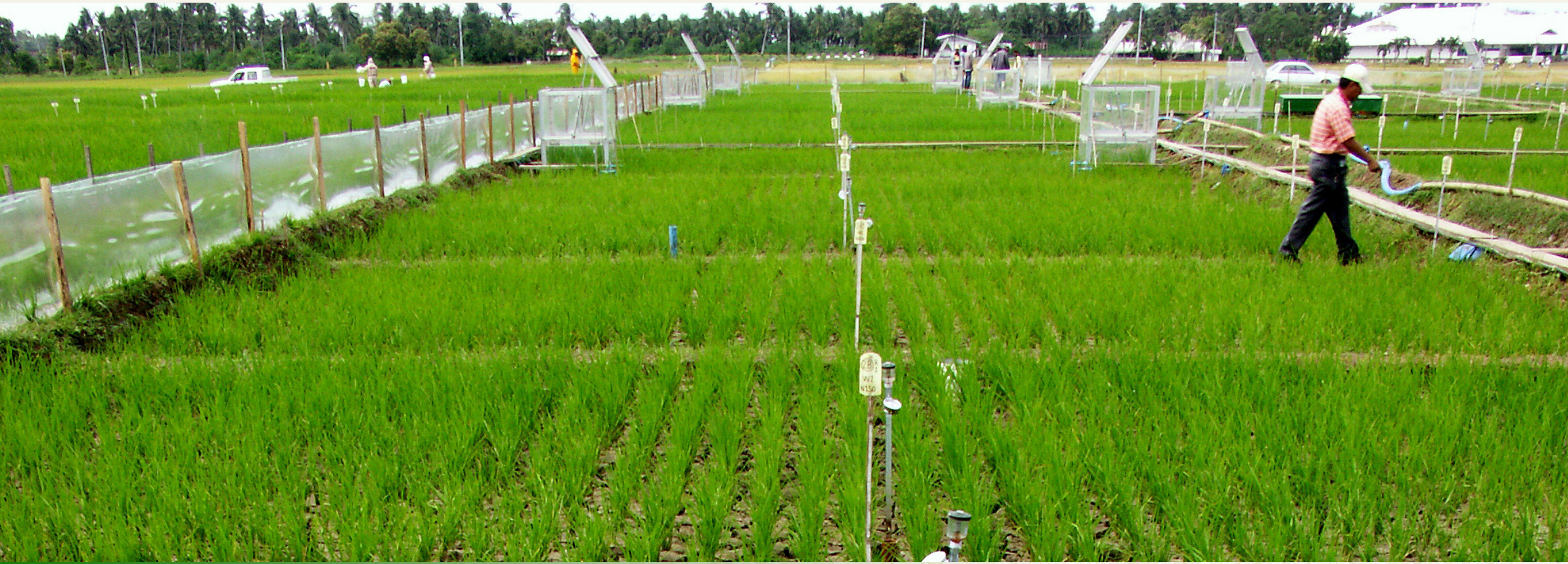
Rice, cultivated on more than 100 million hectares around the world, is usually grown in flooded rice paddies. But, flooded rice emits a major greenhouse gas (GHG), methane, to the atmosphere, especially when plant residues are added back to the soil. The anoxic condition (absence of oxygen) in wetland soils is ideal for microbes to produce methane. Methane's global warming potential (GWP) relative to carbon dioxide, within a 100-year time horizon, is more than 20 times higher on a mass basis.

How does water-saving technology affect GHG emissions? According to Yasukazu Hosen, IRRI soil scientist, alternate wetting and drying (AWD) drastically changes the water regime (the prevailing pattern of water flow over a given time) of paddy soil. Thus, AWD is expected to bring a change in GHG emissions from soil.

According to studies of rice paddies under mid-season drainage management, it can be predicted that methane emissions will be less under AWD because of temporary aerations that reduce methane formation.

In exchange for a reduction in methane emission, however, the emission of nitrous oxide, which tends to emit under relatively wet but not regularly flooded soil conditions and is a more powerful GHG than methane (approximately 300 times more than carbon dioxide), may be increased by this water-saving technique. However, few experiments to quantify this have been conducted.

Field and pot experiments conducted at IRRI show that AWD can significantly reduce the GWP of paddy fields based on methane and nitrous oxide emissions. The reduction in GWP was enhanced by early tillage (early rice straw incorporation), by N



topdressing immediately before or after irrigation, and by keeping flood conditions for several days after nitrogen application.

In a nutshell, the experiments reveal that

- AWD decreased methane emissions by 60–90% during the dry season and by 35–45% in a year.
- With tillage a month earlier (rice straw incorporated with soil), methane emissions can be further decreased by 60% a year.
- Nitrogen topdressing immediately before or after irrigation decreased nitrous oxide emissions by 80% for 1 month after the first topdressing (including the influence of a second topdressing), compared with nitrogen topdressing 2 days before irrigation. And, when this was followed by 7-day flooded conditions, emissions decreased to the level of a continuously flooded treatment (a background level).
- The shift in nitrogen application rate under AWD treatments from 120 (40-40-40) to 210 (70-70-70) kg N per hectare increased nitrous oxide flux fourfold over the whole cropping season. However, because of reduced methane emissions, total GWP caused by both methane and nitrous oxide emissions was 25–40% compared with that of a continuously flooded treatment.

Take-home message

Under AWD water-saving conditions, methane emissions are likely to be mitigated beyond expectations (reduced by 60–90%), and nitrous oxide emissions, which some feared would increase, can be kept at a level similar to that of a continuously flooded paddy system by adjusting the timing of nitrogen fertilizer application and irrigation. Generally, AWD, as an effective and efficient technology, not only increases rice production and helps conserve a limited resource, water, but also mitigates rice paddies' contribution to global warming. Hence, it helps protect our environment.

Promising varieties for water-saving conditions

The tall green grasses fill the horizon and, from them, flowers bloom like dots of puffy cotton. At first glance, this scene evokes peace and tranquility, but not if you are a farmer who once grew rice from where the grasses stand. This could have been a flooded rice paddy had the water not started to dry.

Unfortunately, water has become scarce because of climate change and depleting groundwater level. Farmers in upland areas, where water is limited, face real problems of meager yield or sometimes no yield at all, which could knock the already poor farmers below the poverty line. For more than 40 years, IRRI scientists have been focusing their efforts on how to combat problems of water scarcity in rice production.

Until now, one of the solutions is still developing better varieties that can survive in places where water is limited and will perfectly tie up with water-saving technologies such as aerobic rice and alternate wetting and drying or AWD (see *High and dry* on pages 28-31 of *Rice Today* Vol. 6, No. 4, and *The big squeeze* on pages 26-31 of *Rice Today* Vol. 7, No. 2).

With this specific purpose, Nobuya Kobayashi, plant breeder at IRRI in collaboration with Japan, has already developed a total of 334 near-isogenic lines (NILs) derived from IR64, an elite indica variety popularly grown in South and Southeast Asia. These NILs were bred through recurrent backcrossing using a donor parent that has upland varieties in its pedigree. The donor parent grew well under aerobic conditions when tested by a collaborator in Tokyo, Japan.

By the way, NILs are created by crossing parents with contrasting traits (with and without the genes), then selecting the lines containing the desired genes.

When these NILs were screened in aerobic rice fields and AWD fields at IRRI, many lines performed better than their recurrent parent, IR64. Some lines even showed yields comparable with those of the check varieties, such as Apo and PSBRc 80—commonly used in these water-saving cultivation systems.

From the field trials conducted during the dry season of 2008, Dr. Kobayashi and his team were able to select seven promising candidate lines. Among the seven, some yielded about 50% more than IR64. They have almost the same yield as PSBRc 80, a variety recommended for AWD fields at the Philippine Rice Research Institute and Bulacan Agricultural State College in Central Luzon, Philippines.

Some lines are even more promising and suitable for water-saving cultivation. They outyielded IR64 by more than 100% and are comparable with Apo, a recommended variety for aerobic rice fields at Central Luzon State University. These lines were sent to India, Bangladesh, and Nepal to be tested using AWD technology.

Among these NILs, Dr. Kobayashi identified lines that reach the heading stage 7 to 10 days earlier, without a yield decrease. These are suitable for water-scarce conditions because the shorter the growth duration, the less water is needed.

Dr. Kobayashi further investigated the genetic mechanism of days to heading and, through genetic analysis, he detected two major quantitative trait loci (QTLs, or genomic regions) on chromosomes 6 and 8.

He also conducted genetic analysis of yield-related traits and found several QTLs responsible for number of spikelets per panicle, number of tillers per plant, and grain weight.

Why are these QTLs or finding the genomic regions important? According to Dr. Kobayashi, these materials with QTL information are useful in developing and increasing the yield of rice varieties suitable for water-saving cultivation by marker-assisted selection.

And, since blast is known to be a serious problem under upland and drought-prone rainfed environments, Dr. Kobayashi and his team are likewise developing breeding lines with blast resistance, an important trait for water-saving cultivation.

For future efforts in finding solutions to water scarcity, these NILs could be further used by other scientists, such as crop physiologists and geneticists, as they continue to improve varieties that will meet the specific needs of farmers.

So, even on rice farms where water is limited, we can still see rice plants standing in the fields with panicles teeming with grains, and making farmers happy.

East and southern Africa: rice for rural incomes and an affordable urban staple

Joseph Rickman
Leader, Program 3

IRRI has now been working in the East and southern Africa (ESA) program for a little over two years. Within that period, we have established a strong working relationship with the ministries of agriculture and higher-level institutes in Burundi, Kenya, Mozambique, Rwanda, Tanzania, and Uganda. We have undertaken many joint research and training activities and introduced many innovations and new products.

Socioeconomics

We have been conducting socioeconomic surveys in Mozambique and Tanzania to identify production constraints and to better understand the economics of rice in the region, especially the demand and supply chain. During 2007-08, we conducted a survey at Chokwe, in southern Mozambique, and we started to conduct a survey in Zambezi, Nampula, and Sofala provinces in central Mozambique. Many of the production constraints and problems identified have already been solved. Some of these solutions are developing resistance for plant diseases, such as bacterial leaf blight and blast, as well as seed purification. Many of the varieties now being grown need to be purified. We are also helping the ministries of agriculture in Mozambique and Tanzania to purify existing lines as well as set up multiplication and distribution systems to get better quality seeds to farmers. Since the majority of rice production comes from rainfed systems, varieties with better drought tolerance and with much shorter growing periods—preferably 100 days or less—are needed. Also, we see the need to improve land preparation and water management systems as well as reduce postharvest losses. Timing is critical in all operations, especially during land preparation and harvesting. Thus, we introduced small-scale mechanization in rice farming.

Plant breeding

More than 2,500 breeding lines have been tested in four localities in Mozambique and Tanzania. We have established regional nurseries in six East and

southern African countries and more than 160 lines have been selected to be further tested in national and provincial nurseries and participatory varietal selection trials across the region. Some of the tested new varieties performed well. They doubled the yield of existing local varieties. In Mozambique, during 2008, we produced more than 150 kg of breeder seed for the three most popular varieties from the purification trials. This material will be used to produce 30 tons of foundation and certified seed in 2009. Also, we multiplied the seed for five new varieties and purified the seed for two existing varieties in Tanzania.

Production and postproduction

Timing is critical in all farming activities and in the management of inputs to improve rice production and reduce losses. Small-scale farm equipment, which includes two-wheel tractors, engine-driven and pedal threshers, drum seeders, and cone weeders, plus accessories such as plows, pumps, and trailers, is being demonstrated and assessed. In fact, a mechanical thresher has already been fabricated locally. Agronomic studies, including plant establishment and fertilizer and weed management, have already been conducted in Mozambique.

In addition, we have conducted village-level demonstrations on the whole rice production process from land preparation to marketing in Zambezi Province in Mozambique. This includes the use of better quality seed, fertilizer, land preparation, and water management as well as improved harvesting, storing, and milling techniques.

Capacity building

During 2008, 36 plant breeders from six East and southern African countries attended varietal selection workshops in Mozambique and Tanzania. Breeders were taught techniques for selecting and conducting their own national nurseries. Another 18 scientists attended a 3-week rice production and postharvest workshop at IRRI in the Philippines. Twelve pathologists and plant breeders from the region also attended a 2-week plant pathology workshop there.

A Rice Knowledge Bank workshop and writing workshop were conducted for 24 scientists and researchers in Mozambique, and one PhD student is being supported to undertake studies on the effects that drought has on rice production in Tanzania.

Mechanization: the way forward for rice production in Africa

In sub-Saharan Africa, rice is a very important staple and cash crop. In 2006, more than 21.6 million metric tons of rice were produced in Africa and another 9.4 million tons imported. African imports accounted for more than one-third of the internationally traded rice, which cost approximately US$2 billion in foreign exchange.

Over the past 3 years, local rice prices have increased sharply. In Mozambique during 2008, rice imported from Asia sold for $930 per ton in local stores and markets, which was nearly three times the price in 2007. Even today, in many villages and rural markets, polished rice continues to sell for $0.80–0.90 per kilogram or $800–900 per ton.

Many African governments now realize that relying on the world market to supply their rice is very risky and expensive and many now consider this an unwise long-term strategy. To avoid severe food insecurity and, in some countries, civil instability, governments are now serious about increasing rice production.

IRRI and the Africa Rice Center (WARDA) are working closely with many sub-Saharan governments, NGOs, and commercial companies to increase rice production across the region.

Potential to increase production

Rice productivity in East and southern Africa is now very low, with yields averaging between 1 and 1.5 tons per hectare. However, the potential to double or even triple rice production in the region is very high as there is plenty of fertile flat land, often with ready access to water and other inputs, such as fertilizer. As well, there is a local market that would prefer to buy locally produced rice as long as it is free from foreign material such as stones and soil.

Rice productivity across the region could be significantly increased in different ways. Yields in the existing rice production areas could be easily increased through better management, new rice-growing areas could be brought into production, and current high losses associated with birds and during the postharvest period could be reduced.

Production constraints

The major constraints faced by rice farmers are a combination of inappropriate and poor management, timing of operations, and the availability of labor at critical times. These factors are often interrelated and in many cases are controlled by factors away from the farm.

Diseases such as HIV/AIDS and tuberculosis plus the migration of young people to the mines and other urban industries have reduced the local farm labor pool. When labor is available, productivity is often very low because of poor health and nutrition issues. In many rice-growing areas, malaria infection is high, as are schistosomiasis and tuberculosis.

More than 250 person-days are required to produce 1 hectare of rice on a rice farm that relies totally on manual labor. A study of labor requirements on-farm found that manual land preparation required more than 140 person-days per hectare, planting and weeding 70–80 person-days per hectare, and harvesting and transporting an additional 60–80 person-days per hectare.

In many areas, rice crops are not planted on time and yield losses of up to 2 tons per hectare have been recorded on the same farm with plantings 1 month apart. Farmers often have to wait for rain to soften the soil so they can prepare it using traditional hand implements. This often results in very poorly prepared and uneven fields. To compensate for this, farmers either plant more seeds or transplant older seedlings. Unleveled and uneven fields also result in higher water requirements, more weeds, poor fertilizer efficiency, and nonuniform crop ripening. Uneven crop ripening causes delays at harvest and increased losses to shattering, birds, and weather damage. Late-planted crops are also much more susceptible to pest damage, especially leaf diseases. Delays during harvesting, threshing, and drying also cause losses in both grain quantity and quality.

After the crop has been harvested, postharvest losses are also very high, ranging from 15% to 50%. In some instances, all of the grain is lost, contaminated by mycotoxins or spoiled by rain after harvest. These losses occur because of poor postharvest management, outdated postharvest technology, and poor and unhygienic storage facilities. Most of the crop is hand-threshed. Because of this, farmers prefer to harvest crops at lower moisture content, which makes threshing easier. This often means that the crop is left in the field up to 1 month longer than is necessary, which increases the risk of shattering, bird damage, and weathering. The outcome is less grain and of a poorer quality, which reduces farmers' income and often turns consumers away from purchasing locally produced rice.

In addition to these losses, there is also a lost potential income as many farmers sell their grain at the point of harvest. If farmers could store their grain safely and have access to transportation so they are not at the whim of local traders, they could increase the value of their grain by 20–30% within 2–3 months after harvest.

In these circumstances, if postharvest losses in sub-Saharan Africa were reduced by 50%, this would provide another 2 million tons of paddy or 1.6 million tons of milled rice, which is equivalent to nearly 30% of the imports and has a real value of $700 million per year.

Overcoming the problem

One way to overcome the timeliness problem and improve the efficiency of operations is to add more energy to the system.

Increasing labor is not really an option but the introduction of small machines, such as two-wheel tractors, grain threshers, and mechanical weeders, is. Although it is often argued that draft animals should be considered, in many countries they bring with them other problems. Animals have to be fed, inoculated, wormed, and trained to work in wet conditions and they also succumb to diseases, pests, and poor health.

Where mechanization has been introduced, it has not only improved the timeliness of operations but also the efficiency and quality of the end product. Land is much better prepared, weeds decline, crops can be harvested at higher moisture, and grain stored safely and much earlier. When two-wheel tractors are combined with a trailer, many on-farm transportation and market isolation problems are solved. The engine can also be used as an auxiliary power source for pumping water, crop threshing, rice milling, and generating electricity. This combination of equipment helped pave the way for self-sufficiency in many Asian countries and it has the same potential in Africa.

IRRI and WARDA are building on the lessons learned in Asia and are now importing small-scale machines for testing and demonstration in Africa.

IRRI is collaborating with the government, machinery manufacturers, and dealers in Tanzania and Mozambique to support the importation, fabrication, and field demonstration of equipment.

IRRI already introduced two-wheel tractors, threshers (both engine- and pedal-driven), manual cone weeders, and drum seeders into Mozambique during 2008. Another shipment of threshers was also sent to Tanzania in 2009. As well, a two-wheel tractor and a pedal- and engine-driven thresher are being sent to the IRRI-CARE project in Burundi.

Equipment that was imported to Mozambique in 2008 has already proved successful. After field demonstrations and farmer trials, the government is now ordering two-wheel tractors and threshers from Asia. A local machinery manufacturer has built and tested the first engine-driven thresher. Cone weeders have been built locally and a pedal thresher is on the way. The cone weeders proved to be six times faster than hand weeding when tried in southern Mozambique.

When testing the threshers at Palmera in southern Mozambique, the women preferred the pedal thresher while the men wanted the engine-driven machine. The local rice miller has also requested a husk stove for testing, which will help reduce his husk pile and also save some of the local forest, which regularly gets turned into charcoal.

In Tanzania, two-wheel tractors are starting to become very popular. More than 500 machines have been imported, with many going into the rice-growing areas. IRRI is working with the local importer and the Mechanization Section in the Ministry of Agriculture to further support the expansion of two-wheel tractors and other equipment. Pedal threshers are already being manufactured in Tanzania and an engine-driven thresher will soon follow.

After initial tests, drum seeders are now being fabricated locally in Mozambique and will be very soon in Tanzania. The imported plastic Asian version introduced for demonstrations has already succumbed to African rats and rough handling. A metal version is now being built.

Adoption

The adoption and sustainable use of equipment in Africa will take time. IRRI's experience in Asia suggests that it takes 8–10 years from initial testing to local ownership and wide-scale adoption. The key to a sustainable mechanization program is to base the program on sound business principles from the beginning. The use of the equipment must show a strong financial benefit, have local ownership and dealer support, have a local champion, have government support, and provide training for all players.

The cost of hiring machinery contractors in Africa is now excessively high. Where large tractors are used, local contractors charge $70–80 per hectare for one pass and rice millers charge $80–100 per ton for contract milling. In comparison, these costs are nearly 3 times those of their Asian counterparts. Labor costs in Africa range from $1 to $2 per day, which is similar to Asia.

The asking price for equipment being imported into East and Southern Africa is very high. A tractor that costs $2,500 in Thailand costs more than $5,000 in Tanzania. One-off fabrication costs are also high but, hopefully, these will decline when larger numbers are manufactured locally and more dealers come into the market.

Even with the high cost of imported equipment, there is a substantial economic benefit in using two-wheel tractors for land preparation. One two-wheel tractor can plow 1 hectare a day and will use approximately 20 liters of diesel. Add to this labor, repair, and maintenance, and the total operating cost is approximately $35 per hectare. Obviously, a cost of ownership must be added, so the overall cost will be approximately $50 per hectare. This compares economically very favorably with current manual and large-tractor plowing. Added to this is the benefit of being able to use the tractor as a power source for threshing, pumping water, transportation, and generating electricity.

Cooperative ownership appears to be the obvious solution for purchasing equipment in the short term. Many African farmers are already used to working in associations or cooperatives, so this should not be a problem. Local credit organizations are starting to work with cooperatives and governments are seeing mechanization as the way forward. Eventually, local entrepreneurs will emerge to take over as contractors to plow, harvest, and mill.

When introducing machines, changes to current farming practices are often required. Several examples have already taken place in Mozambique. Traditional manual threshing requires straw to be left long, whereas mechanical threshing requires short straw. The use of long straw has already caused mechanical problems with some threshers. Similarly, the use of mechanical cone weeders requires seedlings to be sown in rows.

IRRI and WARDA will play a pivotal role in making mechanization happen. On-farm demonstrations, support for the private sector, and, most importantly, local training in the use and maintenance of equipment are already happening. Like in Asia, this will be a long-term transition but it is a basic requirement for rice production to increase in Africa.

Rice and human health: overcoming the consequences of poverty

Gerard Barry
Leader, Program 4

Goal 3 of IRRI's Strategic Plan 2007-2015 is to improve the nutrition and health of poor rice consumers and rice farmers.

Program 4 is largely the IRRI response to this challenge and it addresses several important human health problems related especially to rice consumption.

To meet many of the Millennium Development Goals requires that the widespread problems of health and nutrition that debilitate people and hinder economic growth be solved. Nutritional deficiencies, especially in women and children, often go hand in hand with extreme poverty, which limits access to a diverse and nutrient-rich diet. Reliance on a single staple, such as polished rice, does not provide the suite of minerals and vitamins necessary for healthy growth and development and leads to widespread nutritional deficiency in many rice consumers.

The majority of current Program 4 efforts are devoted to increasing the content of three micronutrients (vitamin A, iron, and zinc) in rice. Deficiencies in these lead to important nutritional consequences that represent significant public health problems. In Southeast Asia alone, 57% of the population suffers from iron-deficiency anemia, 71% from zinc deficiency, and 33% from vitamin A deficiency.

Program 4 is largely funded externally, from long-term donors such as the U.S. Agency for International Development and the Rockefeller Foundation, through initiatives such as the HarvestPlus Challenge Program; the Bill & Melinda Gates Foundation through the University of Freiburg; and other donors.

In developing nutritionally enhanced rice germplasm, Program 4 collaborates with social scientists, economists, food scientists, nutritionists, and public health experts, as well as other rice breeding partners, to deliver and demonstrate the value of this new germplasm.

IRRI is leading the global effort to advance the development of Golden Rice to overcome vitamin A deficiency, working with national agricultural institutes in Asian countries. The Golden Rice trait is being introduced into popular varieties through backcross breeding, and these may be released, following biosafety approvals, as early as 2012, first in the Philippines and Bangladesh, to be followed in other Asian countries.

Program 4 has also made significant progress in developing rice lines with enhanced zinc and iron content through the identification of suitable germplasm and breeding. Three lines of high-zinc rice developed by the Bangladesh Rice Research Institute (BRRI) in collaboration with IRRI are now in advanced yield trials in Bangladesh. In collaboration with Bangladeshi institutions, the University of California at Davis, HarvestPlus, and other international organizations, researchers are investigating the bioavailability of zinc from conventionally bred rice. New varieties of high-zinc rice, expected to be available in Bangladesh and eastern India in 2012, may provide as much as 40% of the daily zinc requirement. The iron content of the rice grain has been increased (fourfold to 8 µg/g), but is still short of the 14 µg/g target set by HarvestPlus.

Fast-tracking the way to more nutritious rice

IRRI researchers are fast-tracking the development of new rice varieties rich in selected essential nutrients to help overcome the micronutrient malnutrition prevalent in many Asian and African countries.

Using a technique that essentially generates a new rice plant from a single pollen grain, researchers plan to reduce the time it takes to breed nutritionally rich rice varieties high in zinc and iron and adapted to grow well in India and Bangladesh. The technique will also help in the discovery of genes involved in the accumulation of iron and zinc in rice grains, which could open the door to new rice varieties with unprecedented amounts of these nutrients and assist the related work in other centers of the Consultative Group on International Agricultural Research (CGIAR) working in wheat and maize.

Affordable and readily accessible sources of iron and zinc delivered through nutritionally rich rice could have a major impact on the health and welfare of people throughout Asian and African countries and on the productivity of their nations. IRRI's work in this project is part of a larger initiative to improve the health and nutrition of rice consumers worldwide.

Nutrient deficiencies in India and Bangladesh

Iron is essential for human health. Nonetheless, the World Health Organization (WHO) estimates that 2 billion people, or 30% of the human population, suffer from anemia—the most acute form of iron deficiency. Many more suffer from iron deficiency to a lesser extent, making iron "the most common and widespread nutritional disorder in the world." The WHO reports that the personal health and national productivity of a country could be raised by as much as 20% if iron-deficiency anemia were overcome.

Zinc deficiency is also widespread. The WHO estimates that 31% of people worldwide suffer from it. Zinc is required for more body functions than any other mineral and the lack of it inhibits normal growth and development, impairs immune function, and contributes substantially to the illness and death of young children worldwide.

According to the International Zinc Nutrition Consultative Group (IZINCG), there is a high risk of zinc deficiency in India and Bangladesh. The Food and Agriculture Organization of the United Nations (FAO) notes that both countries have high rates of iron deficiency. In addition, the Disease Control

estimates that, in South Asia, 76% of children under 4 years old are affected by iron-deficiency anemia and 79% are affected by zinc deficiency.

Eating a varied diet, which includes rich sources of iron and zinc, such as meat, fish, and certain vegetables and pulses, is not feasible for many Indians and Bangladeshis because of its price. Rice is a staple food and is both affordable and available for many. Unfortunately, the rice varieties that are grown today do not contain adequate zinc and iron in the grain. But researchers at IRRI are on a path to change this.

High-iron and high-zinc rice for India and Bangladesh

With funding from the HarvestPlus Challenge Program and other donors, work at IRRI over the past few years has identified some rice varieties, including some japonica varieties that are not well adapted to the tropics, that have much higher zinc and iron content than current varieties. The good news is that plant breeders can seek to transfer the higher nutritional traits of these japonica rice varieties into indica varieties, which are better suited to growing in India and Bangladesh. Using traditional plant breeding, a project such as this could take 8–10 years, but, using a technique involving "doubled haploids," Deepinder Grewal, postdoctoral fellow in Plant Breeding, Genetics, and Biotechnology, plans to significantly reduce this time.

Doubled haploids

In a traditional cross between two plants—the first step of plant breeding—the offspring inherits traits from both parental plants. Plant breeders aim to ensure that all the desirable traits from each parent, and no undesirable traits, are inherited by the offspring and all future generations. It can take up to six generations of recombinations and selections to ensure that a new variety is suitable for the target region, that the traits (such as high grain zinc and iron) are stable in the environment, and that the genes pass on to all future generations.

"Our aim is to develop rice varieties with the nutritional traits that we found in the japonica rice that can also grow in the hot climates of India and Bangladesh," said Dr. Grewal.

Dr. Grewal and her team have already crossed high-iron/high-zinc japonica rice varieties with various indica rice varieties that are favorites among rice farmers in India and Bangladesh. The rice plants resulting from this first cross have a mix of traits from both parents. These plants are then used to produce doubled-haploid plants through anther culture technology.

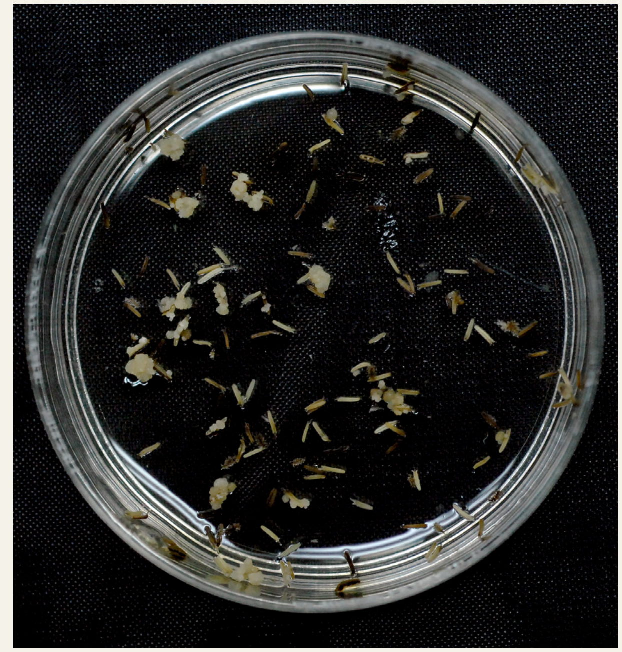
"The doubled-haploid technique involves anthers—the male part of the plant—and then inducing it to form a callus, which then regenerates into a new plant," Dr. Grewal said.

"This unique process produces a plant with two identical sets of chromosomes. Having matching chromosomes means that all the plant's traits are 'locked' into place and will be passed on to future generations. The plants derived from this approach are then screened as for any other breeding lines."

This doubled-haploid technique has been used previously to create new japonica and indica rice varieties, but IRRI has now pioneered its use in indica and japonica crosses with great success. In 2008, Dr. Grewal's team successfully developed 1,500 doubled haploids from these crosses using the technique and more will be generated in the future.

Each of these 1,500 doubled haploids will now undergo a micronutrient analysis to determine the content of iron and zinc present in the grain. They have also been tested in the field over two growing seasons to assess their performance in field conditions. From these evaluations, 20 promising lines were selected.

Any new doubled-haploid lines that show high zinc and iron as well as good agronomic properties for growing in India and Bangladesh will be further developed and used to breed other new nutrient-rich rice varieties.



The hunt for high-iron and high-zinc genes

"Many genes are likely to influence the iron and zinc content of rice," said Dr. Grewal. "Genes involved in the uptake of nutrients, in the transport of nutrients to the grain, and in the storage of nutrients in the grain are all likely to play a role."

Another advantage of using doubled-haploid lines is that it makes finding genes of interest much easier because the traits are instantly fixed and are stable over future generations. Such populations could be tested and evaluated across seasons and target environments, thereby increasing the robustness of the gene discovery process.

"We are in the process of identifying genes or regions of chromosomes, called quantitative trait loci, that are linked to high iron and high zinc so that we can target them in our breeding program to boost the zinc and iron content," said Dr. Grewal.

This work will help to understand the genetics of iron and zinc accumulation in the grain and will also yield new research tools—including linked molecular markers—that will accelerate and increase the precision of developing more new varieties. These tools will be shared with related projects in India, Indonesia, the Philippines, Korea, Bangladesh, China, Latin America, and elsewhere.

Rice genetic diversity and discovery: meeting the needs of future generations for rice genetic resources

Hei Leung
Leader, Program 5

Genetic diversity is the foundation for genetic improvement of crops. Knowledge of multiple facets of rice genetic diversity from molecule to phenotype is essential for effective conservation and use, for both current and future needs. This program has three components:

- Genetic diversity characterization and creation, and gene function assignment;
- Germplasm conservation and documentation; and
- Enabling access to and use of genetic diversity and associated tools.

The program also houses activities of an exploratory nature but with high potential payoffs. We are carrying out this program by extensively collaborating with NARES and ARIs through consortia and networks, including novel partnerships with the private and nongovernment sectors.

In 2008, we made progress in developing a genetic diversity research platform, identifying genes of high agronomic impact, and enhancing the exchange and dissemination of rice germplasm.

Through a consortium approach, we have discovered 160,000 single nucleotide polymorphisms, or SNPs (pronounced “snips,” these are tiny differences in DNA sequence; see pages 15-17), in 20 diverse rice varieties, which provide abundant SNP markers for major parental lines and mega-varieties. This has laid the foundation to unveil genome-wide variations in thousands of rice varieties and germplasm accessions. We have also established a new method of gene silencing using artificial micro RNA, which provides an efficient and specific means for validating gene function. A robust chip-based method was developed to detect genomic deletions in irradiation-induced mutants that enhance the utility of the large collection of IR64 mutants for forward and reverse genetics.

To solve disease-related problems, we have made progress in defining the gene responsible for rice tungro spherical virus (RTSV) resistance. We have narrowed down the SNP that is strongly associated with RTSV resistance, which was derived from a traditional variety, Utri Merah.

Gene-based markers are particularly useful in developing tungro-resistant varieties in contrast to the difficulty in screening tungro resistance by conventional screening. We have fine-mapped a blast resistance gene, *Pi40*, originally derived from wild rice *Oryza australiensis*. This gene shows broad-spectrum resistance to multiple races of the pathogen. Now, it is being incorporated in both indica and japonica breeding lines. To search for stable quantitative disease resistance, we have identified a germin-like protein gene family that functions as a quantitative trait locus conferring broad-spectrum disease resistance, including to blast and sheath blight.

To counteract abiotic stresses, we have pinpointed candidate genes conferring tolerance

of phosphorus deficiency, with a potential to alleviate problems caused by P deficiency.

Making use of the drought-tolerant breeding lines developed by breeders, we combined physiological and whole-genome expression analysis to define the chromosomal regions important for drought tolerance. This integrative method of genetic mapping and expression analysis holds promise for determining the underlying genetic control of complex traits.

In addition to stress tolerance, research in rice grain quality has led to the discovery of multiple genetic mechanisms conferring aroma in rice and to a better understanding of the biochemical pathway contributing to aroma.

An important event in Program 5 was the launching of the C_4 Rice Project that aims to identify genetic variation for C_4-ness and apply such variation to improve photosynthetic efficiency in rice (see pages 3-6). This project involves a broad consortium of institutions and laboratories working together toward designing rice plants with C_4 photosynthesis attributes. In the first year of this long-term endeavor, customized screening infrastructure and phenotyping protocols were designed to advance C_4 research.

To facilitate germplasm conservation and exchange, we implemented a new data management system and workflow for processing germplasm requests under the Standard Material Transfer Agreement (SMTA) of the International Treaty on Plant Genetic Resources for Food and Agriculture. Since its implementation, NARES are exchanging more germplasm with IRRI than they did before.

Creating a second Green Revolution: supercharging photosynthesis

Research shows that maximum yields are approaching a fundamental yield barrier that is shaped by the efficiency of solar energy conversion. How do we break through this yield barrier to meet the ever-growing demand for increased rice production? This requires careful thought, going beyond "business as usual." A growing body of scientific opinion believes that the only way to achieve rice production targeted in the future is by making the rice plant a more efficient user of solar energy.

Rice has what is known as a C_3 photosynthetic pathway, which is less efficient than that of maize, which has a C_4 pathway. In most plants, including rice, the first stable product in photosynthesis is a three-carbon sugar (hence, the term C_3 photosynthesis), and the enzyme Rubisco mediates this process. Rubisco is inherently inefficient because it also participates in a wasteful process called photorespiration (the inverse of photosynthesis). C_3 photosynthesis also decreases dramatically at temperatures above 20 °C.

Rice is predominantly grown in the hot tropics, where photosynthesis becomes inefficient, resulting in lower yields than those of C_4 plants. C_4 photosynthesis, on the other hand, creates a four-carbon sugar from the conversion of carbon dioxide (CO_2), mediated by the enzyme PEPCase (phosphoenolpyruvate carboxylase). Compared with Rubisco, PEPCase strongly prefers CO_2 and does not get diverted into the wasteful photorespiration process. The whole process of C_4 photosynthesis, together with the arrangement of specialized photosynthetic cells in the leaf, known as Kranz anatomy, can convert even a small amount of CO_2 into sugars, thus making up an efficient photosynthetic system.

Nature has shown that C_4 plants evolved from C_3 plants more than 50 times on different occasions and this involved rearrangement of cell structures in the leaf and more activity of certain enzymes related to the photosynthetic pathway. In fact, all the components of C_4 photosynthesis already exist in the rice plant; however, little is known about how these components work together during photosynthesis. IRRI organized a C_4 Rice Consortium and sponsored a scientific meeting that gave rise to the book *Charting New Pathways to C_4 Rice*. Subsequently, the Bill & Melinda Gates Foundation provided support to launch a project titled *Creating the second Green Revolution by supercharging photosynthesis: C_4 rice.*

Screening for C_4-ness in wild rice

Wild relatives of rice have been screened for C_4 traits, covering 3,500 accessions of wild species of *Oryza* and a dozen or so species from related genera. One of the important traits examined was the ability of the wild relatives of rice to use CO_2 efficiently and turn it into sugars and eventually yield. The lower the value of this compensation point (closer to zero), the more efficient the plant is, as in the case of C_4 plants. C_3 plants need to take in more than 50 ppm of CO_2 to start growth, whereas C_4 plants can cope with below 10 ppm. The C_4 Project found that the lowest compensation point in the pool of wild relatives of rice was from an accession of *O. nivara* (41 ppm). Accessions of interest will be examined more closely to eliminate random extreme examples.

In addition to measurements of photosynthetic parameters, traits related to leaf anatomy for the arrangement of photosynthetic cells in the leaf are distinct between C_3 and C_4 plants. Protocols for the gold-standard measurement of these parameters for C_3 and C_4 plants were developed from a field experiment using best crop management practices. The genotypes used were BTx623 and B73, for sorghum and maize (C_4), respectively. IR72 was the standard genotype for rice (C_3).

The measured value of CO_2 compensation point for IR72 was 50 ppm, while those of sorghum and maize were close to zero, typical of C_3 and C_4 plants. Measurements of vein density of maize and sorghum using a portable microscope showed that these two had more veins in a unit area of leaf (9–10 veins per mm), whereas rice had a lower density (5 veins per mm). Consequently, there were two mesophyll cells between veins for maize and sorghum, but seven to eight cells in IR72, both values typical of C_4 and C_3 plants, respectively.

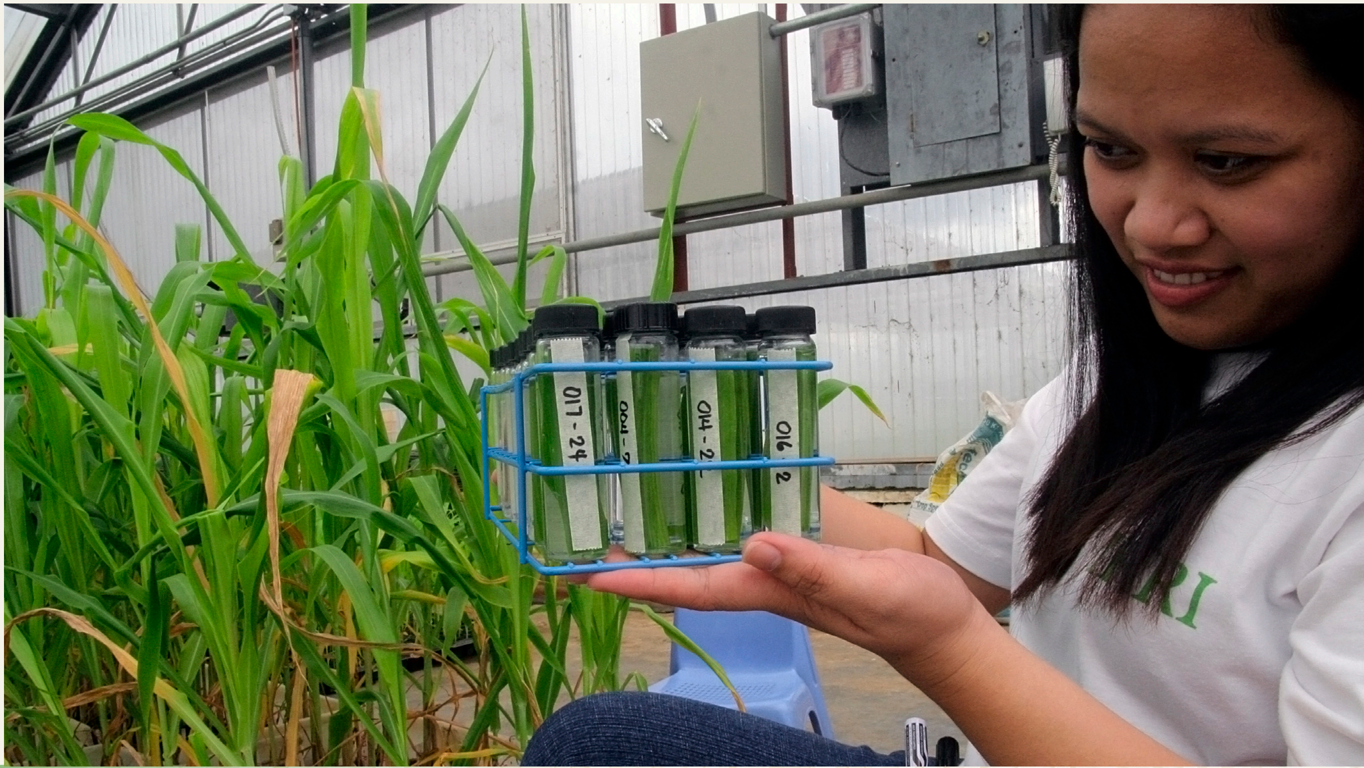
A search for revertants

The evolution of the C_4 pathway occurred independently at least 45 times in angiosperms, which suggests that the transition from C_3 to C_4 could be relatively simple in nature. Many studies support the idea that C_4 plants evolved from C_3 plants in response to environmental pressure by creating changes in the biochemical and anatomical aspects of photosynthesis.

The C_4 Project started to explore mutants of maize and sorghum to look for alterations in parameters related to C_4 photosynthesis, such as vein density and CO_2 compensation point. Reliable and high-throughput screening technologies were developed to identify the phenotypes that could be used as platforms of discovery for C_4 characteristics in rice.

Approximately 38,000 maize mutant plants were screened for changes in vein density from high (9–10 veins per mm) to low (5 veins per mm). There were initially 29 candidate maize mutants with a count of 7 veins or lower per mm. However, this change in vein density was due to the veins becoming larger rather than increasing number of cells between veins. None of the mutants showed changes in the CO_2 compensation point despite having variations in growth rate and morphological phenotypes.

For sorghum mutants, some candidates showed significantly changed vein density from high to intermediate and also had alterations in leaf cell structure. These early results support the potential of screening a large mutant collection to identify phenotypes relevant for C_3-C_4 transition.



High-throughput screening

Screening chambers were built to look for mutants or revertants that could grow at very low CO_2 and hence have a low CO_2 compensation point. Any plants that grow well at low CO_2 will have a functional C_4 pathway; those that do not grow well may be compromised in their C_4 metabolism and are possible C_4 revertants. These plants are then integrated into the analysis of leaf anatomy, gene expression, and biochemistry. Moreover, this work highlighted the need for special environments to be developed that would allow the survival of mutant plants.

Prototypes of different airtight growth chambers were designed and built. One type of chamber had a mechanism that could bring the CO_2 concentration down to as low as 8–10 ppm.

Rice, sorghum, and maize were enclosed together in the airtight chambers, competing for CO_2; within a few days, the rice plants died. The compensation point of C_4 plants is lower than that of C_3 plants. C_4 revertant plants would not survive at this low CO_2 concentration and hence another type of chamber had a mechanism to deliver high CO_2 concentration (1,500 ppm) to allow the survival of these plants (a plant hospital) and the generation of seed for future experiments. So, when a collection of C_4 mutants is enclosed in this low-CO_2 airtight chamber, any C_3 revertants should begin to die and can then be rescued for further investigation. This is an important achievement because this is a faster way of determining which plants have altered their photosynthetic capacities. A system that can generate a lot of revertants in the fastest way is now in place, and this will serve as a platform for the other members of the C_4 Rice Consortium to further investigate other aspects of C_4-ness.

The exploratory work using different growing media in a chamber and various growing conditions for seedlings showed that well-puddled soil that was allowed to stand for a week was best to correct nutritional deficiencies at the seedling stage. Since plants were observed for photosynthetic and leaf anatomy parameters at a very young stage (5-leaf stage), it was important that the plants were very healthy, green, and devoid of pest injury. Iron deficiency, which leads to leaves turning pale, was the main challenge, but was corrected by using the puddled-soil approach.

Unraveling genes for P-deficiency tolerance

Phosphorus (P) deficiency due to low soil P concentration or P fixation in certain soils is a widespread problem that limits crop growth and yield. P deficiency can aggravate the negative effect of drought because a lack of P in plants reduces root growth and thereby limits access to water.

Often, adding phosphorus is not an option for resource-poor farmers as it is too expensive for them. To help farmers cope with this problem, rice scientists have been looking for an affordable way for rice to efficiently absorb phosphorus in P-deficient soils.

Fortunately, more than 10 years ago, they found an answer through a major quantitative trait locus (or QTL, a genomic region), *Phosphate uptake 1 (Pup1)*, which confers tolerance of P deficiency. Matthias Wissuwa, a crop physiologist, now at the Japan International Research Center for Agricultural Sciences (JIRCAS), identified the *Pup1* locus by screening 30 rice varieties in a P-deficient field in Japan. Later on, using the tolerant Kasalath, an aus-type variety, and the intolerant japonica variety Nipponbare as parents, he developed near-isogenic lines (NILs). NILs are lines that are genetically similar (about 95% identical), but are distinct by the presence or absence of the QTL region. This allows testing of the effects of the QTL since phenotypic differences between the contrasting lines can be attributed to the genes present in the QTL.

But, despite efforts to understand what makes a plant tolerant of P deficiency, scientists were not able to observe expected responses that plants commonly show under P-limiting growth conditions, such as exudation of organic acids, and longer roots and root hairs, when they analyzed the *Pup1* NILs.

Sigrid Heuer, an IRRI molecular biologist, spearheaded further investigation on *Pup1*. Through the Nipponbare genomic sequence, researchers assessed the genes in the *Pup1* corresponding genomic region on rice chromosome 9, but still, none of these genes were obviously related to P uptake. They then considered that novel or different tolerance genes might be present in the *Pup1* genomic region in the tolerant variety Kasalath. So, the *Pup1* locus was sequenced in Kasalath in collaboration with JIRCAS and the National Institute of Agrobiological Sciences (NIAS) in Japan. Indeed, comparing the sequence of the *Pup1* genomic region between Nipponbare and Kasalath revealed major differences in overall size as well in the number of genes. The *Pup1* region of tolerant Kasalath is more than double the size of the *Pup1* region of intolerant variety Nipponbare.

Within both loci are more than 50% transposable elements (mobile genetic elements that can "jump" between chromosomes). These "jumping genes" are responsible for major rearrangements, truncation (mutation of genes), and insertion or deletion of genes (Fig. 1a).

At first, Dr. Heuer and her team predicted 68 putative Kasalath *Pup1* genes; however, after detailed validation of these putative *Pup1* genes, the number of candidate genes dropped to six.

As with the earlier data, none of these genes can be directly associated with P uptake. By this time, Dr. Heuer concluded that the *Pup1* major QTL might confer tolerance by an unknown mechanism or a regulatory protein (one controlling the expression of other genes or the activity of other proteins).

Then, in 2008, the group discovered *OsPupK46*, a protein kinase gene, and *OsPupK20*, a dirigent gene. Dirigent genes are responsible for producing lignin and/or lignans (also known as plant-defense molecules). As part of the cell wall, lignin is involved in making the plant structure rigid, strong, and resistant.

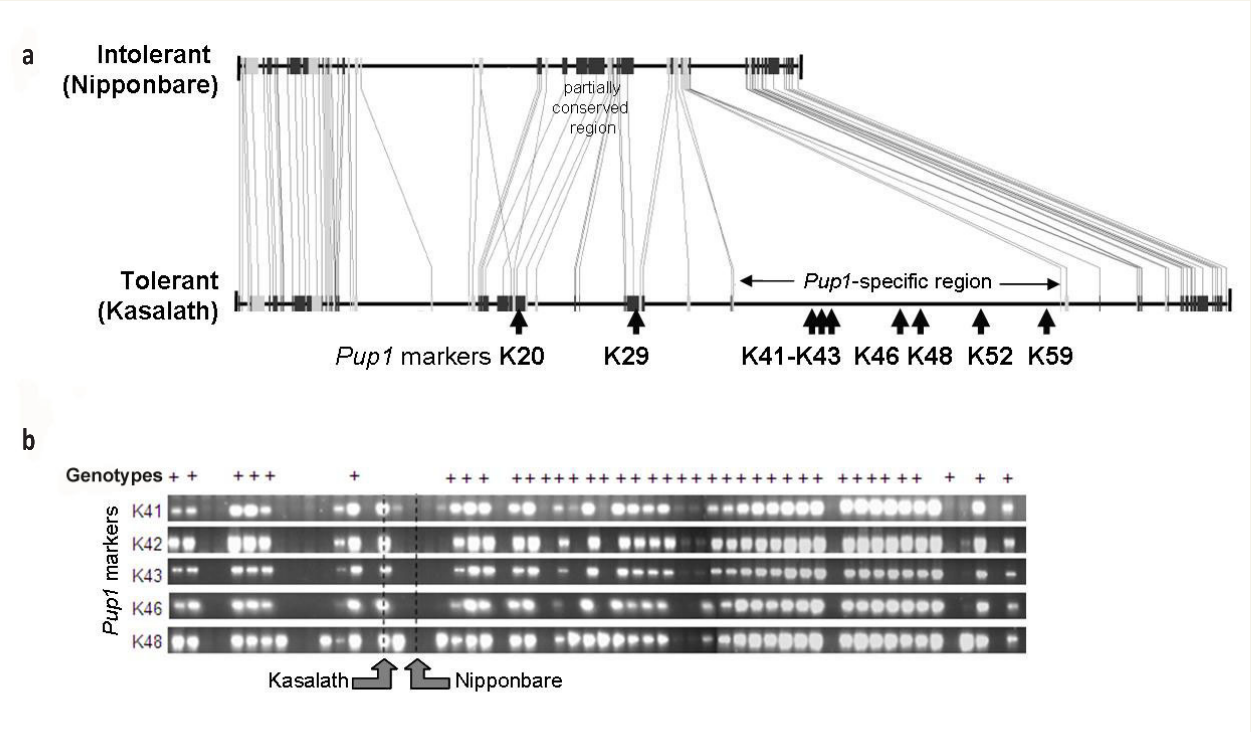


Fig. 1. Alignment of the *Pup1* genomic sequence and gene-based markers.

(a) *Pup1*-specific markers were developed based on sequence information on genes that are partially conserved in the Nipponbare reference genome (K20, K29), and genes that are specific to the *Pup1* region as present in the tolerant donor variety Kasalath (K41-K59). Testing these markers in diverse rice genotypes (b) confirmed their diagnostic value and revealed that *Pup1* is present in most drought-tolerant accessions (+), suggesting that breeders have unknowingly selected for Pup1.

The finding that the *OsPupK20* gene sequence differs between tolerant and intolerant rice genotypes provided further evidence that this gene is an interesting candidate. Since roots are an important part of the plant in the absorption of water and nutrients, scientists are now analyzing the role of *OsPupK20* and lignin in the roots in response to P deficiency and drought stress.

According to Dr. Heuer, *OsPupK20* might be directly involved in a tolerance mechanism by altering the cell wall properties in roots under stress. On the other hand, the protein kinase gene, *OsPupK46,* might be important for P signaling and signal transduction. It is possible that *OsPupK46* signals that P is lacking or available and then communicates this to the plant, triggering processes that help to take up more P or to adjust to low-P conditions.

Protein kinases use inorganic phosphate, which they transfer to other proteins. Protein kinases are also known to play important roles in many stress-response pathways. They are central to the P-starvation response in yeast, and putative phosphorylation sites are present in high-affinity rice P transporters, which are proteins located in the cell membrane that are responsible for transferring P from the soil into the root. The team is now working on identifying the processes regulated by *OsPupK46* and its target proteins.

In addition to assessing *Pup1* genes, Dr. Heuer and her team were able to develop molecular markers to facilitate the breeding of *Pup1* rice varieties through marker-assisted backcrossing. When these markers were tested in more than 150 diverse rice breeding lines, the specificity of the *Pup1* markers was confirmed (Fig. 1b).

The team also discovered that *Pup1* can be found in rice grown in unfavorable rainfed environments but is absent from most modern irrigated varieties

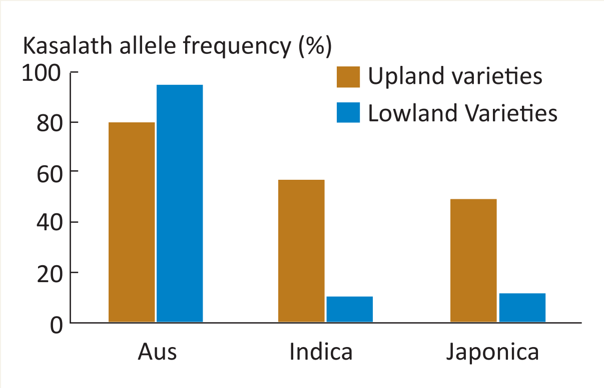


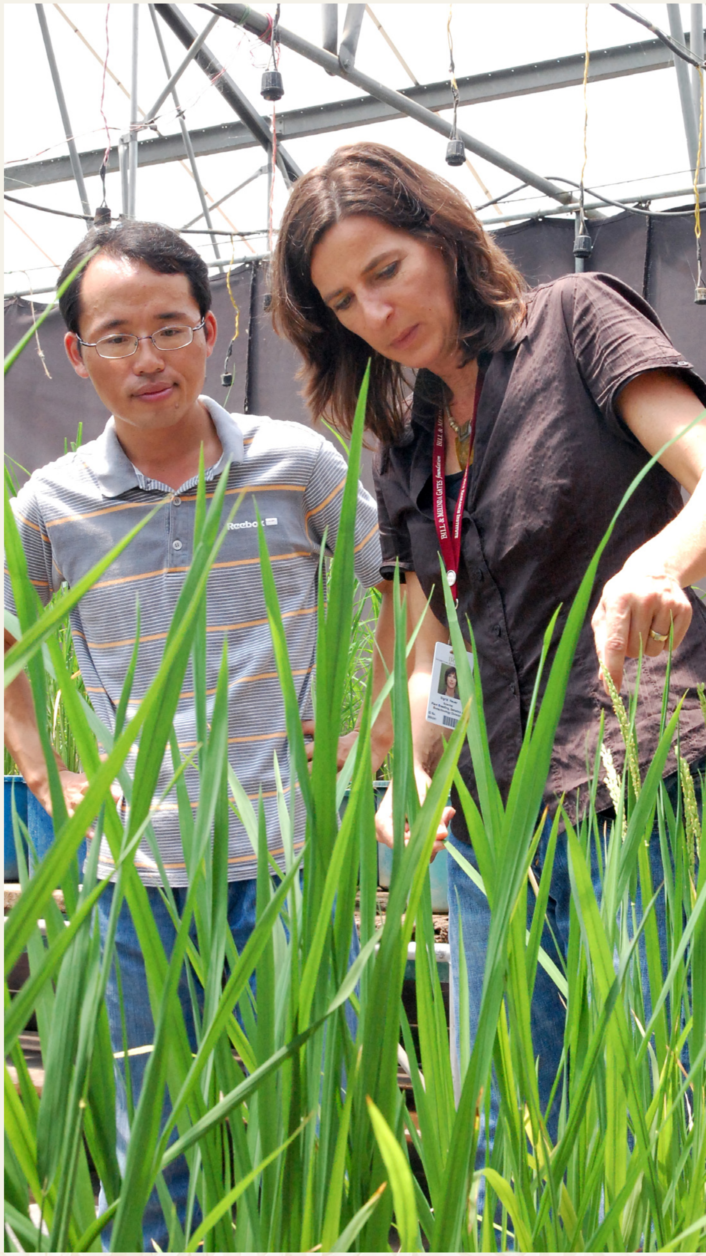
Fig. 2. Representation of the *Pup1* locus in diverse rice genotypes. A molecular marker survey showed that the *Pup1* QTL is conserved in most aus-type varieties, regardless of cropping system. In indica and japonica genotypes, *Pup1* is conserved in about 50% of the accessions developed for rainfed environments, in contrast to only about 10% of accessions grown in irrigated/lowland environments.

(Fig. 2). In fact, *Pup1* is conserved in more than 80% of the drought-tolerant breeding lines that were analyzed, suggesting that breeders have unknowingly selected for *Pup1*. With the *Pup1* markers now available, breeders can make sure that *Pup1* is present in their breeding materials by a simple test in the laboratory.

Working with the Institute of Agricultural Biotechnology and Genetic Resources Research and Development (Indonesia), *Pup1* will be introgressed into three modern Indonesian upland varieties, Situ Bagendit, Batur, and Dodokan, which will be evaluated at two sites in Indonesia, (Jasinga, West Java and Lampung, Sumatra), in 2009.

At IRRI, *Pup1* is being introgressed into two irrigated varieties (IR64 and IR74) and seeds will be available for field testing in 2010.

The unraveling of the genetic basis of tolerance, along with the application of molecular marker technology, will help to efficiently incorporate these genes into rice cultivars providing farmers as an affordable solution to P-deficient lands.



INGER makes a small, small world

Here is a fine example of countries opening up their coffers to help one another, except that the coffers contain valuable seeds instead of the usual cash.

The development of new rice varieties that yield better and thrive amid harsh environments or pestilence would not have been possible without countries opening up their respective rice germplasm “reserves” to international exchange through INGER, or the International Network for Genetic Evaluation of Rice. In fact, roughly 60% of all modern rice varieties released since 1975 can be traced back directly or indirectly to this network that has 39 countries as regular participants.

But good things do not always run smoothly. Despite INGER’s early success, it had to grapple with serious challenges that threatened its position as the longest-lasting global network for multilateral germplasm exchange in the Consultative Group on International Agricultural Research (CGIAR). In the early 1990s, INGER operations began downsizing because of a reduction in and eventual withdrawal of traditional donor support. By the mid-1990s, INGER activities had to be supported by IRRI's unrestricted funds. At the turn of the century, the network had to contend with the unwanted effects on germplasm exchange of international agreements and national legislation entered into or enacted by INGER-participating countries.

All of this jointly contributed to declining participation of national agricultural research and extension system (NARES) scientists in INGER activities. In 2004, only three countries sent in entries to INGER for evaluation; in 2005, contributions of breeding material from traditional providers dried up. This declining trend was recognized in recent successive External Program and Management Reviews of IRRI, setting the stage for the revitalization of INGER.

INGER bounced back quickly. Things went so well that, 2 years after its operations began to flourish again, in 2008, the INGER team at IRRI received the CGIAR Science Award for Outstanding Scientific Support Team. These were the fruits of a redesigning of INGER that involved streamlining and multifaceted modernization of its operations. Under a new framework, INGER continued to build strength around its three anchors—scientists, breeding materials, and information—and exploited advances in biotechnology and information chnology.

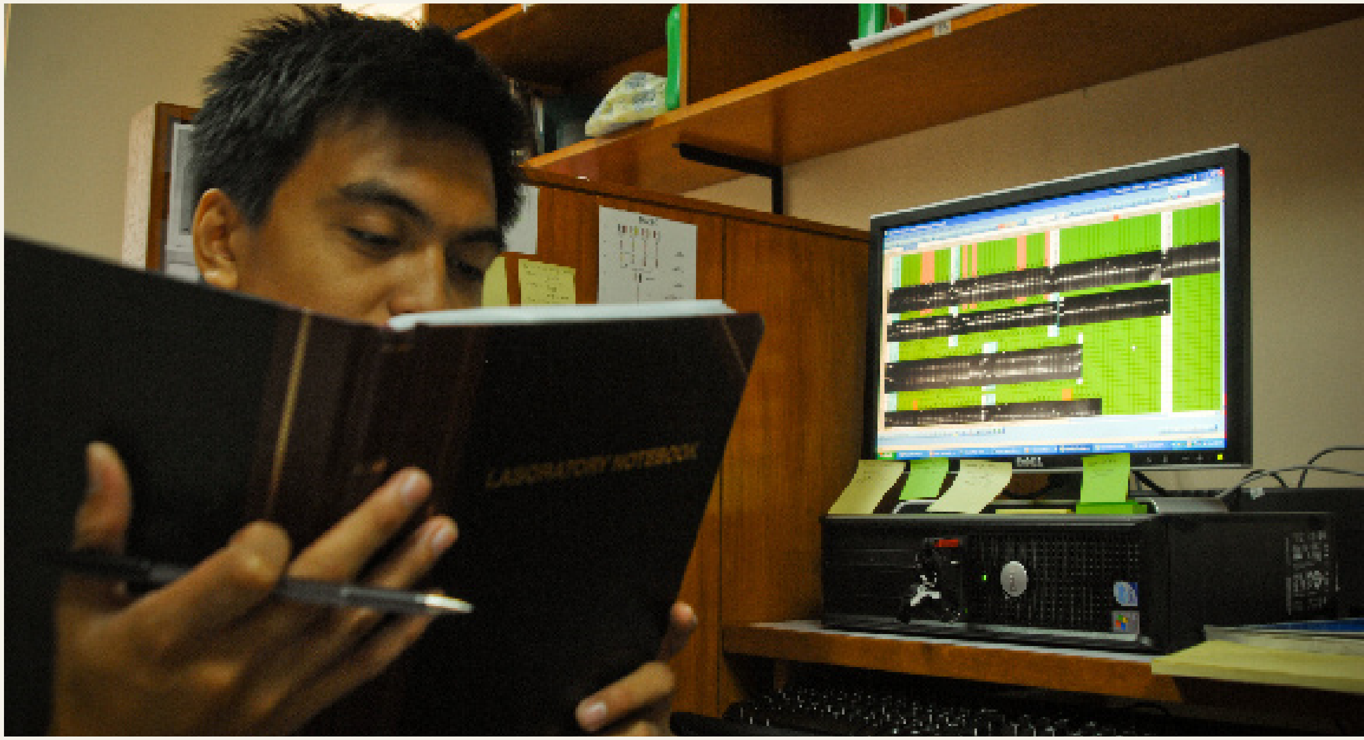
A timely convergence of new ideas and funding from new donors gave way to innovations that eventually led to INGER’s revitalization.

DNA barcoding of entries

This started in 2007 on outstanding INGER entries from the NARES. All new breeding materials submitted by NARES breeding programs were routinely DNA "fingerprinted" by 2008. The DNA barcodes for the entries became publicly accessible via the INGER Web site. The hope was that this move would aid intellectual property (IP) protection and build confidence among NARES scientists concerned over IP misappropriation. Online publication of all master seed lists, including grain quality profiles of entries and results of genetic diversity analyses based on the DNA barcodes, added even more value to seeds distributed by the network.

New Web site

To facilitate information access and maximize information sharing and interaction among collaborators, INGER developed a new Web site in 2007 using the latest Web 2.0 technology. The site published, among others, a list of available nurseries and breeding materials for distribution, a directory of collaborating institutions and scientists, information and links on procedures and documents involved in seed movement across countries, and relevant news. Through this medium, cooperators could navigate through the sometimes complex processes of germplasm exchange solely online; hence, the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) Secretariat considered this as a possible model for a global online germplasm ordering system in 2008. Moreover, the easy, cheap, and fast communication made possible by the site was expected to help open up new channels for collaboration while strengthening those already in place.



Rapid reporting turnaround time

The turnaround time from data generation to analysis and reporting used to take up to 4 years—so long that whatever value the data might have had for breeders would already have diminished by the time the reports were published and, hence, be of no use in the kind of dynamic decision-making process that is needed for running an efficient breeding program. With INGER's Web-aided data submission system and sustained follow-up efforts, data return increased to almost the same high levels experienced by the network in the 1980s and all reporting backlogs were eliminated by 2008, with all nursery reports published in print, electronically, and online.

Training for the next generation of breeders

International exchange of rice genetic material through INGER would not be as successful without strong and steady ground support. The capacity of NARES scientists, particularly breeders, had to be developed and strengthened. The *Rice Breeding Course (RBC): Laying the Foundation for the Second Green Revolution*, which INGER coordinated, has greatly enhanced the capacity of NARES scientists to become adept in the use of both conventional and modern tools and techniques to increase the precision and impact of their breeding programs. The course has also provided a rare opportunity for young scientists to interact and develop potentially lifelong working and personal relationships that are facilitative—in fact, almost a prerequisite—for unhampered sharing of germplasm and information

multilaterally, as envisioned under both INGER and the ITPGRFA. Some 70 NARES scientists in three batches had taken the RBC since INGER started offering the course in 2007.

Increased NARES participation

NARES participation is at the core of INGER's essence and identity. Half of the 60% of the varieties released worldwide since 1975 that are traceable to INGER are products of INGER-facilitated NARES to NARES germplasm exchanges (the other half being exchanges between international agricultural research centers, [IARCs], and NARES). The initiatives set in motion beginning in 2006 have rekindled NARES participation in the network, in terms of both seed requests and entry submissions. Up to 177 new breeding lines from 15 countries were nominated to INGER nurseries in 2008, a threefold increase since 2005, while other IARCs (CIAT and the Africa Rice Center) nominated 878 breeding lines the same year.

Clearly, the benefits of participation in INGER are universal. Participant countries—whether having strong or weak breeding programs, diverse or limited plant genetic resources, large or small rice-growing areas, rich or poor rice farmers; or whether they are major or minor rice producers, rice importers or exporters, or party or nonparty to the ITPGRFA—have all gained immensely from active participation in the network. These benefits have transcended geographic, political, religious, economic, and social boundaries. The revitalization of INGER can therefore be expected to result in even more benefits by reinvigorating the rice varietal development process. This is, indeed, an important and timely development for tackling new challenges, such as those posed by the recent food crisis and the projected climate change.

Creating super aromatic rice

The aroma of rice is an important trait because it determines the market price and indicates a clear local and national identity. For example, many different varieties of Jasmine rice are consumed in Southeast Asian countries while many types of Basmati rice are consumed in South and Central Asian countries. Consumers can easily differentiate the flavor and aroma of these two types of rice, even though the major aromatic component in both types is 2-acetyl-1-pyrroline (2AP).

Recently, developments in genetics and biochemistry revealed how 2AP is synthesized. Some scientists explained that, in almost every fragrant variety, 2AP accumulates because of a mutation in the gene betaine aldehyde dehydrogenase 2 (*BADH2*) (Chen et al 2008).

In 2008, Melissa Fitzgerald, head of the Grain Quality, Nutrition, and Postharvest Center at IRRI, identified a number of traditional varieties of rice that contained 2AP, but they did not have a mutation in the *BADH2* gene. In collaboration with Cornell University, researchers found another nine mutations in the coding region of the gene that resulted in aroma.

Both the location and the nature of the mutation (single nucleotide polymorphisms, (SNPs), insertion or deletion) are associated with the amount of 2AP that the grain accumulates. These mutations can be found in all germplasm classes of domesticated rice, and the different mutations cluster by geographic origin of the rice, suggesting that the *BADH2* gene mutated many times during the domestication of rice. Interestingly, the fragrance gene seems to have been introgressed into indica germplasm from japonica germplasm during domestication. *BADH2* is thought to oxidize 4-aminobutyraldehyde, produced from putrescine, to gamma-amino butyric acid (GABA). In varieties that have a mutation in *BADH2*, a nonfunctional copy of the gene, this oxidation step to GABA cannot be carried out, and they accumulate both 4-aminobutyraldehyde and delta-1-pyrroline; this is proposed to activate the pathway of 2AP synthesis (Bradbury et al 2008).

The role of *BADH2* has been confirmed biologically. When it is expressed in *E. coli*, *BADH2* shows a greater affinity for 4-aminobutyraldehyde than for betaine aldehyde, and it is capable of

oxidizing 4-aminobutyraldehyde to GABA. In *Bacillus ceres*, delta-1-pyrroline, a precursor of 2AP, is the cyclic form of, and exists in spontaneous equilibrium with, 4-aminobutyraldehyde (Chen et al 2008). Thus, scientists conclude that *BADH2* participates in the pathway of GABA synthesis by oxidizing 4-aminobutyraldehyde, produced from putrescine, to GABA.

In 2008, Dr. Fitzgerald discovered that a number of varieties accumulate 2AP even though they do not carry the deletion on exon 2 or 7 of *BADH2*, or any of the other deletions identified so far. Therefore, it is suspected that there must be another fragrance gene. IRRI has already created mapping populations to locate the second fragrance gene, and will hunt for the second gene in collaboration with Cornell University. Dr. Fitzgerald's suspicion is founded in science—she has been able to produce doubly aromatic lines from crosses between parents with each gene. The new genes will be detected by using a SNP mapping coupled with metabolomic profiling. Metabolomics is a science representing the detection, identification, and quantification of small chemicals and compounds (see *Illuminating the gap* on pages 38 to 39 of *Rice Today* Vol. 7, No. 2).

With these developments, the full genetic and biochemical stories of 2AP synthesis will be fully written. Most of all, a rice variety teeming with aroma, which may even be called super aromatic rice, will be developed.

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Characterizing a tungro-resistant cultivar

Yellowed leaves and stunting are bad news for rice farmers. These are classic signs of tungro, one of the most serious diseases of rice in South and Southeast Asia. Panicles form late in tungro-infected plants, and those that form are often short and sterile.

Rice tungro disease (RTD) is caused by rice tungro spherical virus (RTSV) and rice tungro bacilliform virus (RTBV)—both of which are transmitted by green leafhoppers (GLH). RTSV acts as a helper virus in transmitting RTBV by GLH. RTSV alone causes only mild stunting but RTBV infection results in both stunting and leaf discoloration. And, when both viruses are present, these symptoms worsen.

RTD is widely distributed in tropical Asia, which makes resistance to RTD an important breeding aim for rice improvement in the region. Resistance to GLH was the method initially used to control RTD. Most GLH-resistant varieties, however, were not resilient enough for continued use in the field. Although there are dozens of germplasm sources resistant to RTSV, sources are limited for the control of RTBV.

An Indonesian cultivar, called Utri Merah, was found to be highly resistant to RTSV and tolerant of RTBV. In several field trials, advanced breeding lines derived from Utri Merah consistently showed low infection rates from both viruses.

RTBV infects Utri Merah, too, but the virus does not accumulate in the cultivar as much as it does in susceptible cultivars. Comparing resistance to RTD among near-isogenic lines derived from Utri Merah, scientists found that resistance involved suppression of the interaction of the two viruses in order to prevent symptoms from worsening.

The characterization of Utri Merah is one facet of the work of IRRI scientists on tungro; the other is identifying an RTSV resistance gene. A genome region was mapped and mutations of one of the genes in the region seem to be responsible for the resistance to RTSV in Utri Merah. Such gene mutations were also found in other indica and japonica rice cultivars resistant to RTSV. Genetic information on resistance to tungro viruses is expected to facilitate the development of RTD-resistant varieties in Asian countries.

The OryzaSNP project: diving deep into the rice gene pool

Understanding the rice genome so that genomic information can be readily applied to gene discovery and allele mining is a crucial forward-looking activity. This opens up rich information in rice that will help improve the crop, feed more people, and alleviate poverty worldwide.

Hence, IRRI undertook the OryzaSNP project in cultivated Asian rice, *Oryza sativa,* to discover genetic variation in the form of single nucleotide polymorphisms (SNPs). SNPs allow scientists to determine genetic differences that could be linked to traits. Identifying these differences in SNPs among major rice varieties may help uncover the genetic basis behind important agricultural traits.

Variations in SNPs may mark the difference in important traits in rice such as tolerance of different stresses such as drought, salinity, and flooding, and resistance to pests and diseases. Moreover, they could also spell the difference in desirable qualities in the crop—early maturity, high-quality grains, and increased yield, among other potential improvements.

The SNP data set discovered in the OryzaSNP project at IRRI is a new genomics tool that can be immediately applied in genetics, genomics, and breeding activities by researchers worldwide. The OryzaSNP project is funded by IRRI, a grant from the Generation Challenge Program, and a grant from the U.S. Department of Agriculture (USDA) program for Cooperative State Research, Education, and Extension Service. Moreover, collaborators from across the world contributed their time, expertise, and money in analyzing and interpreting the data sets.

Twenty rice varieties were chosen to understand their genome makeup by identifying and comparing the differences among their DNA sequences. The selected varieties span the deep genetic diversity of cultivated rice, including landraces, modern varieties, and improved donors from the temperate and tropical japonicas, aromatic, aus, deepwater (Aswina/Rayada), and indica types of rice. The lines included Nipponbare as a reference since a high-quality complete genome sequence was available from the International Rice Genome Sequencing Project (IRGSP). The other lines consisted of Tainung

DNA attached to silicon wafers). These arrays allowed the sequence variation of more than 100 Mbp (1×10^8 nucleotides per strand) to be interrogated for both DNA strands of the genome sequence. The 100-Mbp fraction of the rice genome was chosen from the gene-rich, nonrepetitive regions of Nipponbare using a methodology from McGill University that had been used in the annotation of Nipponbare by the IRGSP. With the exception of those areas absent from the IRGSP pesudomolecules, the areas interrogated on the arrays evenly covered the genome. Perlegen optimized the production of target DNA by long-range–polymerase chain reactions (LR-PCR) and performed labeling and hybridization. They applied their "model-based" algorithmic tools to predict a set of around 250,000 SNPs based on the "hybridization signatures" of a probe and its neighbors. Subsequently, IRRI scientists worked with teams in Germany to adapt and apply "machine learning" prediction methods to define a set of 326,000 additional SNPs. In total, more than 420,000 SNPs were predicted by both methods and about 160,000 of these were in common, and hence of highest quality.

Analyses of the OryzaSNP data have offered new insights about how rice diversity is distributed as well

67, Li-Jiang-Xin-Tuan-Hei-Gu, M202, Azucena, Moroberekan, Cypress, Dom-sufid, N22, Dular, Rayada, Aswina, Zhenshan 97B, Pokkali, Swarna, IR64-21, Shan-Huang Zhan 2, Sadu-cho, and Minghui 63.

These lines were purified via single seed descent and multiplied prior to preparing high-quality genomic DNA. SNP discovery through hybridization-based re-sequencing, a technology previously proven effective in human, mouse, and *Arabidopsis* genomes, was done at Perlegen using very high-density arrays of oligonucleotides (short single-stranded probes of as glimpses of rice breeding history (McNally et al 2009. Proc. Natl. Acad. Sci. USA 106:12273-12278):

1. Population and phylogenetic structure determination in which three main groups—japonica, aus, and indica—were supported. For example, the deepwater types grouped either with aus (Rayada) or with indica (Aswina). Other molecular data sets also support this observation.
2. The extent of linkage disequilibrium (LD, a measure indicating the extent of recombinations occurring in rice since its domestication and dispersal, and defining blocks that are more or less prone to recombination). LD was found to be highest in japonica (about 500 kb in length) and lowest in indica (about 200 kb) in this sample of germplasm. These values agree with some published estimates, but may be biased since temperate japonicas were overrepresented relative to the diversity within other types.
3. Introgressions from modern (human) or historical events were observed where blocks of SNPs have been incorporated from one type of rice into another, even though they are geographically isolated today. For example,
   a. Cypress and M202, japonica types from the U.S., contain blocks of indica SNPs on chromosome 1. These blocks overlap at the position where the semidwarf gene, *sd1*, is located. Both Cypress and M202 contain IR8 in their pedigrees.
   b. Pokkali from western India contains a large region of aus-type SNPs, whereas aus types originate from Bangladesh and eastern India. This region overlaps with the major QTL, *Saltol*, for salinity tolerance.
4. Regions of introgressions shared between three or more genomes are not randomly distributed and tend to cluster together. These clusters comprise about 9% of the total genome and are highly correlated to genes/QTLs for domestication-related functions such as yield and grain quality.
5. Pairwise comparisons among all combinations of the 20 genomes indicated a large block on chromosome 5, where most indica (except Pokkali) and all japonica share the same patterns. Pokkali and the aus types are different for this region.

The OryzaSNP data set is the largest collection of SNP data for rice to date. Many projects worldwide and at IRRI are already using the data in their experiments. This extensive collection of SNP data is the first step for developing high-density genotyping platforms to investigate rice diversity, evolution, population genetics, and gene-phenotype relationships. One of IRRI's key objectives is to enable genome-wide association studies in rice, as is now routine in human genetics. Having SNP data is also advantageous because the bi-allelic nature of SNPs (one base is substituted for another of the same class more than 97% of the time) means that more convenient sets of marker systems can be implemented for marker-assisted breeding programs. The 20 OryzaSNP lines are also being used to generate a series of recombinant inbred line populations for detailed functional genomics studies. These populations will be useful for validating gene-phenotype relationships predicted by association genetics studies.

Information and communication: convening a global rice research community

Noel Magor
Leader, Program 6

IRRI, through Program 6 initiatives, has continued to convene communities of researchers and extension workers who face real problems and challenges in rice research and development. Moreover, through these initiatives, IRRI is building a critical mass that will represent the next generation of rice scientists.

Crop science information resources

In 2008, we made significant progress in organizing the IRRI Web portal component relating to germplasm, the so-called "Seeds" portal covering genetic resources (T.T. Chang Genetic Resources Center or GRC), evaluation (International Network for the Genetic Evaluation of Rice or INGER), and crop improvement (Plant Breeding, Genetics, and Biotechnology), including the "next-generation" Web interface for the International Rice Information System (IRIS), based on Generation Challenge Program (GCP) and International Crop Information System (ICIS) technology.

This included significant progress on the prototyping of a Web application that allows users to order seeds from INGER nurseries, in a manner consistent with standards set by the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA).

Rice is one of a few model plant organisms whose genome has been fully sequenced. We currently intend to collaborate more closely with CIMMYT-CRIL to establish a comparative (rice, maize, and wheat) genome information catalog focusing mainly on documenting candidate genes related to priority crop traits for (abiotic and biotic) stress response and C_3 versus C_4 photosynthesis. This resource will build on the comparative stress-gene catalog previously funded by the GCP.

The Rice Knowledge Bank

The Rice Knowledge Bank (RKB); (see video clip at left) is now under local management in Bangladesh, Laos, Thailand, Indonesia, Vietnam, and Cambodia. At an annual meeting in Siem Reap, Cambodia, each of these countries reported progress on the development within their country. This showed that local ownership was in place. For Thailand, Vietnam, and Cambodia, a monitoring and evaluation report clearly showed the local ownership.

IRRI with its partners has developed a process for the management of rice knowledge for the Rice Knowledge Bank, which is part of the Cereal Knowledge Bank. This is reflected in IRRI RKB management and country management, which is inclusive of material development, its testing, and its updating.

World rice community on the Web

In general, IRRI made significant progress in organizing and publishing rice digital resources in 2008. In collaboration with Google Books, flickr, and YouTube, access to IRRI-generated information resources (publications and images) increased markedly. This has resulted in large numbers of book page views (1,500,000 in 2008), book downloads (9,469 in 2008), image views (230,000 in 2008), and video views (108,360 since 2007). We need to find mechanisms to stimulate more community curation and feedback.

IRRI used the Web in responding quickly to the rice price crisis that erupted in early 2008. In a background paper, IRRI explained in layman's terms the roots and effects of the crisis. We offered possible solutions such as increasing production by using higher-yielding rice varieties, reducing losses by using new postharvest technologies, and increasing investment in agricultural infrastructure, training, and research.

The "Solutions" Web site, as it came to be called, for awhile, now the Rice policy site, registered 115,703 page views for its first 6 months, or an average of 643 page views a day. Interest in the online World Rice Statistics also spiked during the crisis, thus validating IRRI's reputation as a credible and authoritative source of information on rice.

As a service to the research community, IRRI developed the *Rice Thesaurus*, which is a repository of standard terms used in rice production. This thesaurus, which now has 3,229 terms, seeks to facilitate the search for and retrieval of rice information. The thesaurus uses MultiTes software, making it searchable and publishable on the Web.

With the aid of Google Analytics, we now monitor usage for the almost 6,000 Web pages in the IRRI system. The information gathered has been invaluable. It has enabled us to enhance our communication capability by guiding our work priorities and developing content targeted at our audiences.

The new IRRI Web site breaks from the "old mold" by placing greater emphasis on the Institute's products and services: seeds, know-how, education, etc. The News & Events section has been streamlined and reorganized. Although one can do a key word search across the entire IRRI Web system, a more focused search facility allows users to search for information in different "news channels" such as *Rice Today*, Press Releases, Rice News Worldwide, and IRRI History.

Finally, to help manage its Web resources and achieve consistency in its corporate identity, IRRI shifted from a file-based, proprietary Web system to the free, open-source Joomla content management system. This has also allowed us to tap into a library of free software that is now used in various parts of the Institute's Web site, such as the staff directory, recruitment site , the Events calendar, and, soon, the Employee Orientation site.

Informatics and communication services for science and extension

In 2008, we released IRRI-contributed software technology to the GCP and continued to enhance ICIS software for crop research communities. Progress was made on developing and enhancing ICIS tools for crop information management. Version 5.5 of ICIS was released in July 2008. The facilities in IRIS to manage seed exchange in compliance with the Standard Material Transfer Agreement were improved. Also, we made progress in developing an International Maize Information System (IMIS) genealogy database. A maize pedigree parser was developed by programmers at IRRI and has been deployed to harvest maize pedigrees from the International Maize and Wheat Improvement Center's (CIMMYT) maize Fieldbook application.

In early 2008, we completed an online introductory course for crop bioinformatics. This online course material was a key resource in March 2008 training for IRRI staff. The workshop curriculum is also available online. The project was funded by the GCP.

In 2008, materials on good practices in research data management were developed, with support from the knowledge management program of the Consultative Group on International Agricultural Research. Ten training courses were conducted at IRRI using these materials.

The IRRI Crop Research Informatics Laboratory made use of videoconference and online collaborative technology such as Wikis, CropForge, Webex, and Joomla. Other tools such as Access Grid will be assessed for future use.

Banking our rice knowledge

Generating relevant and useful research solutions to agricultural problems is only half way to improving farm productivity and sustainability, and helping raise farmers out of poverty. These solutions need to get to farmers, who, in turn, learn and adopt them to realize their full potential benefit.

Extending rice research

In 2002, the International Rice Research Institute (IRRI) discovered that, while it had vast amounts of valuable rice-farming knowledge, the information was not really accessible to the wider extension community of government and nongovernment organizations, universities, and the private sector. To bridge this gap, the Institute formed the Rice Knowledge Bank (RKB), which brought together all of IRRI's current validated rice-farming knowledge relevant to the extension community, and made it available in a one-stop shop on the Internet and on CD.

The RKB covers the whole seed-to-market cycle of rice production that includes seeds, land preparation and crop establishment, water management, integrated nutrient management, integrated pest management, harvesting and threshing, drying, storage, milling, processing, and economics and marketing.

Moreover, the RKB presents information in the form of fact sheets, which can easily be printed out. It also prepares online training courses designed with nonscientists in mind, to ensure effective communication with users.

Aside from providing practical information on rice, the RKB also offers information that aims to build the skills of extension workers and help them improve their capacity to teach farmers.

Noel Magor, head of IRRI's Training Center and one of the leaders in developing the RKB, explains that the RKB complements the suite of face-to-face and online/CD training programs that IRRI runs for extension officers.

"We train extension officers and others worldwide to teach them the latest best practices in a range of rice-related topics," Dr. Magor said. "When these people head back to their home countries and start providing training and information to rice farmers, they can draw upon the resources of the Rice Knowledge Bank to support them.

"This is the real power of the Rice Knowledge Bank—helping provide information to rice farmers through established local extension mechanisms and information delivery routes," he added.

Getting local

Stage one of the RKB focuses on providing information exclusively generated from IRRI research. Although considered high-quality, current, and scientifically credible, IRRI's research is recognized as only part of a bigger picture, because two important ingredients are included: national research results and indigenous knowledge.

In 2005, IRRI started to work with its partners in the national agricultural research and extension systems (NARES) and planned country-based versions of the RKB to complement the overarching IRRI research component.

This effort has since culminated in the launching of the country-based RKBs for all the major rice-growing countries such as Nepal, Sri Lanka, Bangladesh, Myanmar, Thailand, Lao PDR, Cambodia, Vietnam, China, the Philippines, and Indonesia. The team has also started to apply the RKB concept in India. Each national RKB is translated into the country's respective language, and is developed and managed by the pertinent local authority to include validated information that is locally relevant and owned.

For example, the Bangladesh Rice Knowledge Bank (BRKB) was established in 2004. Since then, 76 government and nongovernment extension providers have been trained how to use it, 3,860 participants in 95 rice production training courses have been informed about it, 900 CDs have been distributed, and more than 20,000 people have visited the BRKB Web site.

"The Bangladesh Rice Knowledge Bank is a one-stop repository of rice information including a training module, rice production handbook, and flip charts," said Dr. Jahirul Islam, chief scientific officer and head of the Training Division at the Bangladesh Rice Research Institute.

"It is well accepted and used by the rice community as it is reader-friendly," he added. "The government is also planning to use it through telecenters at the farm level, to improve the country's rice production. The Bangladesh Rice Knowledge Bank is a cost-effective new route toward food security."

The impact

More than just a Web site or CD, the RKB is a gateway to information and resources to help improve the knowledge and capacity of extension officers, who, in turn, can tailor the delivery of information to their local farming communities. National RKBs have also greatly improved the use of national research, making the best knowledge readily available to the extension community.

In Thailand, an evaluation of the RKB has shown that extension officers saved, on average, about US$2,500 a year each when they used the RKB. This is based on the time they saved searching for information and revisiting farmers, and on the costs they saved on photocopying. More importantly, Thai farmers who used the RKB had fewer costs and higher revenue. They had a total net income of $60 per hectare more than non-RKB users.

The evaluation also gave suggestions on how to increase the use of RKB information, including encouraging farmers to participate in RKB meetings and improving the general knowledge of farmers about computers. This feedback will be used to further improve the extension of the RKB program.

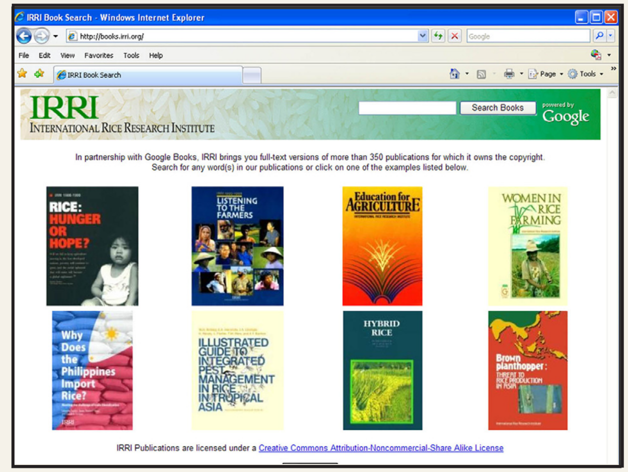
In Vietnam, farmers, extension practitioners, and other users appreciate the Vietnam RKB because, for the first time, they have a bank of comprehensive, up-to-date, and easily understood rice knowledge, which was previously scattered across various sources. With the Vietnam RKB available online, extension staff can access and select the updated information from their RKB to develop training materials and handouts for their work. More than 500,000 people accessed the Vietnam RKB online in its first 4 months of operation. Where the Internet is unavailable, users can access the Vietnam RKB by using CDs that are reproduced for distribution.

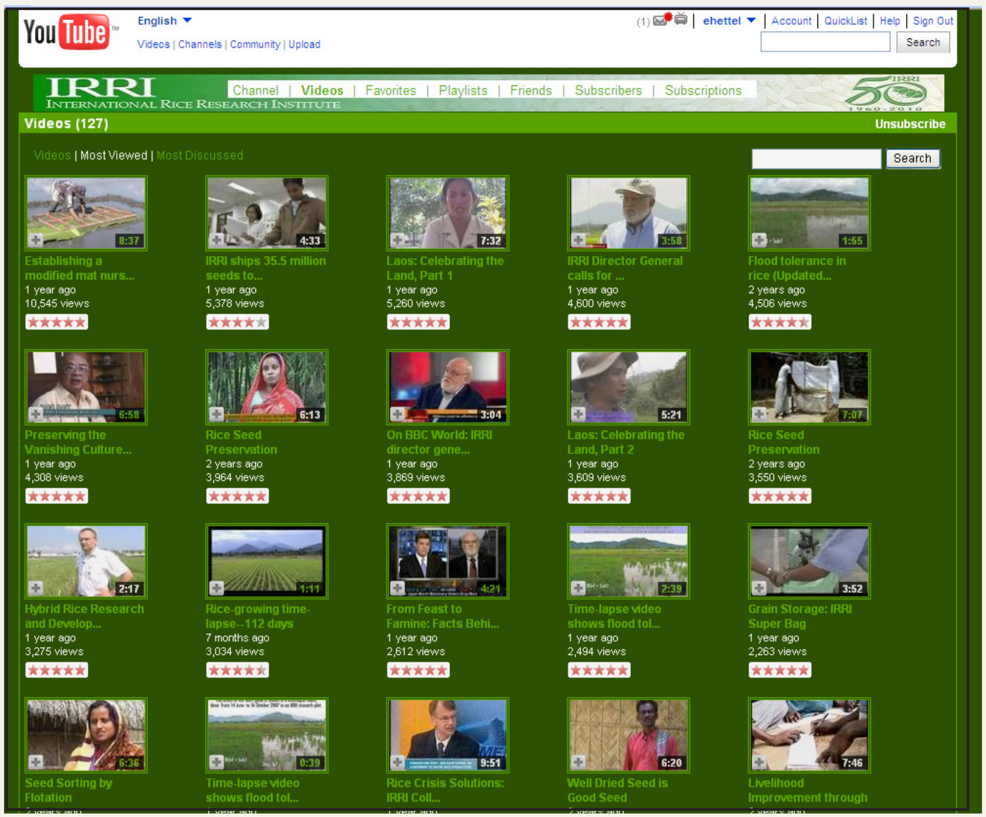
Furthermore, the Cambodian RKB was officially launched by the Ministry of Agriculture, Forestry, and Fisheries. The event was followed by training activities in 15 target provinces. According to Mr. Ty Channa, head of the Training and Information Center at the Cambodian Agricultural Research and Development Institute (CARDI), the Cambodian RKB has provided effective support for field-level demonstrations for farmers. CARDI's efforts in the development of new rice varieties have been strengthened by the Cambodian RKB. Cambodian farmers are now using new rice varieties on 48% and 87% of the total cultivated areas in the wet and dry season, respectively.

With such demonstrated successes, the RKB concept is now also being used as a model for other crops and livestock. Particularly, the International Maize and Wheat Improvement Center (CIMMYT), based in Mexico, is partnering with IRRI to build upon the successes of the RKB with other cereals, and to jointly launch the Cereal Knowledge Bank.

An Internet footprint far larger than a Web site

The IRRI Web Project began in late 2007 with the initial aim of giving IRRI's Web presence and its subsites a face-lift. Along the way, the aim evolved into revamping (more than the visual design) the Web site's structure and features so that IRRI could begin to have a significant presence in cyberspace.





Since January 2008, IRRI has been posting most of its books (new and old) on Google Book Search (GBS). Communication and Publications Services (CPS) had started scanning IRRI's historic publications at high resolution years before there even was an online facility like GBS. So, when the time came, IRRI already had almost 300 titles with optical character recognition of 99% accuracy, making the books fully searchable online.

A unique feature that IRRI introduced, with impressive results, was to change the "Buy This Book" link on GBS to "Free PDF Download." Apparently, because of the enticement for a free download, the rate at which people clicked the new link shot up immediately to an amount higher than any that GBS had seen among the publishers it services. IRRI was the first to do this, and since then other CGIAR centers have followed suit.

By the end of 2008, tracking via Google Analytics showed about 200,000 book visits, 1.5 million page views, and nearly 10,000 book downloads from IRRI's GBS presence.

IRRI has always granted permission to clients to use its information products for noncommercial purposes. In 2006, an IRRI Board of Trustees announcement of a new copyright policy reinforced this guiding principle by adopting the use of a Creative Commons (cc) license.

All IRRI publications, including its quarterly magazine *Rice Today* and this annual report, are available to the public under a *cc Attribution-NonCommercial-ShareAlike 3.0 License*. This also applies to more than 4,000 images on IRRI's flickr account and about 120 videos on YouTube.

Rice policy support and impact assessment for rice research

Sushil Pandey
Leader, Program 7

Program 7 is a cross-cutting program that focuses on socioeconomic research, policy research, and impact assessment. The program's primary aim is to provide advice to policymakers, research managers, and donors regarding research priority setting and the design of agricultural interventions through policy analyses, livelihood studies, and impact assessment.

Policies and technologies appropriate for farmers' livelihood needs are crucial in order for rice research to make an impact on poverty reduction and environmental sustainability. Understanding the broad trends in socioeconomic and policy environments that affect the economics of rice production is also important in effectively setting research priorities. This involves analyses of changes in rice production practices and farmers' livelihoods, poverty in rice-growing areas, trends in rice production and consumption at the national and subnational levels, and shifts in comparative advantages in rice production relative to other crops across regions and ecosystems.

Through various projects under Program 7, IRRI is aiming for the following five outputs by 2012: (1) consolidated subnational and farm-level databases relevant to rice policy and impact assessment in the major rice-growing countries; (2) a comprehensive body of research on the long-term dynamics of poverty and rural livelihood systems, with a focus on interactions among technology, infrastructure, and institutions in the major rice-growing countries of Asia; (3) policy reform options based on analyses of long-term changes in comparative advantages in rice production in the major rice-growing countries of Asia; (4) documentation of potential and realized impacts of rice and policy-oriented research on poverty reduction and sustainable management of natural resources; and (5) strategies, policies, and principles for pro-poor dissemination of improved technologies.

A rice policy forum

We held a policy forum, *Rice Policy Research: Key Issues from National Perspectives*, to bring in high-priority policy issues from the NARES into IRRI's research programs and establish linkages with key policy researchers in Asia and Africa. Sixteen papers from Asia and Africa were presented and a panel discussion on rising food prices was held during the forum—the first organized by IRRI in over a decade. The forum, held on 18-19 February 2008, was timely, as the price of rice had been moving up for several years and spiked in April-May.

Information dissemination on the causes and consequences of the rice crisis

Starting with the January 2008 issue of *Rice Today*, we published an analysis of the rice crisis and the role of research investments in avoiding crises of this kind in the future. The policy articles were widely cited and Program 7 scientists became frequent sources of information for the local and international media. We worked hard to make information available and participated in policy discussions within and outside

IRRI. The unprecedented information drive, which we consider a major highlight of the year, helped make policymakers, donors, and the general public more aware of the importance of increased investments in rice research.

Poverty mapping and spatial analysis

We made major progress in identifying the geographical correlates of income and poverty at different spatial scales. We were able to do this using a modeling approach that enabled projections of poverty using geographical correlates when data on income are neither available nor reliable. Poverty maps can then be updated rapidly using this approach.

A study on the dynamics of poverty

The 2008 publication *Rural Poverty and Income Dynamics in Asia and Africa* (edited by K. Otsuka et al.) included two chapters on topics derived from research conducted under Program 7. These chapters, authored by M. Hossain and K. Kajisa, describe the process through which the Green Revolution helped generate income for many in farming through improved agricultural productivity. The chapters also describe a second-round effect of productivity gains, which was further income generation through expanded nonfarm income from nonfarm employment opportunities that eventually helped the poor move out of poverty.

Database consolidation

We made substantial progress in putting together farm-level survey databases and other databases on the economics of rice production. We also formed a gender database of rice farmers from information obtained through various surveys. These databases, together with national and subnational aggregate data on rice production, make the analysis of rice production trends at the national or subnational levels and the study of household economics possible and are in high demand both inside and outside IRRI.

Migration studies

We completed a major study on the impact of migration and off-farm employment on the roles of women in Asian and Australian mixed farming systems. The study, which documented and analyzed the extent of migration of rural labor (men and women) in various countries, drew out clear implications of the migration of farm labor for agricultural research and policy reforms.

Technology dissemination

We brainstormed for a technology transfer strategy that will allow faster dissemination and diffusion of technologies among rice farmers, conducted an impact pathway analysis, and identified approaches from previous projects that will institutionalize the learning process.

Impact assessment of policy-oriented research

We assessed the impact of policy-oriented research using earlier work on pesticide use and farmer health as a case study. The study was commissioned by the Standing Panel of Impact Assessment (SPIA). The results, which indicate that IRRI's past policy-oriented research on the subject has directly generated large economic gains for the Philippines, were published by the SPIA.

How can we avert a rice crisis in the future?

The rice crisis of 2008 saw rice prices rise to levels not seen in the past three decades, resulting in riots and protests in many parts of the developing world. The market was primed for such a crisis with the drawing down of stocks in recent years to a level not seen in decades. Global rice stocks fell from a 135-day supply to a 70-day supply—a 46% drop from 147 million tons in 2001 to 79 million tons in 2007—to fill supply-demand imbalances that arose primarily out of a slowdown in yield growth.

In response to declining stocks, rice prices nearly doubled between 2001 and 2007. The situation, however, did not warrant the tripling of rice prices in a span of 6 months between November 2007 and May 2008. Rising wheat prices due to the expansion of biofuel crops put pressure on rice prices, which led to trade restrictions in many rice-producing countries and an unprecedented rise in prices.

In recent months, rice prices have eased up as market anxiety subsided but they remain high because of the tight global supply-and-demand situation. Basically, current conditions are no different from those in 2008 and any minor disruption in supply could cause a delicate situation to flare up into a crisis again.

The IRRI advantage in rice policy research

The crisis helped expose fundamental imbalances in supply and demand and prompted many parties to renew the call for a second Green Revolution to revitalize sagging yield growth in rice. In 2008, the International Rice Research Institute (IRRI) identified (1) investment in agricultural infrastructure and (2) rice research and extension as keys to improving rice production and helping ensure food for the growing global population.

At IRRI, we recognize that accurate information on the global rice situation at any given time is crucial in stemming panic among countries and averting stockpiling of rice in the future.

The Institute is abreast of technological and varietal developments and the implications these may have for future rice yield and is thus in a unique position to provide accurate and unbiased information on current and future conditions of the global rice market, food security, and impacts of policy. Unlike other organizations engaged in global rice market outlook and policy analysis, IRRI has the added advantage of having field-level data and information on current crop conditions, disease problems, and other factors affecting the rice crop in Asian countries.

A rice information system

The Institute is developing a comprehensive state-of-the-art structural econometric model that will describe the behavior of the world rice market and its connections with other agricultural and nonagricultural inputs and products. This econometric model will be linked to a crop growth simulation model to accurately estimate rice area and yield. Rice production for the current year will be estimated using an Internet-based rice information system developed by Sarmap.

Data on rice area and production generated using these methods will be more accurate and timely than data currently acquired from rice statistics collection systems currently in place in most Asian countries. The new model will be capable of generating short- to medium-term baseline projections of production, consumption, trade, and rice prices under a given set of macro projections (income, exchange rates, inflation, interest rates, and other input markets) and policy regimes. More importantly, the model will aid analysis of a range of issues related to domestic and trade policies, marketing, and food security.

Pathways out of poverty

How does a landless laborer become a small farmer or the owner of three rickshaws? How does a young widow educate her sons and find a dowry for her daughter? How does a family without assets acquire cows and become successful milk sellers? How do households in one of the world's poorest countries move out of poverty?

A study was completed under the IRRI-managed project, Poverty Elimination Through Rice Research Assistance (PETRRA) to probe behind statistics that show declining poverty in Bangladesh and to explore the processes of graduation (leaving poverty behind). Using a variety of qualitative methods, including 30 household case studies, and based on research in three villages representing different rice ecosystems, the study sought to understand graduation from the inside.

Villagers in Bangladesh have responded to new opportunities in agriculture, nonfarm employment, and migration. New livelihood strategies—selling milk, keeping shop, pulling rickshaws or doing repair jobs, and growing vegetables—provide poor people with "opportunity ladders" that require only available skills and a small start-up capital.

Two key "drivers" of graduation—new rice technology and microfinance—illustrate how policy and organizations create pathways out of poverty. Although often treated separately in development literature, both strategies were used simultaneously by households in graduation. Food security in rice

was an important platform from which a household could venture into other enterprises that were often nonfarm. But, this was a stepping stone in graduation and not an endpoint.

A qualitative model captured seven key components of the graduation process: shared household vision, family household structure, informal support, savings, skills, choice of strategy, and sequence of decisions over time. Case-study evidence illustrated these components and showed why some households succeeded while others failed.

Setting the findings within a wider context, the study showed how graduation at the household level is closely linked to the growth of the market economy. The challenge for institutions and organizations is to determine the programs to undertake in order to strengthen the multiple pathways to graduation illustrated in the study. For NGOs, the study supports approaches that enable choice of enterprises at the household level and couples links to diversified sources of expertise (in both agriculture and nonagriculture) and provides links to microcredit. The study supports networks of actors (regional forums, for example) that are able to link households to expertise locally and nationally. To accelerate graduation from poverty, however, there must be a direct engagement with poor households that is gender-inclusive.

For IRRI and the Bangladesh Rice Research Institute, the implication is at the interface between research and development. There is a need for partnerships at the village level with agencies that directly work with resource-poor households. PETRRA, a 5-year project (1999-2004), was funded by Department for International Development (DFID) and was implemented by the Natural Resources Institute (UK), BRRI, Bangladesh Academy for Rural Development (Comilla), and Rural Development Academy (Bogra).

How migration affects women in Asian rice-farming systems

The word "farmer" has always conjured a masculine image. In almost all Asian countries, the male head of the household is culturally perceived as the only full-time "farmer" and sole decisionmaker in the household. But the connotation is losing hold. In many rural places where the men must go elsewhere to earn additional income, the women are left with not much choice but to take over. To understand better how rice farming systems have been changing, IRRI did a study on migration in the farm context.

Why leave the farm?

Rapid rural appraisals and focus group discussions in at least 40 villages each in Thailand, the Philippines, and Vietnam revealed that outmigration was more prevalent in rainfed than in irrigated villages where farming is more risky.

Surveys of farm households (with and without migrants) in the three countries, each with at least 800 household respondents, showed that—with the exception of South Vietnam where rice cultivation remains a major source of income—remittance earnings and nonfarm income made up a larger share of household income than farm income. Remittances are used mainly for food and other daily expenditures, for children's education, farm inputs, house construction or repair, and payment of debt. Thus, for many farm households, migration has become both a way out of poverty and part of a livelihood strategy.

In the areas surveyed, it was mostly male children, rather than fathers, who left to earn more elsewhere. In Vietnam, however, it was commonly the fathers (or the principal males) who left. In cases where the principal males migrate, either the elderly or the wives are left with the huge responsibility of running the farm in addition to household chores and child-rearing.

How is production affected? The average rice yields of households with migrants and those without in the same rice production system, did not differ much, despite the reduction in family labor supply.

Gender roles in the Asian farm

Asian farming systems typically exhibit gender-specificity in division of labor. Men dominate in decisionmaking related to farm operations and crop management while women dominate in household decisions and are custodians of household cash. Hence, male migration had big implications on gender roles; on the upside, it opened up ways for the empowerment of women.

As far as labor participation of principal females is concerned, not much changed in Thailand, where the migrant would usually be a son or daughter. In the Philippines, it declined as principal females were more engaged in nonfarm activities. In Vietnam, the principal females took over tasks that are traditionally of men, such as irrigating the fields, spraying chemicals, and hauling and marketing farm products. Where principal males left, the principal females took over the management of the farm, the extent of which, however, was not uniform across cultures. These women became *de facto* heads of households, taking on responsibilities of supervising labor and managing farms in addition to their traditional roles in keeping house, care of the family, and farm work. When the men leave, the principal females left behind bore the burden of maintaining rice yields.

The authority of wives to make decisions on certain farm and nonfarm matters was measured by calculating a women's empowerment index or WEI. Wives from farming households with migrants posted higher WEIs than those from households without migrants. These women are compelled to make on-the-spot decisions, especially during the peak cropping seasons.

Empowering women is just a start

Women were found to have less access to agricultural training and extension activities, new seeds, and labor-saving and cost-reducing technologies that can help ease their work burden and increase the returns of their labor.

Several strategies and technologies were validated through participatory action research in these areas to enhance women's knowledge and skills in all aspects of rice production. These activities emphasized improved seed health (the Philippines); pest control management practices (the Philippines and Vietnam); and the use of biofertilizer, bioinsecticide, and snail control (Thailand).

In Vietnam, women farmers were interviewed on their current knowledge of pests, weed management, cultural practices, input reduction, and other topics. Assessment of the results helped identify training needs as well as strategies for disseminating technologies. These dissemination strategies included participatory experiments, extension materials, pest specimens, news broadcasts through village loudspeakers, and the participation of local agricultural extension units.

Labor outmigration will continue to increase as long as there are economic incentives for people to move, and as long as the ownership and operation of agricultural land are no longer the predominant source of household income. The next generation of farmers, who are getting better education, may no longer find rice farming financially viable and will continue to seek greener pastures. The elderly parents and women left behind must sustain household food security. The challenge for them and us is how farming can be upgraded from subsistence to commercial levels, using advances in science and technology generated by the international and national agricultural research institutions.

The project, "Impact of migration and off-farm employment on roles of women and appropriate technologies in Asian and Australian mixed farming systems" was coordinated by IRRI and conducted in collaboration with Khon Kaen University in Thailand, Cuu Long Delta Rice Research Institute in Vietnam, and the Muresk Institute of Curtin University of Technology in Western Australia.

Optimal institutional design for water-saving rice cultivation: the Bohol irrigation scheme

International concern has been growing about the sustainability of food production systems as water becomes scarcer. Alternate wetting and drying (AWD) technology for irrigated rice production, which uses 15–30% less irrigation water without a reduction in yield, may help solve the problem (see pages 6-9 and pages 15-20 in Program 2).

As in most irrigation systems, however, dissemination of AWD technology to rice farmers has not been easy. Irrigation authorities commonly charge an irrigation fee based on planted area rather than on volume of water applied. This pricing method gives farmers no incentive to save water. Charging for irrigation water by volume (as with domestic water supply systems) thus seems to be the best way to entice farmers to limit water use. The implementation of such schemes can be expensive, however, when applied to surface irrigation systems.

A cost-effective method observed in some countries involves applying pricing by volume not to individual farmers but to water users' groups. This method, however, usually gives rise to a difficult institutional issue. Within a group, farmers tend to overuse water unless they are strictly supervised. Hence, pricing by volume applied to groups alone does not determine success in water-saving; much of it depends on the characteristics of the group.

A project ongoing in Bohol Province in the Philippines led by Kei Kajisa, IRRI agricultural economist, aims to identify, through an experimental approach, the factors underlying the success, or failure, of water-saving done in groups. It is partially funded by the Japan International Research Center for Agricultural Sciences and covers Bohol Irrigation Systems 2, or BIS2, in Bayongan.

Experiments such as this one are seldom conducted in social sciences; hence, data from some existing studies lack statistical rigor. To overcome this weakness, we used a randomized experimental approach that is becoming popular in social sciences. In this approach, we randomly select control and experimental groups and then apply pricing by volume to the experimental group. We then record (1) how water users' groups successfully move their group toward saving more water (e.g., a change in rules and appointment of water managers), and (2) how each member of the group undergoes behavior changes regarding water use.

Some groups may not be successful in their efforts; in such cases, we investigate why they fail. The factors underlying failure may include a lack of social capital, unsuitable infrastructure design, and a complex topography. By identifying these factors, we draw lessons that will be used to enhance institutional policy to aid water-saving efforts of groups and communities.

In 2008, we conducted a baseline survey, sampling 94 water users' groups for group interview and measurement of water usage by volume. Two farmers from each group were further interviewed for in-depth data collection about rice cultivation and irrigation activities used. In May 2009, we gave lectures on volumetric pricing to 47 randomly selected groups. These groups started using the volumetric pricing method for irrigation of their dry-season crop for 2009. Data gathering using these methods will continue under the project for the next few years.

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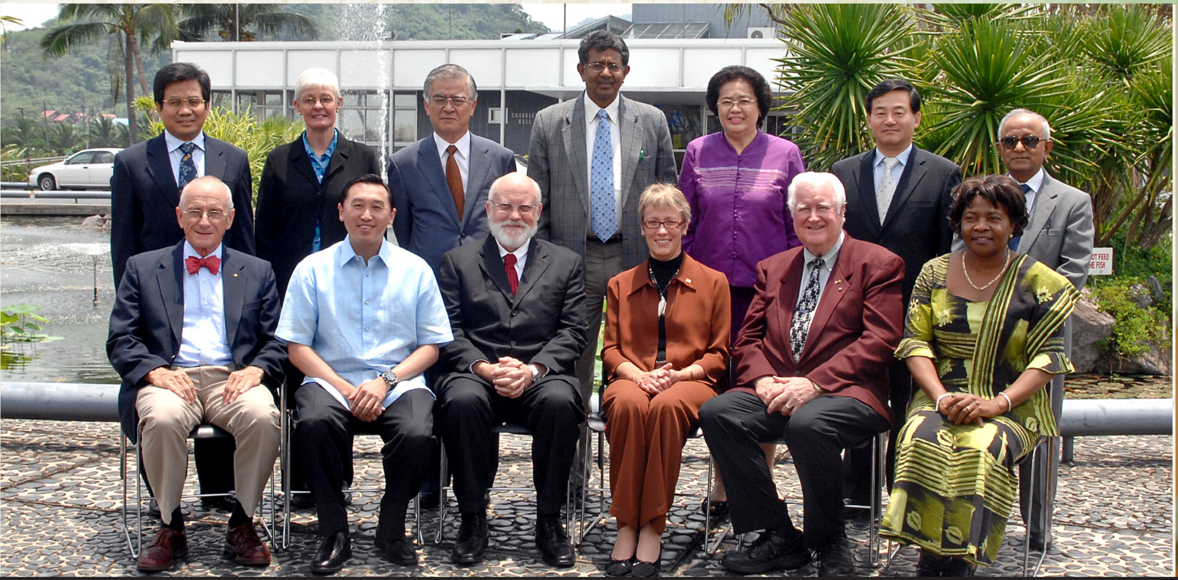

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Crop and Environmental Sciences (continued)

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Crop and Environmental Sciences (continued)

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Yashpal Singh Saharawat, *PhD, scientist*[1]
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Endang Septiningsih, *PhD, postdoctoral fellow*[1]
Hao Chen, *PhD, postdoctoral fellow*[13]
So-Hyeon Baek, *PhD, visiting research fellow*[3]
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Dong-Jin Lee, *PhD, visiting research fellow*[3]
Yohei Koide, *PhD, visiting research fellow*[3]
Jong-Cheol Ko, *PhD, visiting research fellow*[3]
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Choon-Song Kim, *PhD, visiting research fellow*[1]
Yongming Gao, *PhD, visiting research fellow*[1]
Youn-Sang Cho, *PhD, visiting research fellow*[1]
Jian-Long Xu, *PhD, visiting research fellow*[1,3]
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Plant Breeding, Genetics, and Biotechnology (continued)

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Samarendu Mohanty, *PhD, senior economist and head*[3]
Sushil Pandey, *PhD, senior scientist, agricultural economics and program leader, Rice Policy Support and Impact Assessment*
Robert J. Hijmans, *PhD, senior scientist, GIS specialist*
Damien Jourdain, *PhD, senior scientist, agricultural economics*
Kei Kajisa, *PhD, scientist, agricultural economics*
Thelma R. Paris, *PhD, senior scientist, gender specialist*
Deborah J. Templeton, *PhD, scientist, social science/economics*[1]
Shigeki Yokoyama, *MS, IRS seconded from JIRCAS*
Hari Gurung, *PhD, international research fellow, farming systems*
Yann H. Chemin, *PhD, postdoctoral fellow*
Digna Manzanilla, *PhD, postdoctoral fellow*[3]
Hari Nath Singh, *PhD, postdoctoral fellow*[3]
Jacob van Etten, *PhD, postdoctoral fellow*[3]
Devendra Gauchan, *PhD, postdoctoral fellow*[3]
Yoon-Ji Choi, *PhD, visiting research fellow*[1,3]
Chun K. Lai, *PhD, consultant*[3]
S.K. Bardhan Roy, *PhD, consultant*[1,3]
Canesio Predo, *PhD, consultant*[1,3]
N. Venkatesa Palanichamy, *PhD, consultant*[1,3]
Yolanda T. Garcia, *PhD, consultant*[1,3]
Randolph, Barker, *PhD, consultant*[1]
Bhanudeb Bagchi, *PhD, consultant*[1]
Abu Nasar Md. Mahfuzur, *PhD, consultant*[1]
Kamal Paudyal, *PhD, consultant*[1]
Sonia L. Asilo, *MS, senior specialist - remote sensing*[3,4]
Jocelyn G. Barba, *BS, secretary II*
Ma. Romilee L. Bool, *MS, associate scientist*[3,4]
Ellanie R. Cabrera, *BS, researcher*
Pio Adan A. Cenas, *BS, researcher*[1]
Amelia D. Cueno, *MS, associate scientist*[4]
Lydia B. Damian, *BS, secretary III*
Dehner M. De Leon, *BS, officer - database administration*
Catalina P. Diaz, *MS, associate scientist*
Anna Christine A. Doctolero, *BS, secretary II*
Mirla D. Domingo, *BS, officer - administrative coordination*
Cornelia A. Garcia, *BS, associate - graphics*
Rosendo G. Gutierrez, *BS, secretary III*
Zenaida M. Huelgas, *MS, associate scientist*
Alice G. Laborte, *PhD, associate scientist*
Joyce S. Luis, *MS, associate scientist*
Teodora D. Malabanan, *BS, assistant - statistics*
Maria Luz L. Malabayabas, *MS, assistant scientist*[3,4]
Angelina A. Malabrigo, *BS, secretary III*

Social Sciences Division (continued)

Esther B. Marciano, *BS, assistant scientist*
Aileen A. Maunahan, *BS, researcher*
Imelda R. Molina, *MS, associate scientist*
Piedad F. Moya, *MS, senior associate scientist*
Josephine H. Narciso, *BS, assistant scientist*
Ma. Cristina L. Obusan, *BS, associate - database administration*[4]
Leo Angelo L. Ocampo, *BS, researcher*[3]
Arnel B. Rala, *BS, associate scientist*
Joel E. Reaño, *BS, associate - statistics*
Gerlie T. Tatlonghari, *BS, assistant scientist*
Ma. Teresa R. Ulat, *BS, assistant scientist*[1,4]
Ma. Shiela D. Valencia, *BS, researcher*
Orlee P. Velarde, *MA, assistant scientist*
Maria Lourdes E. Velasco, *MS, associate scientist*
Lorena S. Villano, *BS, researcher*
Donald B. Villanueva, *BS, researcher*[4]
Gina E. Zarsadias, *MS, assistant manager I - assistant program manager*

Crop Research Informatics Laboratory

Christopher Graham McLaren, *PhD, senior scientist, biometrics specialist and head; program leader, Information and Communication*[1]
Richard Bruskiewich, *PhD, senior scientist, bioinformatics specialist and acting program leader, Information and Communication*[18]
Thomas Metz, *PhD, senior scientist, research informatics and acting head*[18]
Martin Senger, *PhD, bioinformatics software project manager*[3]
Ramil Mauleon, *PhD, postdoctoral fellow*
Samart Wanchana, *PhD, postdoctoral fellow*[3]
Matthieu Conte, *PhD, postdoctoral fellow*[3]
Michael Jonathan Mendoza, *MS, consultant*[1,3]
Len Wade, *PhD, consultant*[1,3]
Ryan Carlo B. Alamban, *BS, specialist - platform software engineer*[4]
Mylah Rystie U. Anacleto, *BS, associate scientist*
Genevieve Mae B. Aquino, *MS, associate scientist*[4]
Maria Socorro S. Arboleda, *BS, assistant manager I*[10]
Lord Hendrix A. Barboza, *BS, systems analyst/ programmer*[4]
Violeta I. Bartolome, *BS, senior specialist, statistics - consulting and training*
Alexander A. Cañeda, *BS, officer - platform software engineer*[3,4]
Manfred Carlo R. Cardenas, *BS, programmer - web services*[4]
Franjel C. Consolacion, *MS, specialist - systems/ database administration*[3,4]
Warren Vincent E. Constantino, *BS, systems analyst/programmer*[4]
Jeffrey A. Detras, *BS, assistant scientist*[4]
Nelzo C. Ereful, *MS, specialist - bioinformatics*[1,3]
Ma. Corina D. Habito, *BS, specialist - data application programmer*[4]
Emmali A. Manalo, *BS, officer - institutional information systems management*
Kevin L. Manansala, *BS, specialist - platform software engineer*[4]
Michael Jonathan M. Mendoza, *MS, systems analyst/programmer*[4,1]
Jeffrey B. Morales, *BS, specialist - platform software engineer*[4]
Leilani A. Nora, *BS, assistant scientist*
Carlos N. Ortiz, *systems analyst/programmer*[3,4]
Lourdes C. Paunlagui, *BS, officer - administrative coordination*
Barry C. Peralta, *BS, systems analyst/programmer*[4]
Clarissa I. Pimentel, *BS, specialist - database administration*
Arllet M. Portugal, *MS, associate scientist*
Jean Robelle D. Sabado, *BS, programmer*[4]
Veritas Morena R. Salazar, *BS, researcher*
Rowena V. Tulod, *BS, systems analyst/programmer*[4]
Victor Jun M. Ulat, *MS, associate scientist*

T.T. Chang Genetic Resources Center

Nigel Ruaraidh Sackville Hamilton, *PhD, senior scientist, evolutionary biology and head*
Kenneth L. McNally, *PhD, senior scientist, molecular genetics/molecular taxonomy*
Jessica D. Rey, *PhD, postdoctoral fellow*[3]
Tom Hazekamp, *PhD, consultant*[3]
Yunlong Xia, *PhD, consultant*[1]
Remegio L. Aguilar, *technician II - research*
Adelaida P. Alcantara, *BS, specialist - database administration*[1]
Ma. Socorro R. Almazan, *BS, assistant scientist*
Lydia G. Angeles, *BS, technician I - research*
Ricardo A. Apolinario, Jr., *BS, technician II - research*[4]
Vicente M. Arcillas, *technician III - research*
Rancy M. Bauyon, *technician II - research*[4]

T.T. Chang Genetic Resources Center (continued)

Imelda P. Boncajes, *technician I - research*
Nerissa L. Boongaling, *technician I - research*[4]
Jane D. Carandang, *technician I - research*[4]
Belinda R. Caspillo, *technician II - research*
Flora C. De Guzman, *MS, senior. associate scientist*
Isabelita P. De Mesa, *technician I - research*
Lyruth S. Domagsang, *BS, technician II - research*[4]
Hipolito M. Elec, *technician II - research*
Jenniffer P. Eleuterio, *BS, assistant - database administration*[4]
Minerva N. Eloria, *technician I - research*
Michael B. Gamalinda, *BS, researcher*[4]
Arnold B. Gonzales, *technician II - research*
Minerva C. Gulde, *technician I - research*[4]
Emerlinda E. Hernandez, *technician III - research*
Maria Celeste B. Hilario, *MS, assistant scientist*[4]
Edwin H. Jarabejo, *technician I - research*[4]
Nora M. Kuroda, *BS, technician I - research*[4]
Melencio R. Lalap, *technician III - research*
Alicia A. Lapis, *BS, technician I - research*
Felix R. Llanes, *technician III - research*
Wilma L. Lumaybay, *technician I - research*
Minerva I. Macatangay, *technician III - research*[1]
Yolanda P. Malatag, *BS, technician I - research*
Gilbert G. Mamiit, *technician I - research*
Emmanuel T. Manaig, *technician I - research*[4]
Veronica V. Mangubat, *technician I - research*
Violeta T. Manila, *technician I - research*[4]
Bernardo P. Mercado, *technician III - research*
Gregorio M. Mercado, *technician III - research*
Sheila Mae Q. Mercado, *BS, assistant scientist*[3]
Mae C. Merluza, *technician I - research*[4]
Ma. Elizabeth B. Naredo, *BS, assistant scientist*
Roniela H. Prantilla, *BS, specialist - database administration*[1,4]
Romulo R. Quilantang, *technician II - research*[4]
Jacqueline M. Ragudo, *technician I - research*
Joseph M. Ramos, *technician II - research*[3]
Janice A. Rayco, *BS, technician III - research*[3,4]
Renato A. Reaño, *MS, associate scientist*
Nelia A. Resurreccion, *BS, technician III - research*
Mario A. Rodriguez, *technician III - research*
Digna I. Salisi, *BS, secretary III*
Teresita C. Santos, *BS, secretary III*
Lilibeth M. Sison, *BS, specialist - information technology*[4,6]
Anthony N. Telosa, *BA, assistant*
Florencio F. Villegas, *technician II - research*
Liza B. Yonzon, *technician I - research*[4]

Grain Quality, Nutrition, and Postharvest Center

Melissa A. Fitzgerald, *PhD, head*
Martin Gummert, *BS, scientist, postharvest specialist*
Xiangqian Zhao, *PhD, postdoctoral fellow*[3]
Meas Pyseth, *consultant*
Sorn Vichet, *consultant*
Can Van Hung, *consultant*[1]
Nguyen Van Doan, *consultant*[1]
Ho Thi Tuyet, *consultant*[1]
Vu Cong Khan, *consultant*[1]
Nguyen Nang Nhuong, *consultant*[1]
Boru Douthwaite, *PhD, consultant*[1,3]
Juan L. Alzona, *technician II - research*
Romulo N. Aquino, *technician II - research*
Teodoro L. Atienza, *technician II - research*
Carlito B. Balingbing, *BS, assistant scientist*
Paterno C. Borlagdan, *PhD, assistant scientist*
Mariafe N. Calingacion, *MS, researcher*
Venea Dara A. Daygon, *BS, researcher*
Ana Lyn J. Genil, *BS, secretary II*
Rosario R. Jimenez, *BS, assistant scientist*
Artemio V. Madrid, Jr., *technician III - research*
Don L. Pabale, *MS, assistant scientist*[1,4,6]
Adoracion P. Resurreccion, *PhD, associate scientist*
Fernando C. Salisi, *technician II - research*[4]
Lucena C. Samadio, *technician II - research*[4]
Enofra I. Sandoval, *BS, technician III - research*[12]
Eduardo L. Secretario, *technician III - research*
Elenita C. Suñaz, *BS, officer - administrative coordination*
Harold Glenn A. Valera, *MS, assistant scientist*[3,4]

Training Center

Noel P. Magor, *PhD, head*
Yoke Sau Metz, *consultant*[3]
David Shires, *consultant*
Imee L. Aspiras, *BS, assistant manager I*[1]
Lauro M. Atienza, *BS, officer - training*
Eugenio C. Castro, Jr., *MS, associate scientist*
Ma. Teresa A. Clabita, *BS, officer*
Priscilla P. Comia, *BS, secretary II*
Maria Angeli G. Maghuyop, *MS, specialist - training*

Training Center (continued)

Anilyn D. Maningas, *MS, assistant manager I*[7]
Macario B. Montecillo, *assistant - training logistics*
Melanie M. Quinto, *secretary III*

International Programs Management Office

Headquarters-based

Mark Bell, *PhD, consultant*[1, 3]
Julian A. Lapitan, *MS, senior manager*
Marilyn G. Belen, *AB, secretary III*[9]
Marianne R. De Luna, *MS, officer - administrative coordination*
Margaret Ann S. Jingco, *BS, assistant manager II*

Country-based

Mohammed Zainul Abedin, *PhD, IRRI representative for Bangladesh and FoSHoL project leader*
Craig Meisner, *PhD, consultant*[3, 1], *IRRI-Bangladesh Office*
Gary C. Jahn, *PhD, coordinator for the Greater Mekong Subregion (GMS), IRRI representative and Lao-IRRI project manager, and senior scientist, entomology*[1]
Joseph F. Rickman, *MS, program leader, Rice in East and Southern Africa, and IRRI representative for the East and Southern Africa region*
Surapong Sarkarung, *PhD, consultant, IRRI-East and Southern Africa Regional Office*
Carlos Zandamela, *consultant, IRRI-East and Southern Africa Regional Office*
Zakaria L. Kanyeka, *PhD, regional plant breeder for East and Southern Africa region*
M.A. Hamid Miah, *PhD, liaison scientist for Bangladesh*
Ahmad Salahuddin, *consultant, IRRI-Bangladesh Office*
Mahyuddin Syam, *MPS, liaison scientist for Indonesia/Malaysia/Brunei Darussalam*

Bangladesh

Md Ahsanullah, *driver*[4]
Md. Jafar Alam, *MS, secretary II*[3, 4]
Ruhul Amin, *office attendant*[4]
Mohammad Asaduzzaman, *MS, accountant I*[1]
Tahmina Banu, *MS, officer-administrative coordination*
Jopinath Bazi, *driver*[4]
Md. Abdul Hamid, *guard*[3, 4]
Nurul Islam, *guard*[4]
Md Abdul Mannan, *information technology officer*[4]
Fazlu Miah, *guard*[4]
Shahjadi Parvin, *MA, secretary II*[1,4]
Anthony Sarder, *motor vehicle operator*
Shamima Sultana, *MA, secretary II*[4]
Md. S.M. Suzat, *office attendant*[4]
A. S. M. Zahiruddin, *accountant I*[1,4]
Abutaher M. Ziauddin, *monitoring and evaluation specialist*[4]

Cambodia

Marie Kim Leng, *BS, assistant manager I*

China

Cao Meng, *office assistant*[4]
Yonghong Sun, *BA, officer-administrative coordination*
Zhongqiu Wang, *BA, assistant manager II*

India

Gopal Krishna Agarwal, *Bcom, administrative officer (finance & accounts)*
Dalpat Chand Bhandari, *PhD, assistant manager II (lead coordinator)*[1]
Parvesh Kumar Chandna, *MS, scientist (remote sensing and GIS applications)*[3, 4]
Vanita Gupta, *MCom, administrative associate*[1,4]
Puneet Khurana, *Bcom, administrative associate*[3]
Virender Kumar, *PhD, scientist - crop & soil science*[3, 4]
Ayodhya Lodhi, *driver cum gen. assistant*
Vijaya Kumar Marthi, *MBA, assistant manager II*[3]
Prempal, *assistant (housekeeping)*[4]
Savita Sharma, *administrative associate*
Anurudh Singh, *assistant (housekeeping)*[4]
Rajan Kumar Yadav, *driver cum utility assistant*[3]

Indonesia

Iwan Adidharmawan, *BS, accounting supervisor/ administrative coordinator*
I Made Agus Mahardhika, *driver*
Diah Wurjandari Soegondo, *BS, researcher*

Korea

Seung-Hee Han, *BS, administrative coordinator*[4]
Suh Jung-Pil, *PhD, senior research scientist*[4]

Lao PDR

KhamSouk Mosky, *driver cum office assistant*
Sone Mosky, *BS, administrative coordinator*
Sonedalinh Phoumvongxay, *BA, secretary II*[1]

International Programs Management Office Country-based (continued)

Ounheuane Phouthachit, *administrative coordinator*

Sommai Yasongkua, *driver cum office assistant*

Sansai Samountry, *accountant*[4, 1]

Mozambique

Mahamudo Ismael Jala, *driver*[4]

David Jose Muhale, *technician III-research*[4]

Myanmar

Nanda Soe Myint, *driver/office aide*

Ohnmar Tun, *BAg, assistant manager II*

Nepal

Bhaba Prasad Tripathi, *PhD, senior associate scientist*[4]

Tanzania

Mohamed Selemani Mkuya, *research technician*[3, 4]

Anna Kato Nyacho, *administrative coordinator*[3, 4]

Ezekiel Joachim Shilili, *driver*[3, 4]

Thailand

Vitchu Chowanapong, *BS, office clerk*

Amporn Limsorn, *office assistant*

Apinporn Phuengwattanapanich, *MS, assistant manager II*

Punjama Tasana, *BA, senior accountant*

Vietnam

Nguyen Thanh Huyen, *BS, assistant manager II*

Nguyen Van Khang, *driver*

Do Phuong Thao, *accounting assistant*

Office of the Director for Program Planning and Communications

Zenaida M. Federico, *BS, executive secretary*

Program Planning and Coordination Unit

Corinta Q. Guerta, *MS, senior manager and head*

Marileth U. Enriquez, *MS, assistant manager I*[3]

Ma. Sol V. Ogatis, *BS, assistant manager I*[1]

Ma. Velinda H. Ilao, *BS, secretary III*

Communication and Publications Services

Eugene P. Hettel, *MA, editor and head*

Bill Hardy, *PhD, science editor/publisher*

Adam Barclay, *Grad Dip Science, international research fellow*[1]

Robert Hill, *consultant*[1,3]

Cris Hemmings, *consultant*[1,3]

Anna Natasha A. Arsenal, *specialist - marketing*[1]

Albert A. Borrero, *manager*

Antonette Abigail E. Caballero, *MS, officer - administrative coordination*

Jose M. Ibabao, *officer - video production*

Ariel D. Javellana, *BS, officer - photography*[1]

Juan V. Lazaro IV, *associate - graphics design*

Sylvia Katherine S. Lopez, *MS, assistant manager II - product development*[1]

Diadema I. Martinez, *BS, assistant - editorial*

Maria Guadalupe Y. Mondoñedo, *BS, specialist - technical writing*[1]

Jose Raymond D. Panaligan, *associate - photography/video*[1]

Emmanuel A. Panisales, *BS, associate - graphics design*

Chrisanto G. Quintana, *specialist - photography/ video*

Cynthia C. Quintos, *BS, secretary II*

Rogelio R. Quintos, *BS, secretary III*

George R. Reyes, *BS, associate - graphics design*[1]

Lanie C. Reyes, *MS, assistant manager II*[3]

Teresita V. Rola, *MPS, specialist - editorial*

Development Office

Duncan I. Macintosh, *BA, head*

Marie Antoinette P. De Jesus, *MA, officer*[4]

Noreen N. Mira, *BS, secretary II*[4]

Information Technology Services

Marinus Cornelis van den Berg, *head*

Victor L. Alarcon, *BS, systems analyst/programmer*

Rogelio P. Alvarez, Jr., *BS, manager*

Eric B. Clutario, *BS, assistant manager II - MIS*

Ildefonso B. Cosico, *BS, officer - systems administration*

Bonifacio C. De Ocampo, *technician III - IT*

Jesus S. Fugen, *technician III - IT*[1]

Rolando V. Laguitan, *BS, systems analyst/ programmer*[1]

Sergio R. Magadia, *BS, assistant manager II - network and telecommunications engineering*

Nestor D. Marcelo, Jr., *BS, assistant manager I - MIS*

Bayani N. Perido, *technician III - IT*

Loreto R. Puyod, *BS, assistant manager II*

Analiza R. Ramos, *BS, secretary III*

Reynaldo L. Stevens, *printer*

Personnel (as of 31 December 2008)

Library and Documentation Services

Mila M. Ramos, *MS, chief librarian*
Rowena M. Andaya, *BS, assistant - library*
Maria Aisa M. Atienza, *BS, assistant - library*
Carmelita S. Austria, *MS, assistant. chief librarian - library information*
Reagan R. Austria, *MA, senior librarian*[1]
Marilyn O. Bonador, *BS, assistant - library*
Jonnel G. De Jesus, *BS, assistant - library*
Natalia V. Delos Reyes, *BS, senior librarian*
Isagani P. Garcia, *assistant -library*
Emerald L. Lansangan, *BS, senior librarian*
Mauro T. Malabrigo, Jr., *assistant - library*
Emmanuel P. Mendoza, *BS, assistant - library*
Maria Consuelo S. Parducho, *associate*

Office of the Director for Management Services

Gordon MacNeil, *consultant*[1, 3]
Vilma T. Ramos, *BS, executive secretary*

Brent School

Malaya S. Capiña, *BS, officer - administrative coordination*[3,4]

Community and Employee Relations Services

Maria Charina Asuncion G. Ocampo, *BA, BL, manager*
Juanito F. Goloyugo, *MS, specialist-information service*
Kathryn Rose C. Victoria, *BS, officer-HRS coordination*
Joselito A. Platon, *BS, associate-community project*

Financial Operations Unit

Elisa S. Panes, *BS, senior manager*
Grace P. Abanto, *BS, officer*
Lily G. Aquino, *BS, officer*
Edelisa M. Bardenas, *BS, assistant manager I*[1]
Mary Grace R. Bautista, *BS, assistant manager I*
Cynthia R. Borbe, *BS, officer*[3]
Betty Sarah R. Carreon, *BS, assistant manager I*
Julie C. Carreon, *BS, assistant manager II*
Ferdinand B. Comia, *BS, officer*
Gemma N. Corcega, *BS, officer*[1]
Michelle V. Ella, *BS, officer*
Maricel I. Encanto, *BS, officer*
Johan F. Hernandez, *BS, associate*[1]
Grace D. Javier, *BS, officer*
Visitacion A. Labog, *BS, officer*
Nestor C. Lapitan, *BS, assistant manager II*[1]
Ma. Donnina S. Lopez, *BS, assistant manager II*
Jelo D. Magat, *BS, assistant*
Richard N. Malaiba, *BS, associate - property and assets*[3]
Paulito J. Oleta, *BS, officer*
Vernadette Kristen A. Ordoño, *BS, officer*[3]
Marianne G. Pizarra, *BS, officer*
Cindy Shella S. Salazar, *BS, officer*[1]
Miriam M. Telosa, *BS, assistant manager I*
Marilyn I. Villegas, *assistant*

Financial Planning and Reporting Unit

Melba M. Aquino, *BS, senior manager*
Eunice S. Andarin, *BS, assistant manager I*
Fernando B. Artates, *BS, officer*
Maria Zenaida V. Borra, *BS, assistant manager I*
Jane B. Carlos, *associate*
Francis P. De Castro, *BS, officer*[1]
Iris M. Ferrer, *BS, officer*
Evelyn V. Inocencio, *BS, officer*
Annie C. Magcamit, *BS, officer*
Mae Christine I. Maghirang, *BS, officer*
Rodelita D. Panergalin, *BS, assistant manager II*
Luisa D. Urriza, *BS, officer*
Anabel V. Valdenarro, *BS, officer*

Human Resource Services

Hershey V. Aquino, *BS, assistant - HRS*[3]
Sylvia P. Avance, *MS, specialist - HRS*
Maria Liza R. Milante, *BS, officer - administrative coordination*
Larry A. Montermoso, *associate - HRS*
April Jane D. Muere, *BS, secretary II*
Selene M. Ocampo, *BS, officer - HRS coordination*
Iluminada B. Oleta, *BS, associate - HRS*
Myrna Benilda C. Pablo, *MS, specialist-HRS*[1]
Alfredo R. Reyes, *BS, officer - HRS coordination*
Nida E. Reyes, *BS, officer - HRS coordination*
Jhea Laurish S. Solis, *BS, associate - HRS*[3]

Procurement and Materials Management Services

Hiram D. Gomez, Jr., *MS, senior manager*
Conception Elybeth A. Alcantara, *BS, officer*
Fred B. Angeles, *warehouseman*
Remedios E. Ballesfin, *BS, assistant manager I - CRS*
Lourdes A. Belison, *BS, officer - purchasing*
Priscilla T. Cabral, *BS, officer - shipping*

Procurement and Materials Management (continued)

Anthony C. Daluz, *BS, officer - purchasing*[1]
Felix C. Estipona, *assistant - Makati office*
William M. Estrellado, *warehouseman*
Norvin O. Fortuna, *data encoder*
Wilmer B. Jacob, *assistant - mailroom*
Felicisimo N. Kalaw, *BS, assistant manager I*
Delfin M. Lacandula, Jr., *attendant*
Anatolio A. Magampon, *BS, officer - property disposal*[1]
Anicia R. Malabanan, *data encoder*
Mari Joyce N. Maningas, *BS, officer - purchasing*
Ernesto L. Nimedez, Jr., *BS, warehouseman*
Luzviminda G. Oleta, *BS, officer - purchasing*
Fortunato L. Parducho, *driver*
Fortunato P. Presto, *attendant*
Francisco T. Quilloy, *materials expediter*
Jose L. Sibal, *warehouseman*
Louell R. Tanzo, *BS, assistant - central files*
Angelica P. Valintos, *BS, officer - administrative coordination*

Office of the Deputy Director General for Operations and Support Services

Gerard F. Barry, *PhD, coordinator, GoldenRice Network; head, Intellectual Property Management Unit; and leader, Rice and Human Health*
Inez Slamet-Loedin, *PhD, shuttle scientist*[1, 3]
Edgar Paski, *PhD, consultant*[1, 3]
Salvie F. Mariñas, *BS, executive secretary*[5]
Ramon A. Oliveros, *MS, executive assistant I*
Rosalie P. Trinidad, *BS, executive secretary*[1]

Intellectual Property Management Unit

Raul M. Boncodin, *BS, assistant manager II*
Frances Florifel B. Tesoro, *BS, secretary III*

Legal Services

Ildefonso R. Jimenez, *BS, senior counsel*
Cherryl C. Breva, *BS, secretary III*

Events and Visitors Office

Bita S. Avendaño, *MS, assistant manager II*[7]
Arvin A. Benavente, *BS, officer - audio/visual*[10]
Ria Anna B. Dimapilis, *BS, associate - visitors*[7]
Zorayda T. Menguito, *BS, associate*[7]

Rice Museum and Exhibit Office

Paul Benjamin R. Hilario, *BS, assistant manager I - riceworld*[10]
Harris L. Tumawis, *assistant - riceworld*[10]

Operations Management

Terry B. Jacobsen, *BA, head*
Mark Jones, *consultant*[3]
Ricardo M. Hernandez, *BS, assistant manager I*

Experiment Station

Tomas P. Clemeno, *BS, senior manager*
Arnold R. Manza, *MS, senior manager*[1]
Pedro C. Aala, *technician II - research*
Isaias C. Abuyo, *BS, technician III - research*
Benedicto S. Alborida, *technician III - research*[4]
Fabian L. Alcachupas, Jr., *technician II - research*
Carlos P. Alforja, *technician II - research*
Danilo O. Amoloza, *technician II - research*
Roslen S. Anacleto, *MS, programmer*
Nestor M. Angeles, *technician II - research*
Anthony L. Aquino, *technician II - research*[4]
Virginia G. Aranda, *BS, secretary III*
Melecio J. Arcillas, *technician II - research*
Quirino L. Atienza, *technician I - research*
Efren A. Bagui, *technician II - research*
Jesse C. Banasihan, *technician III - research*
Restituto M. Bandoy, *technician II - research*
Policarpio S. Barbadillo, *technician II - research*
Rogelio V. Bargola, *technician II - research*
Efren P. Bautista, *technician II - research*
Efren L. Blanco, *technician II - research*
Pedro G. Cabrera, Sr., *technician II - research*
Francisco G. Calibo, *technician III - equipment*
Luis M. Calma, *technician II - research*
Lino M. Carandang, *technician II - research*
Vicente E. Carandang, *technician II - research*
Oscar L. Caspillo, *technician II - research*
Aurelio M. Catangay, *technician II - research*
Bonifacio B. Chavez, *technician II - research*
Abraham G. Dalid, *BS, technician III - research*
Edgardo T. Diaz, *technician II - research*
Ariel R. Dimapilis, *technician II - research*
Rogelio M. Elbo, *technician II - research*
Roberto P. Escandor, *BS, officer*
Cesar Z. Esguerra, *technician II - research*
William C. Fortuna, *technician II - research*
Benjamin C. Garcia, *technician II - research*
Danilo O. Gonzaga, *technician II - research*

Experiment Station (continued)

Rolando G. Guevarra, *technician III - mechanic*
Jose F. Hernandez, *technician III - equipment*
Delfin M. Ilagan, *technician II - equipment*
Nestor L. Ilaw, *technician II - research*
Abraham G. Javier, *technician II - research*
Eduardo A. Lajarca, *technician II - research*
Virgilio T. Lalap, *technician II - research*
Fidel G. Lanorio, *technician II - research*
Enrico A. Lucero, *secretary III*
Nicasio V. Malabanan, *technician II - equipment*
Sulpicio J. Malabanan, *technician III - research*
Lucas M. Malbataan, *technician I - research*
Mario M. Malbataan, *technician II - research*
John Mark C. Mamiit, *technician II - welder*
Mario A. Mandilag, Sr., *officer*
Bienvenido B. Manimtim, *BS, assistant manager I*
Leopoldo P. Manito, *technician II - research*
Jose D. Manuel, *BS, technician III - research*
Mateo F. Manzanilla, *technician II - research*
Pedro C. Mendoza, *technician II - research*
Andres M. Mercado, *technician II - research*
Godofredo M. Mercado, *technician II - research*
Gelardo R. Morales, *technician II - research*
Edwin B. Nuevo, *BS, assistant manager I*[3,4]
Gregorio S. Oca, *technician II - research*
Erlinda A. Oracion, *MS, officer - administrative coordination*
Pablito M. Pabalate, *technician II - mechanic*
Rolando R. Pacion, *associate - stock inventory*
Rogelio R. Pamulaklakin, *technician III - mechanic*
Ramiro C. Panting, *technician II - research*
Reynaldo A. Pelegrina, *technician II - research*
Alfredo G. Regalado, *attendant - grounds maintenance*
Roberto B. Revilleza, *technician II - research*
Antonio B. Rivera, *technician III - research*
Nestor G. Rizaldo, *technician II - research*
Juanito M. Rosario, *technician III - mechanic*
Nazario B. Timbol, *technician III - research*
Celso L. Varron, *technician III - research*
Cecilio L. Villamayor, *secretary II*
Mario F. Villegas, *technician I - research*
Efren E. Viquiera, *technician III – mechanic*

Food and Housing Services

Ma. Obdulia B. Jolejole, *BS, senior manager*
Limberto S. Aldipollo, *assistant - stock inventory*[1]
Priscilla S. Argosino, *MS, officer*
Ricardo L. Bejosano, Jr., *assistant - stock inventory*
Rolly M. Camayudo, *assistant - recreation*
Cristina E. Cauntay, *attendant - housing*
Fe C. De Ocampo, *BS, associate - food service*
Irene S. Escoses, *attendant - housing*
Laureano M. Escuadra, *attendant - housing*
Edgardo S. Estenor, *BS, attendant - housing*
Aurelio C. Garcia, *attendant - housing*
Leody M. Genil, *BS, assistant manager I*
Francisca O. Oro, *attendant - housing*
Benita M. Pañgan, *BS, officer*
Anselmo R. Reyes, *assistant - recreation*
Gina A. Ypil, *BS, secretary II*

Physical Plant Services

Douglas D. Avila, *BS, senior manager*
Regalado Q. Alcachupas, *technician II - plumbing*
Fidel L. Alvarez, *technician III - carpentry*
Apolinario T. Armia, *technician III - welding*
Robert F. Austria, *BS, technician III - drafting*[1]
Danilo F. Banasihan, *technician III - instrument and telephone*
Enrique D. Baterina, *technician III - electrical*
Jose T. Beato, *BS, technician III - electrical*[1, 4]
Rodolfo G. Calibo, *technician III - physical plant*
Teodoro G. Carreon, *officer*
Manolo M. De Guia, *technician III - refrigeration and airconditioning*
Enrique O. Delos Reyes, *BS, manager*
Roberto E. Escueta, *BS, technician III - electrical*
Jaime A. Fojas, *BS, assistant manager I*[1]
Mario C. Garcia, *technician III - electrical*
Rufino R. Gibe, *BS, technician III - electrical*
Hilarion A. Hibek, *technician II - plumbing*
Jennifer R. Jarlego, *BS, secretary I*
Fermin L. Junsay, *BS, assistant - stock inventory*
Benjamin C. Libutan, *technician III - electrical*
Anito Q. Mabalhin, *technician III - welding*
Fernando B. Madriaga, *BS, assistant manager I*
Nestor A. Malabuyoc, *BS, assistant manager I*
Levi C. Malijan, *technician III - carpentry*
Leonardo S. Mangubat, *technician III - refrigeration and airconditioning*
Alfredo M. Mazaredo, *BS, manager*
Marcelino M. Navasero, Jr., *technician III - electronics and instrument repair*
Dionisio A. Ng, *technician III - refrigeration and airconditioning*

Physical Plant Services (continued)

Domingo M. Ortiz, *technician III - telephone*
Juan L. Petrasanta, *technician III - refrigeration and airconditioning*
Mario S. Pinero, *painter*
Dorina L. Rebong, *BS, technician III - drafting*[3]
Rolando N. Simon, *technician III - electrical*
Ramon R. Suarez, *technician III - electronics and telephone*
Ricardo C. Tabilangon, *technician III - refrigeration and airconditioning*
Roberto N. Tamio, *technician II - masonry*
Melencio E. Tapia, *technician III - plumbing*
Marissa E. Templanza, *BS, officer - administrative coordination*
Virgilio V. Verano, *technician III - carpentry*
Luisito R. Vitan, *technician III – civil*

Safety and Security Services

Glenn A. Enriquez, *BS, senior manager*
William G. Amador, *BS, core guard*
Maria Cristina B. Andaya, *BS, assistant manager II (pollution control officer)*
Crisostomo M. Dela Rueda, *core guard*
Rodelo M. Empalmado, *core guard*
Pablo C. Erasga, *core guard*
Roberto M. Espinosa, Jr., *core guard*
Juanito C. Exconde, *BS, core guard*
Bionico R. Malacad, *security investigator*
Francia Indira V. Olivar, *BS, officer - occupational safety and health*
Esteban C. Palis, *core guard*
Macario C. Punzalan, *BS, core guard*
Ernesto S. Regulacion, *core guard*
Salvador T. Zaragoza, Jr., *security investigator*

Transport Services

Manuel F. Vergara, *MS, senior manager*
Danilo G. Abrenilla, *driver*
Martheen Francis O. Aquino, *BS, technician II - mechanic*
Carlos Levy C. Banasihan, *driver*
Edwin S. Cabarrubias, *technician III - mechanic*
Carlito C. Cabral, *BS, officer - administrative coordination*
Roger M. Cuevas, *technician III - mechanic*
Amador L. De Jesus, *driver*
Reynaldo G. Elmido, *associate - MPDS dispatch*
Rodrigo M. Fule, *driver*
Emilio R. Gonzalez, Jr., *technician III - AC mechanic*
Romeo L. Jarmin, *technician III - mechanic*
Perlita E. Malabayabas, *BS, secretary III*
Armando E. Malveda, *technician III - mechanic*
Diosdado D. Mamaril, *BS, driver*
Hernani M. Moreno, *driver*
Jomar P. Ofrecio, *BS, technician II - mechanic*
Bonifacio M. Palis, *associate - MPDS dispatch*
Eduardo L. Pua, *driver*
Roduardo S. Quintos, *technician III - mechanic*
Rolando L. Santos, *associate - MVRS service advisor*
Oscar A. Templanza, *associate - MPDS dispatch*
Ronilo M. Villanueva, *BS, technician II - mechanic*
Renato C. Vivas, *driver*
Argyll D. Viyar, *BS, technician II – mechanic*

Seed Health Unit

Patria G. Gonzales, *MS, manager*
Myra C. Almodiel, *MS, assistant scientist*
Jay A. Angeles, *BS, technician I - research*
Jose F. Banasihan, *technician I - research*
Salome P. Bulaquiña, *data encoder*
Aurelio A. Gamba, *technician II - research*
Evangeline G. Gonzales, *BS, secretary III*
Carlos C. Huelma, *BS, assistant scientist*
Florencio I. Lapiz, *BS, technician II - research*
Atanacio B. Orence, *technician III - research*
Isabel L. Penales, *technician III-research*

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[1]*Left during the year*
[2]*On leave*
[3]*Joined during the year*
[4]*On project appointment*
[5]*Transferred from Crop and Environmental Sciences Division*
[6]*Transferred from Crop Research Informatics Laboratory*
[7]*Transferred from Events, Visitors, and Information Services*
[8]*Transferred from International Programs Management Office*
[9]*Transferred from Plant Breeding, Genetics, and Biotechnology Division*
[10]*Transferred from Training Center*
[11]*Retired during the year*
[12]*Died during the year*
[13]*Resigned*
[14]*Returned from study leave*
[15]*Effective April 2008*
[16]*Effective January 2008*
[17]*Effective July 2008*
[18]*Effective September 2008*

January

- Dr. Bas Bouman was appointed head of the Crop and Environmental Sciences Division.
- Dr. Inez Slamet-Loedin joined as shuttle scientist, Intellectual Property Management Unit.
- Dr. John Bennett, senior scientist, molecular biology, Plant Breeding, Genetics, and Biotechnology Division, left after completion of his assignment.
- Dr. Yolanda Chen, scientist, entomology, Crop and Environmental Sciences Division, left after completion of her assignment.
- Dr. Mark Bell joined as consultant, International Programs Management Office, and left after completion of his assignment.
- Dr. Keijiro Otsuka joined as consultant, Director General's Office.
- Dr. Edgar Paski joined as consultant, Crop and Environmental Sciences Division, and left after completion of his assignment.
- Dr. Digna Manzanilla joined as postdoctoral fellow, Social Sciences Division.
- Dr. Samart Wanchana rejoined as postdoctoral fellow, Crop Research Informatics Laboratory.
- Dr. Dirk de Waele joined as consultant, Crop and Environmental Sciences Division.
- Dr. S.V. Krishna Jagadish, visiting research fellow, Plant Breeding, Genetics, and Biotechnology Division, left after completion of his assignment.
- Dr. Roh Jaewan, visiting research fellow, Plant Breeding, Genetics, and Biotechnology Division, left after completion of his assignment.
- Dr. Jianliang Huang, visiting research fellow, Crop and Environmental Sciences Division, left after completion of his assignment.
- Dr. Martin Kropff, consultant, Office of the Director General, left after completion of his assignment.
- Dr. Edgar Paski rejoined as consultant, Office of the Deputy Director General for Operations and Support Services, and left after completion of his assignment.
- Dr. Yunlong Xia, consultant, T.T. Chang Genetic Resources Center, left after completion of his assignment.
- Dr. Yongming Gao, visiting research fellow, Plant Breeding, Genetics, and Biotechnology Division, left after completion of his assignment.
- Dr. Stephen Zolvinski, postdoctoral fellow, Plant Breeding, Genetics, and Biotechnology Division, left after completion of his assignment.
- Dr. Bhanudeb Bagchi, consultant, Social Sciences Division, left after completion of his assignment.

February

- Mr. Martin Senger joined as bioinformatics software project manager, IRRI-CIMMYT Crop Research Informatics Laboratory.
- Dr. Deborah Templeton, scientist, social science, Social Sciences Division, left after completion of her assignment.
- Dr. S.V. Krishna Jagadish joined as postdoctoral fellow, Crop and Environmental Sciences Division.
- Dr. Jacob van Etten joined as postdoctoral fellow, Social Sciences Division.
- Mr. Gordon MacNeil joined as consultant, Office of the Director for Management Services, and left after completion of his assignment.
- Mr. Woon-Chul Shin joined as visiting research fellow, Plant Breeding, Genetics, and Biotechnology Division.
- Mr. Michael Jonathan Mendoza joined as consultant, Crop Research Informatics Laboratory.
- Dr. Youn-Sang Cho, visiting research fellow, Plant Breeding, Genetics, and Biotechnology Division, left after completion of his assignment.
- Dr. Abu Nasar Md. Mahfuzur, consultant, Social Sciences Division, left after completion of his assignment.

March

- Dr. Uma Shankar Singh joined as South Asia regional project coordinator for *Developing Abiotic Stress Tolerance in Rice*, Plant Breeding, Genetics, and Biotechnology Division.
- Dr. Philippe Hervé, scientist, molecular biology, Plant Breeding, Genetics and Biotechnology Division, resigned.
- Dr. To Phuc Tuong, acting deputy director general for research, completed his assignment.
- Dr. John Bennett joined as consultant, Plant Breeding, Genetics, and Biotechnology Division.
- Dr. Alberto Barrion joined as consultant, Crop and Environmental Sciences Division.
- Dr. Matthieu Conte joined as postdoctoral fellow, Crop Research Informatics Laboratory.
- Mr. Robert Hill joined as consultant, Communication and Publications Services, and left after completion of his assignment.

- Dr. Len Wade joined as consultant, Crop Research Informatics Laboratory.
- Ms. Yoon-Ji Choi joined as visiting research fellow, Social Sciences Division.
- Dr. Xiangqian Zhao joined as postdoctoral fellow, Grain Quality, Nutrition, and Postharvest Center.
- Dr. Dong-Jin Lee joined as visiting research fellow, Plant Breeding, Genetics, and Biotechnology Division.
- Mr. David Paige joined as consultant, Crop and Environmental Sciences Division.
- Dr. Matthias Wissuwa joined as consultant, Crop and Environmental Sciences Division.
- Mr. Chris Hemmings joined as consultant, Communication and Publications Services.
- Dr. Binying Fu, visiting research fellow, Plant Breeding, Genetics, and Biotechnology Division, left after completion of his assignment.
- Ms. Yoon-Ji Choi, visiting research fellow, Social Sciences Division, left after completion of her assignment.
- Dr. Yuichiro Furukawa, postdoctoral fellow, Crop and Environmental Sciences Division, left after completion of his assignment.

April

- Dr. Achim Dobermann was appointed as deputy director general for research.
- Dr. To Phuc Tuong returned to Crop and Environmental Sciences Division as water management engineer.
- Dr. Rakesh Kumar Singh was appointed as scientist, plant breeding, Plant Breeding, Genetics and Biotechnology Division.
- Dr. Kasushige Sogawa joined as consultant, Crop and Environmental Sciences Division.
- Dr. Tom Hazekamp joined as consultant, T.T. Chang Genetic Resources Center.
- Dr. Nobuko Katayanagi joined as visiting research fellow, Crop and Environmental Sciences Division.
- Dr. Yohei Koide joined as visiting research fellow, Plant Breeding, Genetics, and Biotechnology Division.
- Dr. Craig Meisner joined as consultant, International Programs Management Office.
- Dr. S.K. Bardhan Roy joined as consultant, Social Sciences Division.
- Mr. David Paige, consultant, Crop and Environmental Sciences Division, left after completion of his assignment.
- Dr. Alberto Barrion, consultant, Crop and Environmental Sciences Division, left after completion of his assignment.
- Mr. Woon-Chul Shin, visiting research fellow, Plant Breeding, Genetics, and Biotechnology Division, left after completion of his assignment.
- Mr. Jan Orsini, consultant, International Programs Management Office, left after completion of his assignment.
- Dr. Kamal Paudyal, consultant, Social Sciences Division, left after completion of his assignment.
- Dr. Choon-Song Kim, visiting research fellow, Plant Breeding, Genetics, and Biotechnology Division, left after completion of his assignment.
- Dr. Do-Yeon Kwak, visiting research fellow, Plant Breeding, Genetics, and Biotechnology Division, left after completion of his assignment.

May

- Dr. Inez Slamet-Loedin, shuttle scientist, Intellectual Property Management Unit, left after completion of her assignment.
- Dr. Serge Savary joined as senior scientist, plant pathology, Plant Breeding, Genetics, and Biotechnology Division.
- Dr. Laetitia Willocquet joined as scientist, plant pathology, Plant Breeding, Genetics, and Biotechnology Division.
- Dr. Samarendu Mohanty joined as senior economist and head, Social Sciences Division.
- Atty. Hector Hernandez, head, Human Resource Services, resigned.
- Dr. Canesio Predo joined as consultant, Social Sciences Division, and left after completion of his assignment.
- Dr. Sarah Covshoff joined as postdoctoral fellow, Crop and Environmental Sciences Division.
- Dr. Dev Mani Pandey joined as consultant, Plant Breeding, Genetics, and Biotechnology Division.
- Dr. John Bennett, consultant, Plant Breeding, Genetics, and Biotechnology Division, left after completion of his assignment.
- Dr. S.K. Bardhan Roy, consultant, Social Sciences Division, left after completion of his assignment.
- Dr. Craig Meisner, consultant, International Programs Management Office, left after completion of his assignment.

- Dr. Michael Thomson, postdoctoral fellow, Crop and Environmental Sciences Division, left after completion of his assignment.
- Dr. Muhammad Farooq, visiting research fellow, Plant Breeding, Genetics, and Biotechnology Division, left after completion of his assignment.
- Dr. Larry W. Harrington joined as consultant, Crop and Environmental Sciences Division.

June

- Dr. Michael Thomson was appointed as international research fellow, molecular genetics, Plant Breeding, Genetics, and Biotechnology Division.
- Dr. Christine Kreye, international research fellow, Crop and Environmental Sciences Division, left after completion of her assignment.
- Dr. Kyu-Seong Lee, senior scientist, plant breeding, left after completion of his assignment.
- Ms. Yoke Sau Cheng Metz joined as consultant, Training Center, and left after completion of her assignment.
- Dr. Kasushige Sogawa, consultant, Crop and Environmental Sciences Division, left after completion of his assignment.
- Mr. Gordon MacNeil rejoined as consultant, Office of the Director for Management Services, and left after completion of his assignment.
- Dr. Nguyen Thi Duong Nga joined as consultant, Crop and Environmental Sciences Division.
- Dr. Yolanda Chen joined as collaborative research scientist, Crop and Environmental Sciences Division.
- Dr. Gail Langellotto joined as collaborative research scientist, Crop and Environmental Sciences Division.
- Dr. Jong-Cheol Ko joined as visiting research fellow, Plant Breeding, Genetics, and Biotechnology Division.

July

- Dr. Jagdish K. Ladha, senior scientist, soil science; coordinator, Rice Wheat Consortium; and country representative for India, returned from study leave.
- Dr. Gary Jahn, coordinator for the Greater Mekong Sub-region; country representative and Lao-IRRI project manager; and senior scientist, entomology, left after completion of his assignment.
- Dr. Satya Nugroho joined as consultant, Plant Breeding, Genetics, and Biotechnology Division.
- Dr. Larry W. Harrington, consultant, Crop and Environmental Sciences Division, left after completion of his assignment.
- Dr. Larry W. Harrington rejoined as consultant, Office of the Deputy Director General for Research, and left after completion of his assignment.
- Dr. Kay Sumfleth joined as visiting research fellow, Crop and Environmental Sciences Division.
- Dr. Hao Chen, postdoctoral fellow, Plant Breeding, Genetics, and Biotechnology Division, resigned.
- Dr. Suk-Man Kim, visiting research fellow, Plant Breeding, Genetics, and Biotechnology Division, left after completion of his assignment.
- Dr. Yolanda Chen, collaborative research scientist, Crop and Environmental Sciences Division, left after completion of her assignment.
- Dr. Gail Langellotto, collaborative research scientist, Crop and Environmental Sciences Division, left after completion of her assignment.
- Mr. Nguyen Nang Nhuong, consultant, Grain Quality, Nutrition, and Postharvest Center, left after completion of his assignment.
- Mr. Vu Cong Khan, consultant, Grain Quality, Nutrition, and Postharvest Center, left after completion of his assignment.
- Ms. Ho Thi Tuyet, consultant, Grain Quality, Nutrition, and Postharvest Center, left after completion of her assignment.
- Mr. Nguyen Van Doan, consultant, Grain Quality, Nutrition, and Postharvest Center, left after completion of his assignment.
- Mr. Cao Van Hung, consultant, Grain Quality, Nutrition, and Postharvest Center, left after completion of his assignment.

August

- Dr. Inez Slamet-Loedin joined as scientist, plant biotechnology, Plant Breeding, Genetics, and Biotechnology Division.
- Dr. Kyung-Ho Kang joined as senior scientist, plant breeding, Plant Breeding, Genetics, and Biotechnology Division.
- Dr. Madonna Casimero joined as project scientist, Crop and Environmental Sciences Division.

- Dr. Viacheslav Adamchuk joined as consultant, Crop and Environmental Sciences Division, and left after completion of his assignment.
- Dr. Devendra Gauchan joined as postdoctoral fellow, Social Sciences Division.
- Dr. Hari Nath Singh joined as postdoctoral fellow, Social Sciences Division.
- Mr. Chris Hemmings, consultant, Communication and Publications Services, left after completion of his assignment.
- Dr. Suk-Man Kim rejoined as visiting research fellow, Plant Breeding, Genetics, and Biotechnology Division.
- Dr. Dong-Jin Kang joined as postdoctoral fellow, Crop and Environmental Sciences Division.
- Dr. Amelia Henry joined as postdoctoral fellow, Crop and Environmental Sciences Division.
- Mr. Robert Hill rejoined as consultant, Communication and Publications Services.
- Mr. Michael Jonathan Mendoza, consultant, Crop Research Informatics Laboratory, left after completion of his assignment.
- Ms. Yoke Sau Cheng Metz rejoined as consultant, Training Center.
- Dr. Satya Nugroho, consultant, Plant Breeding, Genetics, and Biotechnology Division, left after completion of his assignment.

September

- Dr. C. Graham McLaren, Program 6 leader; senior scientist, biometrics and head, IRRI-CIMMYT Crop Research Informatics Laboratory, resigned.
- Ms. Fiona C. Farrell joined as head, Human Resource Services.
- Dr. Ajay Kohli joined as senior scientist, molecular biology, Plant Breeding, Genetics, and Biotechnology Division.
- Dr. John Bennett rejoined as consultant, Plant Breeding, Genetics, and Biotechnology Division, and left after completion of his assignment.
- Mr. Robert Hill, consultant, Communication and Publications Services, left after completion of his assignment.
- Dr. Xin'ai Zhao, postdoctoral fellow, Plant Breeding, Genetics, and Biotechnology Division, left after completion of her assignment.

October

- Dr. Finbarr Horgan joined as scientist, entomology, Crop and Environmental Sciences Division.
- Dr. Edgar Paski rejoined as consultant, Crop and Environmental Sciences Division, and left after completion of his assignment.
- Dr. Md. Khairul Bashar joined as consultant, Plant Breeding, Genetics, and Biotechnology Division, and left after completion of his assignment.
- Dr. Susanna Poletti, postdoctoral fellow, Plant Breeding, Genetics, and Biotechnology Division, left after completion of her assignment.
- Dr. Alberto Barrion rejoined as consultant, Crop and Environmental Sciences Division.
- Dr. N. Venkatesa Palanichamy joined as consultant, Social Sciences Division.

November

- Dr. Tajinder S. Bharaj joined as consultant, Plant Breeding, Genetics, and Biotechnology Division.
- Dr. N. Venkatesa Palanichamy, consultant, Social Sciences Division, left after completion of his assignment.
- Dr. Jagadish Timsina, consultant, Crop and Environmental Sciences Division, left after completion of his assignment.
- Dr. Dev Mani Pandey, consultant, Plant Breeding, Genetics and Biotechnology Division, left after completion of his assignment.
- Dr. Dilantha Gunawardana, postdoctoral fellow, Crop and Environmental Sciences Division, resigned.
- Ms. Judith Buresh joined as consultant, Human Resource Services.
- Dr. So-Hyeon Baek joined as visiting research fellow, Plant Breeding, Genetics, and Biotechnology Division.
- Mr. Chun K. Lai joined as consultant, Social Sciences Division.
- Dr. Jessica Rey joined as postdoctoral fellow, T.T. Chang Genetic Resources Center.
- Dr. Jian-Long Xu joined as visiting research fellow, Plant Breeding, Genetics, and Biotechnology Division.
- Dr. Prahbjit Chadha Mohanty joined as consultant, Plant Breeding, Genetics, and Biotechnology Division.
- Mr. Mark Jones joined as consultant, Operations Management Unit.

- Dr. Yolanda Garcia joined as consultant, Social Sciences Division.
- Dr. Alberto Barrion, consultant, Crop and Environmental Sciences Division, left after completion of his assignment.

December

- Dr. Jagadish Timsina joined as senior scientist, cropping system agronomy, Crop and Environmental Sciences Division.
- Mr. Adam Barclay, international research fellow and science writer/editor, Communication and Publications Services, left after completion of his assignment.
- Dr. John Sheehy, senior scientist, crop ecology/crop modeling and head of Applied Photosynthesis and Systems Modeling Laboratory, Crop and Environmental Sciences Division, retired.
- Dr. Impa Somayanda, postdoctoral fellow, Crop and Environmental Sciences Division, left after completion of her assignment.
- Dr. Endang Septiningsih, postdoctoral fellow, Plant Breeding, Genetics, and Biotechnology Division, left after completion of her assignment.
- Dr. Ramaiah Venuprasad, postdoctoral fellow, Plant Breeding, Genetics, and Biotechnology Division, left after completion of his assignment.
- Dr. Boru Douthwaite joined as consultant, Grain Quality, Nutrition, and Postharvest Center, and left after completion of his assignment.
- Dr. Yolanda Garcia, consultant, Social Sciences Division, left after completion of her assignment.
- Dr. Jian-Long Xu, visiting research fellow, Plant Breeding, Genetics, and Biotechnology Division, left after completion of his assignment.
- Dr. Suk-Man Kim, visiting research fellow, Plant Breeding, Genetics, and Biotechnology Division, left after completion of his assignment.
- Dr. Randolph Barker, consultant, Social Sciences Division, left after completion of his assignment.
- Dr. Nguyen Thi Duong Nga, consultant, Grain Quality, Nutrition, and Postharvest Center, left after completion of his assignment.
- Ms. Rizalina Gonzalez joined as consultant, Human Resource Services.
- Dr. Helal Uddin Ahmed joined as postdoctoral fellow, Plant Breeding, Genetics, and Biotechnology Division.
- Dr. Young-Chan Cho joined as visiting research fellow, Plant Breeding, Genetics, and Biotechnology Division.

Olivyn R. Angeles, To Phuc Tuong, Abdelbagi M. Ismail, Ernesto G. Castillo, Romeo J. Cabangon, and James A. Egdane, CESD

- First runner-up (senior category), *Responses of three contrasting rice cultivars to salt stress and water deficit imposed during vegetative and reproductive stages,* 11th Annual Meeting and Scientific Conference of the Philippine Society of Soil Science and Technology, Inc., Bohol, May.

Adam Barclay, managing editor, *Rice Today*, CPS

- Won a gold award in the 2008 Critique and Awards competition of the U.S.-based Association for Communication Excellence in Agriculture, Natural Resources, and Life and Human Sciences (ACE) for his feature article *High and dry* in *Rice Today* magazine, May.

Adam Barclay, George Reyes, Ariel Javellana, Gene Hettel, Meg Mondoñedo, Juan Lazaro IV, Bill Hardy, Jose Raymond Panaligan, Emmanuel Panisales, and Chris Quintana, CPS

- Won three gold awards and one silver award (magazines and periodicals category) in the 2008 Critique and Awards competition of ACE for material in the four 2007 issues of *Rice Today* magazine, May.

Romeo Cabangon, associate scientist, CESD

- Named Outstanding Filipino Agricultural Engineer in the field of soil and water management, Philippine Society of Agricultural Engineers, Laguna, Philippines, April.

Oliver B. Castillo, Jack Deodato C. Jacob, Eufrocino V. Laureles, and Sarah Johnson-Beebout, CESD

- Second runner-up (senior category), *Increasing rice grain zinc by optimizing water and fertilizer management*, 11th Annual Meeting and Scientific Conference of the Philippine Society of Soil Science and Technology, Inc., Bohol, May.

Eugenio C. Castro, Jr., associate scientist, TC

- Named Outstanding Professional of the Year in the field of agricultural engineering, Professional Regulation Commission, Manila, Philippines, June.
- Received the 2008 Distinguished Alumnus Award from the University of the Philippines Los Baños Alumni Association and the College of Engineering and Agro-Industrial Technology Alumni Association for professional competence of the highest degree in the practice of his agricultural engineering profession, Laguna, Philippines, October.
- Awarded the 2008 Excellence Award for demonstrating the highest degree of excellence, ideals, and workmanship in practicing the agricultural engineering profession, Philippine Federation of Professional Associations, Manila, Philippines, November.

Achilleus Coronel, IRRI Web consultant

- Finalist, *Virtruvian Maiden*, Toyota Art Edge Digital Art Competition, Makati City, Philippines, September.

Surajit Kumar de Datta, former IRRI agronomist

- Received a plaque of recognition for his contribution to research and education, University of the Philippines Los Baños, Philippines, May.
- Received a plaque of recognition for his contribution to the Green Revolution in Asia in the 1960s, IRRI, Los Baños, Philippines, May.

Mary Jacqueline A. Dionora, P.P. Pablico, R.T. Mogul, M. Orlina, K.G. Tan, F.R. Danila, and J.E. Sheehy, CESD

- Won the Best Poster Award (Upstream Research) for *CO_2 compensation point in the wild species of rice*, Crop Science Society of the Philippines, Iloilo City, Philippines, May.

Achim Dobermann, deputy director general for research

- Received the 2008 IFA International Crop Nutrition Award for his pioneer research on the fine-tuning of fertilizer and crop management practices to promote the ecological intensification of rice, maize, and soybean production systems in many countries, Vienna, Austria, May.

Evangelina S. Ella, Georgina V. Vergara, and Abdelbagi M. Ismail, CESD

- Won the Best Paper Award (Upstream Research) for *High amylase activity and high ethylene production in rice tolerant of flooding at germination and early seedling stage*, Crop Science Society of the Philippines, Iloilo City, Philippines, May.

Environmental Soap Opera for Rural Vietnam drama series

- Received a commendation certificate from One World Broadcasting Trust for outstanding and unique contribution to the communication of sustainable development and human rights.

Rolly G. Fuentes, collaborator, CESD

- Won the Best Paper Award in Weed Science for his *Biochemical study on the ecotypic variation of upland and lowland purple nutsedge* (Cyperus rotundus *L.*), Pest Management Council of the Philippines, Palawan, Philippines, May.

IRRI

- Received the International Award for Science and Technology, Chinese State Council, June.
- Received a testimonial plaque for outstanding support and cooperation through the organization of mass blood donations, Philippine National Red Cross Laguna Chapter, Sta. Cruz, Laguna, Philippines, July.
- Received a certificate of recognition for supporting the Los Baños Municipal Police Station in logistical needs, Calamba City, Philippines, August.

Joel D. Janiya, associate scientist, CESD

- Received the Pest Management Award in Research, in recognition of his outstanding achievements in crop protection research and contribution to the advancement of weed science research in the Asia-Pacific region, Pest Management Council of the Philippines, Palawan, Philippines, May.

Ariel Javellana, officer-photography, CPS

- Won a gold award and a silver award in the 2008 Critique and Awards competition of ACE for two photographs *(below)* in the October-December 2007 issue of *Rice Today,* May.
- Won second prize (photo service category) in the 2008 Critique and Awards competition of ACE for the *2007 IRRI family photo*, May.

Ariel Javellana and Jose Raymond Panaligan, officers-photography, CPS

- Won a silver award (picture story category) in the 2008 Critique and Awards competition of ACE for the article *Rice in harm's way*, May.

Edwin Javier, former coordinator, INGER

- Appointed international variety development coordinator, Asian Vegetable Research and Development Center, March.

Romeo V. Labios, IRRI consultant and project coordinator

- Received the *"Gintong Butil"* (Golden Grain) Award for science and technology for excellence in his field, Central Luzon State University 2008 Grand Alumni Homecoming, Muñoz, Nueva Ecija, Philippines, April.

Kyu-Seong Lee, former senior scientist, PBGB

- Appointed director of the Reclaimed Land Agricultural Research Division, Department of Rice and Winter Cereal Crops, National Institute of Crop Science, Rural Development Administration, Republic of Korea, October.

Hei Leung, senior plant pathologist, CESD

- Recognized by the National Chung Hsing University, Taichung, Taiwan, as a chair professor in molecular breeding, Department of Agronomy, October.

David Mackill, head, PBGB; Julia Bailey-Serres, University of California (UC) Riverside; and Pamela Ronald, UC Davis

- Received the 2008 United States Department of Agriculture (USDA) National Research Initiative Discovery Award as principal investigators on grants the USDA has awarded them for rice research using sophisticated breeding technology to precisely transfer *Sub1A* into popular high-yielding rice varieties of countries in South and Southeast Asia, UC Riverside, December.

Ramil Mauleon, Genevieve Aquino, Jill Cairns, Somayanda Impa, D.C. Liu, Rachid Serraj, and Rolando Torres (IRRI); Truschar Shah, Cristelle Bencivenni, Guy Davenport, and Jean-Marcel Ribaut (CIMMYT); Claude Welcker, François Tardieu, and Benoit Bousugge (INRA); and Brigitte Courtois (CIRAD)

- Won the Best Poster Award in Theme 2: Genomic resources and gene/pathway discovery for the poster *Identification of orthologous regions associated with tissue growth under water-limited conditions*, Generation Challenge Program Annual Research Meeting 2008, Bangkok, September.

Colin McClung, former IRRI assistant/associate director

- Named 2008 Fellow of the American Society of Agronomy, Houston, Texas, October.

Teodoro R. Migo, assistant scientist, CESD

- Elected president of the Weed Science Society of the Philippines for 2008-09, Philippines, May.

Norman Oliva, Editha Abrigo, Jeanette Lescano, Genelou Atienza, Susana Poletti, Marina Manzanilla, Conrado Dueñas, Jr., Reynaldo Garcia, Philippe Hervé, Gerard Barry, and Inez Slamet-Loedin, PBGB/IPMU

- Won the Best Poster Award for *Enhancing nutrition in rice through biotechnology*, 6th Scientific Conference, Philippine Association for Plant Tissue Culture and Biotechnology, Los Baños, Laguna, Philippines, October.

Alvaro M. Pamplona, associate scientist, PBGB

- Conferred the 2008 CSSP Achievement Award for Technology Development for his significant contribution to the development of improved rice varieties for unfavorable rice-growing environments in the Philippines, Crop Science Society of the Philippines, Iloilo City, Philippines, May.

H. Pathak, co-facilitator, Rice-Wheat Consortium, IRRI-India Office

- Elected president for 2008-09 of the Section of Agriculture and Forestry Sciences, Indian Science Congress Association, January.

Renato A. Reaño, associate scientist, GRC

- Received a testimonial award for his significant contributions as CSSP president for 2006-07, Crop Science Society of the Philippines, Iloilo City, Philippines, May.

Edilberto Redoña, Ma. Concepcion Toledo, Marcelino Laza, Franco Nazareno, Glenn Alejar, Virgilio Ancheta, Jose Angeles, Fe Danglay, Cenon Lanao, Nestor Leron, Virgilio Magat, Jose Marasigan, Honorio Oboza, Renato Pizon, Allan Salabsabin, Ernesto Sumague, and Joseph Vicente, INGER (photo below)

- Won the 2008 CGIAR Science Award for Outstanding Scientific Support Team, CGIAR Annual General Meeting, Maputo, Mozambique, December.

Swe Zin Myint Thein, T.H. Borromeo, R.K. Singh, and J.E. Fernandez, PBGB

- Won the Best Paper Award on the *Introgression of salinity* (Saltol) *and submergence* (Sub1) *QTLs to new genetic background of rice* (Oryza sativa *L.*), 7th Annual Research Conference, Myanma Academy of Agriculture, Forestry, Livestock, and Fisheries, Myanmar, October.

T.P. Tuong, senior scientist, CESD

- Received the 2008 International Society of Paddy and Water Environment Engineering (PAWEES) Award for outstanding work on natural resource management, PAWEES 2008 International Conference and Annual Meeting, National Taiwan University, Taiwan, Republic of China, October.

Sant Virmani, former principal scientist, PBGB

- Conferred the Padma Shri Award (science and engineering category) by President Smt. Pratibha Devisingh Patil, Republic Day, India, May.
- Honored as one of the world's leading agricultural scientists in the field of hybrid rice by the Plano City mayor, with the proclamation of 22 June as *Dr. Sant Virmani Day*, Texas, USA, June.

Reiner Wassmann, coordinator, Rice and Climate Change Consortium

- Recognized for substantial contributions to the 2007 Nobel Peace Prize, United Nations Intergovernmental Panel on Climate Change, July.

Robert S. Zeigler, director general

- Named president of the Los Baños Science Community Foundation, Inc., Los Baños, Philippines, July.

ANALYTICAL SERVICE LABORATORIES

The Analytical Service Laboratories (ASL) continue to provide analytical and analysis-related services to IRRI's research projects, in addition to undertakings that aim to improve its analytical capability and to work on its ISO 17025 accreditation.

Analytical services

A total of 42,861 analyses were completed for routine plant, soil, solution, and fertilizer samples, including elemental C/N and stable isotope ratio analysis of ^{13}C and ^{15}N. Of the total analyses, 75% were done on plant samples, 23% on soils, and 2% on solutions (ASL Table 1). About 92% of the total samples received came from the Crop and Environmental Sciences Division (CESD); the rest came from Plant Breeding, Genetics, and Biotechnology Division (PBGB); Grain Quality, Nutrition, and Postharvest Center (GQNPC); World Agroforestry Center (ICRAF); and external clients from the University of the Philippines Los Baños (UPLB), the Ecosystem Research and Development Bureau (ERDB), and Mindanao State University (MSU) (ASL Table 2).

ASL Table 1. Analyses completed in 2008.

Analysis	ASL section		Total	Percent
	PSL[a]	MSL[b]		
Plant	30,134	2,002	32,136	74.98
Soil	8,793	1,050	9,843	22.96
Solution	874	–	874	2.04
Fertilizer	–	8	8	0.02
Total	39,801	3,060	42,861	100.00

[a]Plant and Soil Laboratory. [b]Mass Spectrometry Laboratory.

ASL Table 2. Profile of samples and analyses completed in 2008, by OU.

OU	Samples (no.)	Percent	Analyses (no.)	Percent
CESD	11,337	92.25	39,909	93.11
PBGB	758	6.17	2,469	5.76
GQNPC	8	0.06	112	0.26
ICRAF	33	0.27	33	0.08
External clients (UPLB, ERDB, MSU)	153	1.25	338	0.79
Total	12,289	100.00	42,861	100.00

Interaction with clients

ASL continued its effort to improve client interaction by conducting short training programs to help clients and research staff understand quality assurance as it applies to ASL results. A division seminar on "*Chemical waste management among CESD laboratories*" was conducted and a tutorial video on "*In-house treatment of acid wastes by neutralization*" was presented. These activities equipped laboratory staff with skills in laboratory waste treatment before disposal; it also initiated the development of the "Chemicals, Office Supplies, Consumables, and Other Materials" (COCO) exchange program by the PMMS unit. Another seminar, "*ASL: meeting the analytical needs of IRRI scientists and researchers,*" provided up-to-date information on the unit and gave guidelines in choosing the appropriate laboratory method and analysis for samples. Survey results on IRRI researchers' analytical requirements were also presented and audience feedback solicited to further improve client interaction. A new ASL brochure was also distributed.

Data management system

ASL's data management system, which was developed in-house, continued to expand in 2008. Among the significant improvements were multiuser access with password security, detailed sample tracking and reporting, a charging system, reference material database, analysis report generation, control charts, and data retrieval by e-mail attachment.

Staff training

Continuing education among ASL staff was given priority through short training programs and tutorials every week, thus increasing staff competency to provide quality services. The topics included the following:

1. Control charts and trends
2. Safe handling of laboratory chemicals and toxic and hazardous wastes
3. Practical and cost-effective solution to laboratory wastes
4. Use of laboratory notebooks and logbooks
5. Pipette and balance—in-house calibration/verification
6. First- and second-level quality assurance evaluation of analytical data by research technicians and researchers

ASL consultants

ASL availed of the expertise of two consultants: 1) Ms. Soledad Castañeda of the Philippine Nuclear Research Institute conducted a 1-day training on liquid scintillation counting at the Radioisotope Laboratory of IRRI; and 2) Dr. Edgar F. Paski of the British Columbia Institute of Technology had a 5-day consultation on the ASL laboratory information management system, inductively coupled argon plasma method development, and trace cadmium determination in plant and soil samples.

IRRI-CIMMYT CROP RESEARCH INFORMATICS LABORATORY

Institutional progress

The Crop Research Informatics Laboratory (CRIL) team at IRRI, in particular the International Crop Information System (ICIS) development and support team, lost several key staff members in 2008, among them the head of CRIL. While some staff have moved abroad into the private sector, others have moved to other divisions within IRRI where they are still part of the wider ICIS community. Staff turnover in the area of informatics continues to be an ongoing problem due to market pressures, even within the Philippines.

The IRRI CRIL staff comprises 26 NRS positions, of which 13 are project-funded, as well as three postdoctoral fellows and four internationally recruited staff. IRRI currently hosts three CIMMYT CRIL staff. The head of CRIL, Graham McLaren, has moved to the Generation Challenge Program (GCP) as leader of the Bioinformatics and Crop Information subprogram. A breeding informatics specialist is being recruited as a replacement.

The initial 3-year IRRI-CIMMYT CRIL Memorandum of Agreement, which ended in December 2008, is under review for extension, possible expansion, and alignment with the CGIAR Change Program.

Technical progress

IRRI CRIL staff conducted or assisted with 21 training courses in 2008 (CRIL Table 1) in addition to continued consultation on experimental design and data management. A support site for research data management in the form of a Wiki was established at IRRI (http://cropwiki.irri.org/everest). The site has been populated with best practices, data management recipes, and guidelines and is used as the basis for the research data management training courses. Research projects over all programs in IRRI and CIMMYT consulted with CRIL staff on data management, design, and analysis of experiments and bioinformatics.

Progress has been made in developing and enhancing ICIS tools for crop information management. Version 5.5 of ICIS was released in July 2008 (http://cropforge.org/projects/iciscomm). The enhancement of the International Rice Information System (IRIS) with facilities to manage seed exchange in compliance with the Standard Material Transfer Agreement continued and is now considered a model for the CGIAR (www.iris.irri.org/smta). These facilities are also being implemented in the Seed Inspection and Distribution Unit at CIMMYT for maize and wheat. Progress has been made in developing an International Maize Information System genealogy database for maize. A maize pedigree parser has been developed by programmers at IRRI and was tested and deployed to harvest maize pedigrees from the maize Fieldbook application.

Work is continuing on the GCP Bioinformatics Platform designed to integrate diverse data sources via Web services and provide a workbench of integrated bioinformatics analysis and visualization tools. Two postdoctoral fellows provided bioinformatics support to GCP projects, one specializing in analysis of microarray data and the other in analysis of candidate gene families.

CRIL Table 1. Courses and workshops supported by CRIL in 2008.

Course/workshop	Date	Participants (no.)
Introduction to Computers, Excel, Experimental Designs, and Data Analysis, Luang Prabang, Lao PDR	14–18 Jan	22
Research Data Management Course	29–31 Jan	10
Research Data Management Course	18–20 Feb	10
Basic Experimental Designs and Data Analysis using CropStat	18–22 Feb	20
ICIS Developers' Workshop	3–7 Mar	35
ICIS Breeders' Training Course	10–14 Mar	22
Bioinformatics Workshop	24–28 Mar	28
Research Data Management Course	26–28 Mar	10
ICIS Developers' Workshop, Nunhems, The Netherlands	14–15 Apr	8
Research Data Management Course	22–24 Apr	10
Crop Bioinformatics section of the Rice Production Course	May	29
Research Data Management Course	13–15 May	8
Research Data Management Course	3–5 June	11
Research Data Management Course	1–3 July	11
Rice Breeding Course	30 July–14 Aug	27
Introduction to SAS Enterprise Guide (SG)	15 Aug	22
Research Data Management Course	19–21 Aug	10
IRIS workshop for brain Quality/Chalk Project	20–22Aug	14
Analysis of Mixed Models Using CropStat	23–25 Sep	12
Research Data Management Course	6–8 Oct	11
Research Data Management Course	2–4 Dec	12
Statistics Training Course, Kathmandu, Nepal	1–5 Dec	13
Statistics Training Course, ICAR NEH, India	8–12 Dec	13

COMMUNICATION AND PUBLICATIONS SERVICES

Through CPS, IRRI produced eight titles in 2008, including two scientific books, four issues of *Rice Today*, and the award-winning 2007 annual report on DVD and the Web. Also produced were four issues of *Rice Research for Intensified Production and Prosperity in Lowland Ecosystems (RIPPLE)*. Currently, around 10 titles are in the production queue for 2009 and beyond.

The *International Rice Research Notes (IRRN)* went open access in 2008 using Open Journal Systems (OJS) and is available online only. New articles are added as soon as they have been reviewed, edited, and approved for publication.

In 2008, IRRI teamed up with *The Rice Trader*, the world's leading trade publication dedicated to in-depth analysis of the global rice industry, which took over publishing of the Institute's award-winning flagship publication, *Rice Today*, with the April 2009 issue. IRRI retains full editorial control in this "marriage" and we anticipate an even better and more relevant publication that will serve the overall rice world.

IRRI on the Web

The Institute moved forward in earnest in 2008 toward developing a new IRRI Web presence, which involves establishing a unique Web content management system. It will be an integrated system with multiple sites and institutional information clustered around an *irri.org*-branded corporate Web portal. Throughout 2008, CPS took the lead to begin the long-term task of developing the new site—a beta version was launched in which www.irri.org now takes clients to the front page of the new site, although certain links still go back to the old site as transition of files from old to new continues (about 65% complete). If you have an opportunity, take a look at the new http://irri.org. Please send feedback to the Web community manager, Albert Borrero, a.borrero@cgiar.org.

The project to make IRRI publications available using Google books (coordinated with ITS) yielded fantastic results. See the ITS section for more details.

From December 2006 up to mid-2008, CPS and Library and Documentation Services (LDS) partnered to produce the *IRRI Rice Thesaurus*, a searchable electronic database consisting of more than 3,200 standard terms pertaining to rice and related subjects. The thesaurus is used by information providers as a source of controlled vocabularies for the subject description of books, journal articles, conference papers, and other information sources. Likewise, it aims to fill the gap in the search process by enabling comprehensive searches via the use of standard terms that are linked to related, narrower, and broader terms. To make the *IRRI Rice Thesaurus* more useful to scientists worldwide, it is now made available on the Web via the National Agricultural Library (NAL) , Agricultural Research Service, United States Department of Agriculture.

IRRI and the media

The year 2008 was again a busy one for IRRI's relationship with the news media, as rice prices continued to increase and eventually surpassed $1,000 per ton by mid-2008. This led to an unprecedented level of media coverage for IRRI. IRRI and its staff were featured on BBC, CNN, NBC Nightly News, New York Times, Newsweek, NPR, and Bloomberg, among many others.

As IRRI approaches its 50th anniversary in 2010, the Web page on *Significant Dates in IRRI History* at www.irri.org/about/history.asp is continually being updated as new events occur and more past historical events are added. Serving as a window to issues, activities, and features about rice across the globe, Rice News Worldwide (http://ricenews.irri.org) provided links to nearly 1,640 timely stories in 2008 and it continues to be updated daily, now totaling more than 4,560 articles since archiving began in March 2005. This news service has been revamped and retooled to serve as a unique, searchable archive on rice stories in such areas as climate change and rice markets and regional news for Asia, Africa, Australia-Oceania, and the Americas and specific countries such as India, China, and the Philippines.

Communication support

CPS continues to provide communication support for the entire Institute, including editing, graphic design, art and illustration, audiovisual, photography, video, and advice on printing at IRRI's copy center and with outside vendors.

In 2008, approximately 16,600 new digital photographs were produced. This year also saw CPS enhance its Web presence with flickr. With more than 34,000 photos online, rice-related photos can now be searched, downloaded, and delivered to clients at "lightning" speed. Seven video programs were produced and 105 shorter clips were provided for the Bulletin (IRRI's weekly newsletter for staff, BOT, and alumni; http://bulletin.irri.cgiar.org) and PowerPoint presentations. Around 130 IRRI videos are now displayed on YouTube.

Graphic artists produced 70 illustrations, laid out 1,145 pages for publications, and prepared and printed 209 posters on the CPS large-format printer. IRRI editors worked on more than 1,825 pages appearing in refereed journal articles, 1,531 pages appearing in IRRI's scientific books, plus 40 pages for the *International Rice Research Notes*, four issues each of *Rice Today* and the newsletter *Ripple*, and more than 2,100 pages of additional conference papers, abstracts, proposals, and other documents.

The IRRI Copy Center, managed by ITS, generated 863,499 copies during 2008.

External review of CPS and LDS

On 14-18 April, Library and Documentation Services (LDS) and CPS underwent an external review (photo). The review team helped both units determine how they should evolve over the next few years, which technologies to adopt, and how to maintain the services they currently provide to the Institute.

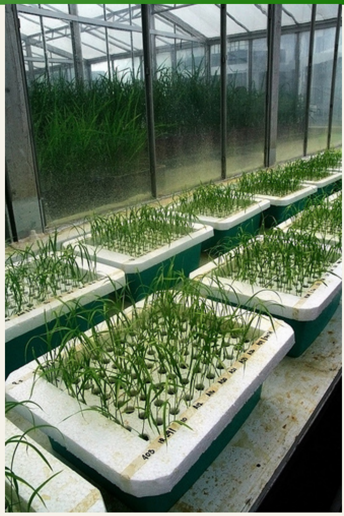
The team comprised

- Jay Maclean (chair)—Jay worked with IRRI to write the Strategic Plan. Has many years of experience in publication and communications (ex-ICLARM), and often works as a consultant to ADB. He lives in Manila.
- Rob Salamon—former head of External Relations at ADB for more than 20 years.
- Albert Atkinson—former IRRI Web specialist who developed the Rice Knowledge Bank, now at ADB heading its Information Resources and Services Unit.
- Janet McCue—director of the Mann Library (Life Sciences) at Cornell University.

The review team's final report and recommendations, together with the CPS/LDS responses, are in a document called *A Golden Opportunity*.

EXPERIMENT STATION

In 2008, the Experiment Station (ES) provided support services to 296 field and greenhouse experiments. The Field Operations Unit served the requirements of 182 field experiments, while the Controlled Plant Growth Facilities and Grounds Unit (CGFG) supported 35 experiments in the Phytotron and CL4 transgenic greenhouse facilities and 79 experiments in all other greenhouses. About 9,900 maintenance and service requests were fully served by the various support units of the ES during the year.



Land use

A total of 311.45 ha were used during the 2008 dry and wet seasons. The biggest user groups were (ES Table 1) and PBGB. ES used 136 ha for field demonstration, seed increase, and rice production purposes, while PBGB planted a total of 130 ha for their various experiments.

Seedling requirements of the different field experiments were established and maintained by the ES on 15.8 ha of dry and wet nursery beds, using field nurseries covering 10.8 ha and 5 ha, respectively. The rest of the seedling requirements were grown on a 40- × 10-m pavement using modified *dapog* nurseries.

ES Table 1. Land use by IRRI OU.

OU	Dry season (ha)	Wet season (ha)	Total (ha)
CESD	23.42	12.65	36.07
ES	67.98	68.15	136.13
GQNPC		0.25	0.25
GRC	5.70	2.59	8.29
PBGB	70.92	58.69	129.61
TC		1.10	1.10
Total	168.02	143.43	311.45

Crop production operations

ES seed increase and rice production operations in 2008 were done on 136 ha, a 3% reduction from the 141 ha in 2007. The currently established practice of producing rice in vacant fields resulted in more efficient and cost-effective maintenance operations, better use of the land, and reduced maintenance cost. It helped the Institute recover costs, with the added value of supplying low-cost but high-quality milled rice to its national employees. Farm operations remain focused on providing research support services to experiments at the station. The purpose of rice production operations at the farm has mainly been more on efficiently maintaining fields not used for research and less on getting high yields. As such, rice production operations are given lower priority than research requirements, thus keeping production costs down and ensuring that resource requirements for the rice production component of ES operations do not compete with Institute research needs and do not conflict with the farm's research support mandate.

Production crops were established mainly by direct seeding through manual broadcasting of pregerminated seeds, drum seeding on wet fields, and seed drilling on dry-prepared areas. The rest were established using manual and mechanical transplanting methods, particularly in deep plots and during wetter periods of the year when weather and field conditions did not favor direct seeding operations.

ES harvested 502 t from ES-managed production plots. Another 125 t of mixed varieties and remnant grains from border rows and excess materials from finished experimental setups were harvested

from researchers' plots. Harvesting in large plots was mainly done with the use of mechanical combine harvesters.

Agrochemical applications and crop protection services

A total of 96 t of different kinds of fertilizers were provided to various users of the farm in the form of ammonium sulfate, complete fertilizer, muriate of potash, solophos, urea, zinc oxide, and zinc sulfate. This total amount reflected a 19% increase in fertilizer applied as compared with the previous year.

Manual bird scaring continues to be the preferred method for avian pest control; the use of bird nets was the second option, with 3.2 ha of field being covered with nets immediately after seeding or near harvest. On the other hand, rat management practices, which mainly include installation of trap barrier systems, maintenance of fallow areas, burrow destruction, field sanitation and hygiene, and closed seasons contributed well to zero incidence of severe rat damage in all rice crops. Rat control services included the installation of 31 baiting stations and 46 ha of active barrier systems. The rat traps yielded a total of 1,025 live catches for the whole of 2008.

During the 2008 wet season, high tungro infestation was observed in the irrigated lowland series and in other fields, thereby increasing the amount of insecticides applied. This could be attributed to the planting of tungro-susceptible varieties NSICRc 148 and IR841. Before harvest, 17 ha of production plots were plowed under to contain the tungro infestation.

Irrigation and drainage services

A team of research technicians working on staggered schedules maintained the irrigation water supply to the entire IRRI farm to meet the needs of the different OUs. Some 232 irrigation requests were filled in 2008. A total of 199 ha in the dry season and 143 ha in the wet season were irrigated. Irrigation pipes were installed at 12 blocks and in the 900 series; sprinklers were installed in seven blocks during the dry season and in six blocks during the wet season. Also installed were 25 irrigation risers located in five blocks and four concrete boxes at Block UI.

Three gate valves in the upland and "old" area were repaired. Eighteen units of drainage outlet were installed and constructed at two blocks. Extraction and installation of submersible pumps were done. For some special irrigation setups, flat hoses were installed in Block B. Support was also provided for road clearing and desilting, and cleaning of waterways in the upland, lowland, and old area. A damaged perimeter fence in the 600-900 block series was repaired. To continuously provide irrigation water to all users, the pumps and reservoirs were regularly monitored, and cleaned and repaired as needed.

Land development and civil works

The whole block of UV2 (1 ha) was used as a drybed area with an improved drainage system. UO1 and UW1 were also developed to improve drainage; UW4 was being reworked with the same objective.

The drainage system was improved in UI1, UI2, and UI3 by installing 500 pieces of concrete pipe. The water supply in certain areas was augmented by installing 200 m of PVC pipes.

The fence materials dismantled from the UPLB coconut plantation were reinstalled at the IRRI perimeter fence, thereby preventing possible encroachment.

A new gate was constructed and the mechanical shop perimeter fence was reinforced as part of security measures being implemented in the area.

Desilting of pumps in four blocks and drilling a new irrigation pump at the Upper MN were done in anticipation of the Institute's high-volume water requirement.

Routine maintenance activities included roadside mowing, reservoir maintenance, road grading, straw and field waste collection and turnover to the soil rotation site, and soil hauling and delivery to the soil-grinding facility.

Equipment fabrication, repair, and maintenance services

The ES mechanical shop provided repair, fabrication, and maintenance services for tractors, farm equipment, implements, machinery, and irrigation facilities. More than 1,200 requests for repair and maintenance of light and heavy equipment and farm implements from the different units and research divisions were met. Forty units of different types of threshers and seed cleaners and 20 units of different dryers were repaired and maintained. Routine maintenance and repair services were also provided to the Rice Mill Unit.

Postharvest services and rice mill operations

Postharvest support services provided by ES include threshing, cleaning, drying, and storage, among others. A majority of the drying requirements of researchers for plant samples and harvested grains were accommodated using oven dryers and flatbed dryers being maintained by the station.

The Rice Mill Unit processed 513 t of paddy harvested from the IRRI farm in 2008. From the 306 t of milled rice produced, 294 t were distributed to the nationally recruited staff, while the rest (12 t) were issued to different organizational units or sold to the highest bidders. The byproducts of milling operations totaled 15 t of broken rice and 54 t of rice bran. Broken rice and rice bran were sold to the highest bidders through sealed bidding. Some of the rice bran was used for the fish production project. The rice hulls were also sold to regular buyers who use these for insulation, animal bedding, and landscaping/composting. The total value of the milled output is estimated at P10 million.

Phytotron/CL4 services

Basic research support services were provided to the 35 experiments conducted in the Phytotron. Some 126 maintenance and service requests were met during the year. The main bulk of manual operations at the CL4 involved autoclaving of incoming

and outgoing soil and plant materials. The staggered annual preventive maintenance shutdown of each transgenic greenhouse bay in the CL4 facility was implemented one bay at a time throughout the year, while the annual preventive maintenance shutdown operations for the Phytotron were done from 15 Nov to 15 Dec.

Phytotron users consumed a total of 14,520 gallons of RO-grade water for their experiments. The Baltimore cooling tower, chilled water pump, rainwater tank, the growth chambers in the Phytotron, and the catwalk in the solar and chiller areas were cleaned and repainted. Significant renovation work done in 2008 included replacement of dilapidated I-beam support and flooring of glasshouse 2, replacement of defective parts of the indoor and outdoor growth chambers, and servicing of the solar panel bays and chiller areas, chilled water pumps, rainwater tanks, and growth chambers. Renovation of the hot water tank will start in 2009. Other projects proposed for 2009 are the replacement of the Baltimore cooling tower and the construction of a new glasshouse as replacement for 12 units; these will help conserve energy, lessen maintenance cost, and eliminate the use of freon 22.

Through proper scheduling and sharing of space among experiments with similar requirements, all requests submitted in 2008 for the use of Phytotron facilities were accommodated.

Greenhouse services

The Greenhouses unit provided basic support services to all 79 experiments conducted in the glasshouses, screenhouses, and associated facilities. This included the servicing of 333 maintenance requests, 139 requests for soil, and delivery of 688.35 t of ground soil to support the soil requirements of greenhouse experiments and some field requirements for soil cover on seedbeds as well.

Preventive maintenance shutdown operations in 13 greenhouses were facilitated. These included clean-up by pressure washing, interior and exterior painting, screen repair/replacement, and minor plumbing work. The procedure helped reduce pesticide applications by providing a long break in the crop, pest, and disease cycles inside these units. Parts of the greenhouse section were refurbished after a typhoon damaged the facility in June. Roof replacement and clearing of drainage canals were done in some greenhouses. An additional 85 units of headhouses and soil bins were added to the plant growth facilities to be maintained by CGFG staff under the full-cost recovery program. Other routine operations included soil hauling, grinding and delivery, glass roof cleaning, screen and glass repair, soil and plant waste collection, and overall upkeep and maintenance of greenhouse surroundings and landscape.

PBGB was the biggest user of all greenhouse facilities, followed closely by CESD. GRC, on the other hand, was the main user of the screenhouse facility in the upland complex dedicated to maintaining wild rice and genebank germplasm collections.

Grounds services

The Grounds Services Unit met 300 requests for plant decoration, landscape maintenance and development, and other services. Service requests from office staff at the research center and from residents at staff housing included indoor plant decorations and outdoor landscaping support services for various residential areas, offices, the auditorium, building halls, and during seminars, workshops, and special events conducted at IRRI. Routine operations involved lawn maintenance and regular mowing services, road sweeping, brush cutting, and garbage collection in the research center, meteorological stations, reservoirs, and various staff housing units of the Institute.

Prominent areas that were improved and landscaped in 2008 were the NCBL and Umali buildings, MVRS parking area, the MSS façade, and the FF Hill Board Room. Fountains were installed at the Umali Building entrance door and in Harrar hallways. Anthills on the research center lawns were removed. New equipment acquisitions for the year included two power saws and other personal protective gear. Trash bins were deployed. Waste segregation in the greenhouse area and staff housing was continued. Trimming of trees and clearing operations on perimeter fence areas were done in staff housing as part of the annual clearing program. Workers' quarters were also refurbished. Regular maintenance of lawns and hedges at the research center, staff housing, PDA, PVA, UPCO, agromet stations, and the ES was done. Periodic pond cleanup was also done. Garbage collected was disposed of the upland dumpsite. Ornamental plants were propagated to meet the demand for indoor plants in the offices; plant decoration and arrangement were likewise facilitated.

Kabesilya labor services

The ES Administrative Unit continuously monitored the performance of kabesilya workers. The summary of performance data taken from services job completion feedback forms revealed 100% acceptability of services provided for contractual labor and bird scaring in 2008. Percentage acceptability is defined as the percentage of acceptable performance over the total number of requests served. Acceptability is indicated by affirmative responses of end-users to the question posted on the form asking users whether the performance of the kabesilya worker is satisfactory or better and whether the worker can be accepted for assignment to the same unit in future similar work requirements. Acceptability of all other task-based services remained high at 99.91%.

Kabesilya services rendered by two agricultural labor providers as requested by the various research divisions and support units in 2008 totaled 781,484 person-hours. This reflected a 25.03% increase in use compared with the previous year's 624,988 person-hours. Manual bird-scaring services, on the other hand, remained almost the same with a slight increase of less than 1% from 113,245 hours to 113,765 hours in 2008. A wage increase for agricultural workers in the region was issued in the middle of the year, following the regional wage order issued by the National Wage Board in October 2007.

Partnership activities and other support services

In coordination with the Office of the DDG-OSS and the Community Relations Unit of IRRI, ES continued to accommodate various approved external requests for equipment assistance and associated technical support services from the surrounding communities. A total of 36 requests (internal and external) were received and accommodated during 2008. These include the conduct of field tours and demonstration for visitors endorsed by the Visitors and Information Services (VIS) office as well as the orientation of new staff members and scholars endorsed by the Training Center office. ES staff also participated as facilitators and trainers in course offerings and provided planning and logistical support for field demonstrations and tours. The Department of Agriculture conducted its Provincial Batches Training for Trainers at IRRI and ES prepared actual demos and hands-on activities. Experimental plots and crops were established to serve as demonstration areas that highlighted the important research projects and activities of the Institute. President Arroyo's visit and the CGIAR meeting in May and September involved the biggest preparations in 2008. The rest of the research center farm and grounds was kept in highly presentable conditions. Several trailers were conditioned for transporting participants safely and comfortably during their tours of fields. Several dry runs were coordinated through ES to help ensure the success of the field days, and most importantly, Mrs. Arroyo's visit.

Audit of the environmental management system

External audit. With the ES environmental management system's (ES EMS) successful certification to ISO 14001:2004 in June 2007, a mandatory external audit by SGS was conducted on 27 May 2008. The objectives of the external audit were to confirm that a) the ES EMS conforms to all the requirements of the ISO 14001:2004, b) it has effectively implemented the planned ES EMS, and c) the unit is capable of achieving the ES policy objectives.

The external audit covered the management of farm operations and other support services, including waste management, grounds maintenance, and landscaping. The audit team conducted a process-based audit focusing on significant aspects/risks/objectives required by the standard(s). The audit methods used were interviews, observation of activities, and a review of documentation and records. The structure of the audit was in accordance with an audit plan and audit planning matrix previously agreed upon.

The external audit team concluded that ES has established and maintained its EMS in line with the requirements of the ISO14001:2004 and has demonstrated the ability of the system to systematically achieve agreed requirements for products or services within the scope of IRRI's policy and objectives. No nonconformities were identified. On the basis of audit results and the ES EMS' demonstrated state of development and maturity, it was recommended that the ES EMS certification to ISO 14001:2004 be continued.

Internal audit. From 27 October to 7 November 2008, the CGIAR Internal Audit Unit (IAU) conducted a scheduled internal audit of the ES EMS as stipulated in the ES EMS implementation plan. The objectives of the audit were to a) determine whether ES complied with the standards of ISO 14001:2004 with respect to its EMS during January to September 2008; b) assess whether the current system of internal control in ES ensures the effectiveness of controlling the implementation of EMS; c) determine the efficiency and effectiveness of EMS operating procedures as designed and implemented by ES; d) identify opportunities to improve or increase the efficiency of related procedures; e) help ES prepare documentation in relation to the internal audit of EMS for review by a third-party ISO 14001:2004 certification authority; and f) follow up on the implementation of past ES EMS internal and third-party audit recommendations.

The scope of the internal audit of the EMS included the following: policy and planning, implementation, and checking and corrective action. The procedure involved an inspection of the ES offices and sites, a review of EMS documentation and records, interviews of personnel involved in the EMS process, and follow-up on the implementation of past audit recommendations.

The CGIAR-IAU audit team found no "big ticket" issues. However, there was mention of areas in the documentation procedure that can be further improved. No official internal audit report summary was forwarded to ES as yet.

Other EMS-related activities in 2008 included the following:

1. Revision of some policies and procedures; conduct of several ES EMS management team meetings
2. EMS-related training for key ES personnel
3. Completion of the ES-controlled dumpsite
4. Appointment of a new senior manager for ES who automatically assumed responsibility as ES EMS coordinator
5. General assembly meeting attended by all ES staff and major farm service providers

LIBRARY AND DOCUMENTATION SERVICES

Just like other information providers all over the world, IRRI Library and Documentation Services (LDS) is going through an era of rapid transformation. In the current IT-driven, dynamic setting and in the face of limited human and financial resources, the LDS is expected to deliver greater value internally and externally. Modes of information delivery have been altered with new IT applications, but the core services remain. Also, there is a growing push to collaborate more and more with partner institutions and libraries worldwide, as the library cannot exist as an independent entity able to provide information on its own.

In spite of all these changes, the mission and vision remain the same. The library's mission is to develop and maintain the world's most comprehensive collection of technical rice literature written in any language by the world's rice scientists and to provide access to this unique body of knowledge in any available format, regardless of time and geographical location. The library accomplishes this mission through prompt procurement and systematic organization of digital or print resources, electronic and conventional document delivery and reference services, an integrated library system, orientation/training on the use of resources and services, and collaboration with partner libraries and scientists all over the world.

The IRRI library envisions itself to be

- the gateway to a comprehensive and dynamic collection of technical rice literature in a variety of formats (accessible 24 hours a day) to rice scientists worldwide,
- a virtual as well as traditional library that adapts to changes in order to meet the evolving needs of its clients,
- an information hub that offers customer-oriented services, and
- a library that encourages professional competencies and life-long learning among its staff.

The library staff

The library functioned with one librarian less during three-quarters of the year. Despite this handicap, operations continued by assigning the tasks of the former staff member to three other librarians. Multitasking resulted in unhampered and smooth operations. Four on-the-job trainees from local universities supplemented the library's work force.

To enhance existing skills and to gain new skills, the library staff participated in training programs within and outside the IRRI campus. Library visits supplemented these learning activities. Some staff members visited the National Library and the libraries of Adamson University and De La Salle University, which exposed them to other types of library services.

The clients

The users of LDS resources and services include both walk-in and remote clients situated on the IRRI campus as well as in other parts of the world. IRRI staff and most other clients prefer to visit remotely and use digital resources linked to the LDS Web site. Walk-in clients totaled 13,080, of which 3,393 were IRRI personnel, scholars, trainees, and fellows. The rest consisted of UPLB students and faculty members, researchers from the Philippine Rice Research Institute, and those from universities in Manila and other parts of the country, and the general public.

Broadening the base of knowledge resources

Collection development in IRRI is hampered by the continuously increasing costs of books, databases, journals, and other information resources. This is further complicated by the dollar devaluation and the push to have more electronic resources available to IRRI staff. In 2008, there was more emphasis on collecting digital resources, especially electronic journals.

Rice technical literature. The IRRI library hosts the world's most comprehensive collection of technical literature. Librarians are alerted weekly on new rice publications via *Current Contents Connect*. The procurement of journal articles published in nonsubscribed journals is a major task shared by all librarians. Free sources are exhausted first before resorting to pay-per-view. Authors were promptly contacted by e-mail to request free e-copies and a majority quickly responded to these requests. When this failed, assistance from partner libraries and information managers from various countries was sought. Among the CGIAR libraries, frequent providers were IWMI, ICRISAT, CIP, IFPRI, and ICRAF. Foremost among other partners who helped in the procurement of free rice articles were Ms. Yonghong Sun, IRRI-China; Dr. Takanori Hayashi and Mrs. Toshie Katsuyama, Agriculture, Forestry, and Fisheries Research Information Center (AFFRIC), Japan; Dr. Bert Collard in Australia; Mr. Jin-

LDS Fig. 1. The IRRI library staff.

LDS Fig. 2. The library reading room.

tien Hu, AVRDC, Taiwan; Dr. Gopal Krishna Agarwal, IRRI-India; and Mr. Sahadat Hossain, BRRI, Bangladesh.

Only 20 articles were purchased via publishers' Web sites under the pay-per-view scheme. Some 3,640 pdf files of rice technical literature from nonsubscribed journals were linked to the rice database. These were obtained from authors, CGIAR libraries, other partner libraries, and the scientists mentioned above. Not counting the additional 71 pdf files of nonrice articles, a savings of US$109,200 was realized, as the average cost of articles ordered online was $30.

E-journals. A recent survey revealed that the cost of journals in subjects relevant to IRRI research (i.e., agriculture, botany, chemistry, biology, and food science) increased by an average of 8.6% in 2008, which was also the figure projected for 2009. The rising cost of journal subscriptions resulted in the cancellation of 47 titles. Subscriptions to 188 journals were placed in 2008, of which 142 were in electronic format. More print subscriptions were dropped in favor of electronic journals, and only those titles available as hard copies only were maintained (LDS Table 1). Despite these obstacles, LDS staff successfully delivered all articles requested by IRRI scientists in nonsubscribed journals. Free trial access to selected titles was availed of, for example, the Freedom collection of Elsevier, so that staff had access to 1,800 scientific journals for almost 2 months. Joint subscriptions with other CGIAR libraries continued, thus making more titles available.

Toward the end of 2008, the librarians conducted a review and evaluation of the journal collection, with particular focus on actual usage, especially for the most expensive journals. Consortial subscription deals with five publishers were also carefully reviewed to achieve a rational allocation of next year's budget.

LDS Table 1. Collection development in 2008.

Publication type	Added in 2008	Total collection
Monographs (books and pamphlets)	930	119,955
Theses	99	4,688
Video cassettes	15	236
CDs	11	184
Rice reprints (print format)	26	27,876
Rice literature (pdf)	3,640	15,400
Total collection (print and digital)	**4,596 (excluding journals)**	**163,231 (excluding journals)**
Other resources		
Journals (print and electronic)	33	1,506 active titles
Journal subscriptions	2	188 titles on subscription
Online databases	0	74 (including free sources)
Electronic links created		
OPAC	349	3,171
Rice database	3,640	12,838

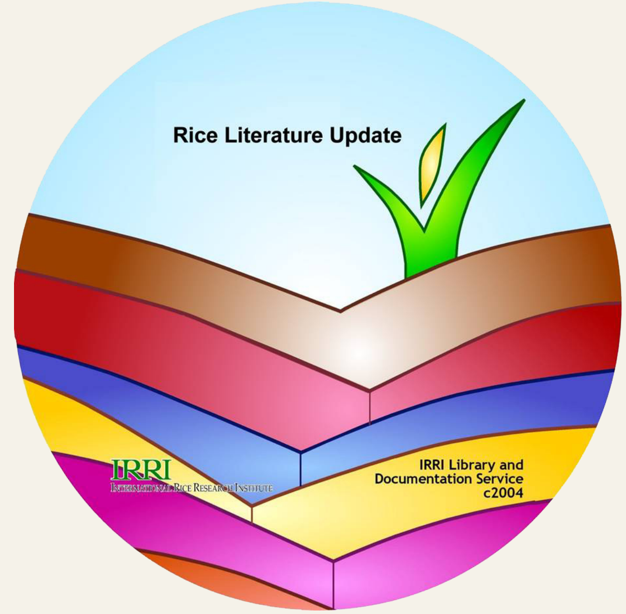
The print collection. Since a big portion of the budget was used for journal subscriptions, only 43 books were purchased for the library and 77 for other units in IRRI. Most of the printed materials received were gifts or exchange materials. The rest, especially theses and dissertations, were downloaded freely from the World Wide Web.

Access points to information resources

The library's Web site at http://ricelib.irri.cgiar.org. The Web site continued to be the key access point to print and electronic resources organized and made available to worldwide clients. Overall, there were 42,928 visits to the Web site in 2008. No change in design took place, but the contents were regularly updated with new resources and these were made available 24 hours a day, regardless of geographical location. The library team worked hard to achieve an ideal scenario where the required information was at the client's fingertips.

The rice database and the Online Public Access Catalog (OPAC). The user-friendly search interfaces of the rice database and the online catalog are the major keys to usage of the library collection. The rice database continued to provide instant access to the world's latest rice literature at http://ricelib.irri.cgiar.org:81/screens/opacmenu.html. Added to the rice database were 5,710 technical articles or books on rice; it now carries 267,473 records. Of the items added, 3,640 are in electronic format and metadata for these carry hyperlinks to full-text works. The total number of records with links to the full text is 12,838.

LDS Fig. 3. The LDS Web site.

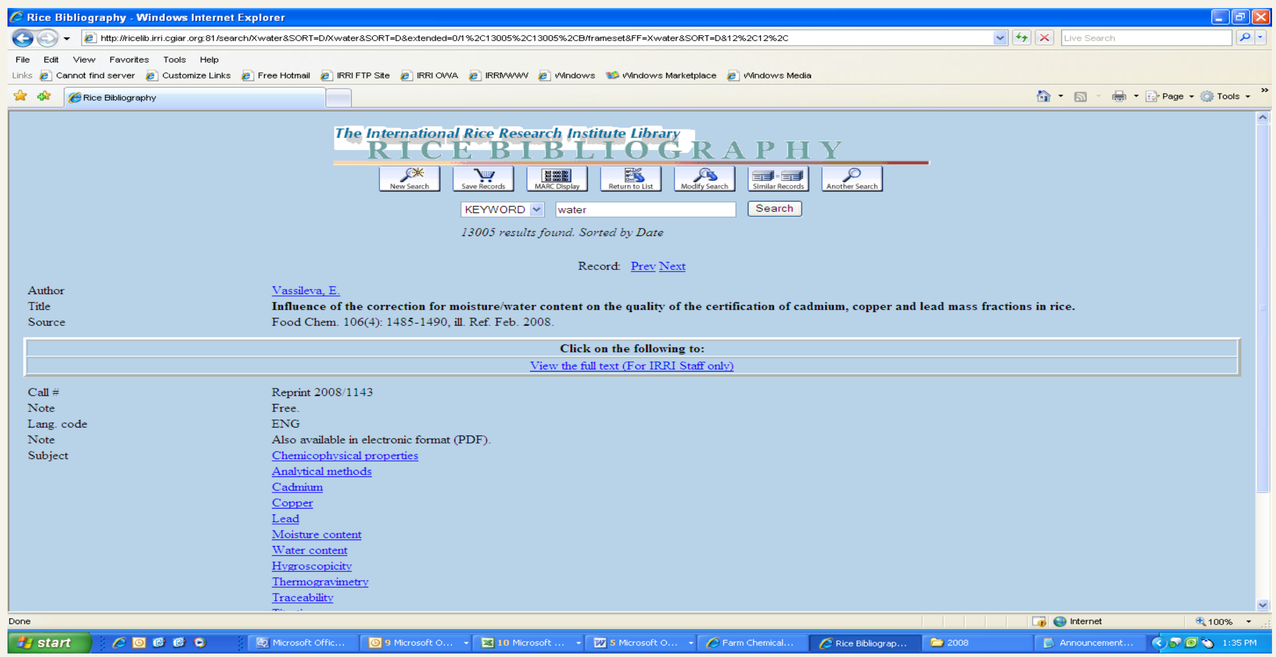


LDS Fig. 4. The *Rice Literature Update* CD.

Two semiannual issues of the *Rice Literature Update* were published on CDs. Only a few hard copies were produced to fulfill paid subscriptions.

Nine hundred and thirty records were added to the OPAC, for a total of 78,265. These consisted of books, pamphlets, reprints, and remote electronic resources. For electronic resources, 3,171 hyperlinks to full-text documents, mostly theses, are now available.

Other databases. *Current Contents Connect, CABDirect, LC Classification Web,* and *LANTEEAL (The Essential Electronic Agricultural Library*) continued to be available to IRRI staff in 2008. The first two are major tools for current awareness of new rice articles and the provision of alerting services to IRRI



LDS Fig. 5. Screenshot of a rice database record with hyperlink to the full-text document.

staff, while the last two facilitated document delivery and the organization of library materials.

In addition, 74 free subject-specific online databases and 11 open-access journal sites were prominently linked to the LDS Web site.

Trial access to databases, e-books, and journals. One way of stretching scarce resources is to avail of free trial offers from various publishers. Free trial access to various online resources benefited IRRI staff as additional titles became available even for a short period of time. Also, this arrangement enabled free downloads of rice articles. In February, full-text access to *CAB Abstracts Plus* was activated for a month and several rice articles were downloaded from the site, free of charge.

An IRRI librarian initiated free trial access to CAB e-books for the entire CGIAR system. From 28 July to 30 August, 2008, all CGIAR staff were able to read from their desktops the full text of 140 e-books in all subject suites of CAB's e-book collection.

Occasional free full-text offers for selected journal titles were arranged as soon as they became available. Announcements about free trial access were promptly posted on the *Library Corner* in the weekly electronic *IRRI Bulletin* so that IRRI staff could peruse the resource within the specified time frame, normally 1 month.

Knowledge-sharing initiatives

Clients from 51 countries used IRRI LDS services in 2008. The volume and frequency of services provided during the year are given in LDS Table 2.

Evaluation of library services

A regular evaluation of resources and services ensures that the right direction is taken to accomplish the LDS mission. Library services were evaluated twice in 2008. The first was a blitz external review conducted by experts in the fields of library and information science.

External review. A panel of external reviewers was invited to look into the operations of LDS and

LDS Table 2. LDS services rendered to worldwide clients in 2008.

Service	Volume/frequency	Remarks
Electronic document delivery	1,547 documents delivered	Predominantly 24-h delivery; includes only those fulfilled by LDS staff; direct downloads not included
Reference services	1,069 reference questions answered	Mostly received through e-mail; others through phone calls or personally asked by walk-in clients
Literature searches	57	
Book loans processed	11,102	Includes check-outs, check-ins, and holds
Interlibrary loans	50	With the libraries of UPLB and PhilRice
Current awareness 1. Library corner in the IRRI Bulletin 2.IRRI announcements Wiki/e-mail 3. Alerts 4. Blogs 5. Featured lists	 1. 51 announcements 2. 17 announcements 3. 35 alerts per week 4. 22 blogs 5. 12 regular monthly updates made	
Orientation/guided tours	337	Given to IRRI staff, scholars, fellows, trainees, and visitors
Instruction on the installation and use of database management software such as EndNote, Procite, or WebAGRIS	20	Does not include outreach activities in local seminars
Purchasing, cataloging, and end-processing of books for other units of IRRI	77	
Bindery	1,223 books and journals 112 Princeton files	
On-the-job training of other librarians	A librarian from the National Agriculture and Forestry Research Institute, Lao PDR, Ms. Pome Phanthavong, underwent a 2-week on-the-job training.	Training module prepared; all librarians involved in the training program

Communication and Publications Services (CPS), two units tasked with information sharing for the Institute. The review, held on 14–18 April, was conducted by experts in communication, publishing, and library and information science. The objectives were to assess the existing situation in both units and to recommend options made possible by advances in ICT that would improve and render current services more cost-effective. While library management was rated excellent by the panel, they identified the need to explore and infuse more IT-driven tools and to equip librarians with greater IT expertise. The recommendations submitted by the panel in the final report are major considerations in deciding what future directions to take in elevating the LDS into Library 2.0 status.

LDS Table 3. Document delivery/reference questions answered in 2008.

Center	Articles delivered (no.)	Reference questions answered (no.)
Bioversity	37	6
CIAT	3	–
CIFOR	1	10
CIMMYT	27	22
CIP	121	39
ICARDA	19	2
ICRAF	60	36
ICRISAT	91	43
IFPRI	18	7
ILRI	12	13
IRRI	703	551
IWMI	48	11
WARDA	11	6
CG secretariat	–	3
Other institutions	396	320
Total	1,547	1,069

LDS Table 4. Information services rendered, by country, in 2008.

Country	Documents delivered (no.)	Reference questions answered (no.)
1. Argentina	2	–
2. Australia	20	1
3. Bangladesh	10	1
4. Belgium	2	–
5. Belarus	1	2
6. Benin	11	6
7. Bhutan	4	–
8. Brazil	9	–
9. Cambodia	2	–
10.Canada	1	1
11. Chile	1	–
12. China	14	1
13. Colombia	4	–
14. Costa Rica	–	2
15. Cuba	34	12
16. Egypt	10	3
17. Ethiopia	13	3
18. France	2	1
19. Germany	1	–
20. Ghana	1	–
21. India	111	63
22. Indonesia	2	11
23. Iran	3	–
24. Italy	40	6
25. Japan	17	9
26. Kenya	61	59
27. Korea (South)	3	
28. Lao PDR	5	9
29. Malaysia	1	
30. Mexico	17	11
31. Myanmar	–	1
32. Nepal	1	–
33. Netherlands	6	6
34. Nigeria	4	–
35. Pakistan	10	2
36. Peru	132	63
37. Philippines	814	725
38. Russia	2	–
39. Singapore	–	3
40. Sri Lanka	101	22
41. Switzerland	1	1
42. Syria	21	2
43. Taiwan	5	2
44. Thailand	4	3
45.timor (East)	1	1
46. Turkey	2	1
47. Uganda	1	3
48. UK	–	2
49. Uruguay	4	3
50. USA	33	28
51. Vietnam	3	–
Total	1,547	1,069

Library survey. In September, an online survey was conducted among IRRI library users using SurveyMonkey. More than 350 IRRI staff responded to the survey and the highlights are given in LDS Table 5.

The five most popular journals among IRRI staff, according to the survey, were *Nature* (107), *Science* (92), *Field Crops Research* (92), *Agronomy Journal* (80), and *Euphytica* (74). Usage of the rice database was the highest (52.7% of the respondents).

LDS Table. 5. Results of survey on library services.

Survey question	Respondents (no.)	Respondents (%)
1. Awareness of LDS services (251 responses)		
a. Adequately informed	197	78.5
b. Not adequately informed	54	21.5
2. Sources of information about IRRI library services and resources (263 responses)		
a. Library Web site	226	85.99
b. IRRI Bulletin	139	52.9
c. Campus announcements	77	29.3
d. Meeting with a librarian	75	28.5
e. Library e-mail alert service	72	27.4
3. Actual visits to LDS (262 responses)		
a. Occasionally	189	72.1
b. Monthly	34	13.0
c. Weekly	33	12.6
4. Resources used when visiting LDS (262 responses)		
a. Journals	204	77.9
b. Books	199	76.0
c. Reference books	94	36.3
d. Electronic resources	84	32.1
5. Satisfaction with overall library services (254 responses)		
a. Extremely satisfied	12	4.7
b. Very satisfied	168	66.1
c. Somewhat satisfied	68	26.8
d. Not very satisfied	5	2.0
e. Not at all satisfied	1	0.4

Collaboration within and outside IRRI

The proliferation of knowledge sources makes it impossible for a single library to have everything. In this digital age, when libraries can fulfill only a portion of clients' requests through their own collection, collaboration is a must. The resources of the LDS are

LDS Table 6. LDS projects in 2008.

Project title	Accomplishments/entries added in 2008	Total	Initiative/ support
1. International Directory of Rice Workers	179 (revisions and additions)	2,574	LDS
2. Intensive searching of free rice articles/monographs from the www	2,753	2,753	LDS/ Program 6
3. Maintenance of rice pdf archives	3,640	12,838	LDS
4. Rice Thesaurus	Terms with subject trees encoded on the MultiTes platform to make it searchable and publishable on WWW	3,229 terms with subject trees	Program 6
5. Enhancing access to IRRI-assisted theses and dissertations (with AgNIC support)	Terminal report and CD containing scanned pages submitted on 1 July 2008	1,395	Agicultural Networks Information Center (USDA)
6. Dspace repository (content development)	1,051	1,313	LDS/ Program 6
7. IRRI in the News and Rice in the News databases	325	16,256	LDS
8. New publications by IRRI staff (e-list posted on the library's Web site)	116	541	LDS
9. Addition of ISSN or ISBN data to bibliographic records (started in April)	54,011	54,011	LDS
10. Broadening the range of electronic resources in the CGVirtual Library	17 tables containing digital resources with pertinent data from various CGIAR centers, the CG secretariat, and systemwide programs were posted on the CGVLibrary Wiki, http://cgvlibrary.pbwiki.com/Broadening+the+Range+of+Information+Resources+Available on 1 June 2008		CGIAR Virtual Library Phase 2
11. Inputs in the FAO AGRIS/ PhilAgriNet databases	87	1,595	LDS
12. Formulation/revision of standard operating procedures (SOPs)	C. Austria was designated as risk management and quality assurance officer; this task was relinquished to N. Delos Reyes in December.	SOPs were revised and risk management tables were submitted on 11 Sep	LDS

not enough to meet the growing demand of clients. Collaboration with other IRRI units, CGIAR librarians, and other partners must be sustained. Table 6 shows the projects undertaken by the LDS with support from other IRRI units or from outside organizations.

Program 6, a component of IRRI's research platform, has for its goals "the optimum stewardship of information and knowledge, sharing this knowledge in an equitable way, and acting as a conduit for research—both basic and applied—from advanced research institutions to NARES and, finally, farmers." LDS activities under the umbrella of Program 6 are given in LDS Table 6. One of the major accomplishments is populating IRRI's Dspace repository, which serves as a one-stop shop for IRRI's intellectual output in full-text digital format and is accessible anytime via the World Wide Web.

Active participation in the CGIARLIS Consortium continued in 2008. It is through consortia that IRRI shares its products of research and information with other agricultural institutions—e.g., the Agricultural Networks Information Center (AgNIC) and the International Information System for Agricultural Science and Technology (AGRIS-FAO)—and gains access to other agricultural knowledge generated by partner institutions in return.

Exchange agreements with more than 300 libraries worldwide continued.

The IRRI librarians shared their expertise in local and international fora:

- Lecture on library resources and services and future initiatives to participants of the Rice: Research to Production Course, IRRI, 3 June 2008
- Seminar-workshop on Enhancing the Capacity of Information Professionals for Effective Agricultural Information Management, Sharing, and Dissemination, Benguet State University, 21-22 Feb 2008; and Silliman University, 22-23 May 2008
- Special Libraries Association Annual Conference held at the Washington State Convention Center, 15-18 June 2008. Topic: The CGIAR Virtual Library: A Vital Tool to Enhance Access to Agricultural Research
- IV Encuentro Internacional del Arroz, Palacio de Convenciones de la Habana, Cuba, 2-6 June 2008)–poster presentation on the rice database
- Joint Conference of IAALD, AFITA, and WCCA on 24-27 Aug 2008, Tokyo University of Agriculture, Atsugi, Japan–Poster presentation on the rice database
- ALAP Forum on New Perspectives in Information Delivery, Camarines Sur State Agricultural College, Pili, Camarines Sur, 26 Sep 2008. Topic: Aiming at Library 2.0

Outlook

The digital age poses many challenges to the roles of libraries and librarians. Currently, the IRRI library is operating as a digital and traditional library. The print collection and electronic resources complement each other in fulfilling clients' needs. The transformation of the IRRI library into a fully digital library is envisioned. This, however, requires considerable time, and human and financial resources. The library team is slowly digitizing the current collection so that clients on the IRRI campus will have full-text documents at their fingertips. Though slow, the electronic conversion process has at least taken off. Realization of this vision will happen in the near future with the library staff's commitment and initiative, upgrading of staff knowledge and skills, management support, and outside partners who can sponsor the digitization of the entire library.

VISITORS' OFFICE

In 2008, the Institute welcomed and hosted 34,476 visitors from different countries, down from last year's 46,833. Because of preparing for several big events at IRRI, including the CGIAR Review Stakeholders Consultation and Change Management Workshop, some visits were curtailed, thereby resulting in a decline in visitor arrivals. Among the VIPs who visited IRRI were H.E. Gloria Macapagal-Arroyo, president of the Republic of the Philippines; H.E. Pascal Couchepin, president of the Swiss Confederation; secretaries of the ministries of agriculture of various countries; 111 ambassadors together with the members of the diplomatic community; H.E. Kristie Kenney, ambassador of the United States; H.E. Ali Mojtaba Rouzbehani, ambassador of the Islamic Republic of Iran; H.E. Rod Smith, ambassador of Australia; H.E. Peter Sutter, ambassador of Switzerland; representatives of various donors and international organizations such as Dr. Xiamara Sinisterra, biotech advisor, United States Agency for International Development; Mr. U. San Hla Baw, deputy general manager and national project coordinator, Food and Agriculture Organization, Myanmar; Drs. Klaus J. Lampe and Ronald P. Cantrell, former directors general of IRRI; Dr. Prabhu Pingali, head of agricultural policy and statistics, Bill & Melinda Gates Foundation; Dr. Chang Qing, deputy director general, Department of International Cooperation, National Natural

Science Foundation of China; Dr. Dyno Keatinge, director general, World Vegetable Center; and Dr. Ren Wang, director, Consultative Group on International Agricultural Research (CGIAR). The Visitors Office prepared more than 400 specialized programs compared with 300 in 2007.

Media exposure increased in 2008 because of the global rice crisis (see "IRRI and the media," p 3), which underlined the importance of public agricultural research and funding support. It also underscored the need for good science communication. As a result, agriculture, especially, rice production, was back on the national agenda of rice-producing countries of the world—and the world media. IRRI thus became the “go-to” place for rice issues because of its credibility, being the world’s premier institution for rice research. The Visitors’ Office arranged 70 programs for visits and media interviews, including those of Mr. Lawrence Ong, BBC World TV; Ms. Heda Bayron, Voice of America; Mr. Friedemann Hottenbacher, German Puplic Channel ZDF; Mr. Keith Bradsher, New York Times; and reporters from NBC News.

In October 2008, the Visitors’ Office was reorganized again as Events and Visitors Office (EVO); three staff members were added. Ms. Bita Avendaño was designated head of EVO. From October to December, EVO handled 72 events.

Workshops, conferences, and meetings

In 2008, IRRI hosted or cohosted 30 regional and international conferences, workshops, and symposia (VO Table1). Some1,687 Delegates from 267 countries participated in regional and international workshops.

Distinguished visitors in 2008

Legislators and government officials

Hon. Magtanggol T. Gunigundo I, congressman, 2nd District, Valenzuela City, and chairman, Committee on Labor and Employment, and party, 8 Feb.

J. Eduardo Malaya III, executive director, Office of Legal Affairs, Department of Foreign Affairs (DFA), and party, 16 Feb.

Grace Relucio Princesa, executive director, Office of the United Nations and International Organizations, DFA, and party, 1 Mar.

Hon. Gabriel Kapris, minister of commerce and Industry, Independent State of Papua New Guinea, and party, 25 Mar.

Mr. Gokul Chandrasekaran, assistant director, IO Programme Office of the New Economic Wealth Generators, Singapore Economic Development Board, 28 Mar.

Dr. Seong-Hee Lee, senior researcher, Crop Physiology and Ecology Division, National Institute of Crop Science, Rural Development Administration (RDA), Suwon, Republic of Korea, 7 Apr.

Dr. Matsuo Iwamoto, president, Society for Techno-Innovation of Agriculture, Forestry and Fisheries, Tokyo, Japan, 10 Apr.

Hon. George Chan Hong Nam, minister of modernization of agriculture, Malaysia, and party, 29 Apr.

H.E. Gloria Macapagal-Arroyo, president, Republic of the Philippines, 2 May.

Hon. Edgardo Angara, senator, Republic of the Philippines, 2 May.

Hon. Ivy Arago, congresswoman, 3rd District of Laguna, 2 May.

Hon. Justin Chipeco, congressman, 2nd District of Laguna, 2 May.

Hon. Dan Fernandez, congressman, 1st District of Laguna, 2 May.

Hon. Ramil Hernandez, vice governor of Laguna, 2 May

Hon. Estrella Alabastro, secretary, Department of Science and Technology, 2 May.

Hon. Jose N. Carrion, governor of Marinduque, 2 May.

Hon. Sally A. Lee, governor of Sorsogon, 2 May.

Hon. Gwendolyn F. Garcia, governor of Cebu, 2 May.

Hon. Ben P. Evardone, governor of Eastern Samar, 2 May.

Hon. Loreto Leo S. Ocampos, governor of Misamis Occidental, 2 May.

Mr. Christopher Lindo, representative of Hon. Maria Plaza, governor of Agusan del Norte, 2 May.

Dr. Emerlinda Roman, president, University of the Philippines, 2 May.

Dr. Luis Velasco, chancellor, University of the Philippines Los Baños, 2 May.

Mr. Jesus Emmanuel Paras and *Josyline Javelosa*, officials, Department of Agriculture, 2 May.

VO Table 1. International and regional conferences, workshops, symposia, and meetings hosted or cosponsored by IRRI in 2008.

	Venue	Participants (no.)	Countries represented (no.)
Final Consultation Workshop on Scoping Study to Identify Research and Implementation Issues Related to Management of the Brown Planthopper/Virus Problem in Rice in Vietnam	Vietnam	43	9
Annual Review and Planning Meeting of the Japan Project	Vietnam	43	7
Inception and Planning Meeting of the Africa component of the IRRI-WARDA joint project on Stress-Tolerant Rice for Poor Farmers in Africa and South Asia	Benin	53	21
14th Regional Steering Committee Meeting of the Rice Wheat Consortium	IRRI	16	8
International Rice Research Institute (IRRI) – Department of Agriculture (DA) Philippines Forum	IRRI	102	1
Forum on Rice Policy Research: Key Issues from National Perspectives	IRRI	30	13
Final Workshop of the ACIAR-funded project on Impact of Migration and Off-Farm Employment on Roles of Women in Asian and Australian Mixed Farming Systems	IRRI	34	4
Launching of the South Asian component of the Bill and Melinda Gates Foundation project	India	150	5
Inception and Planning Meeting of the BMZ-funded project Enhancing and Stabilizing the Productivity of Salt-Affected Areas by Incorporating Genes for Tolerance of Abiotic Stresses in Rice	India	34	7
Philippine Water-Saving Workshop	IRRI	16	1
Inception Meeting of the GCP-funded commissioned project, Speeding the Development of Salt-Tolerant Rice Varieties through Marker-Assisted Selection and Their Dissemination in Salt-Affected Areas of Bangladesh	Bangladesh	27	6
Planning Workshop on Stress-Tolerant Rice for Poor Farmers in Africa and South Asia	Bangladesh	79	2
Inaugural Meeting of the Hybrid Rice Research and Development Consortium	IRRI	71	14
IRRI Board of Trustees Meeting	IRRI	17	10
Biotechnology, Biosafety, and the CGIAR: Promoting Best Practice in Science and Policy	IRRI	42	18
European Action on Global Life Sciences Food Forum: IP and Technology Access Workshop	IRRI	21	10
Korea (RDA)–IRRI Collaborative Work Plan Meeting	IRRI	29	1
Consortium for Unfavorable Rice Environments (CURE) Seventh Annual Meeting	IRRI	45	12
International Conference on Rice Planthoppers	IRRI	95	18
Meeting with Pilot Village Coordinators on the project Improving Knowledge Exchange and Decisionmaking among Rice Stakeholders through ICT-based Technology Promotion and Delivery Systems	IRRI	6	1
Center-commissioned External Review of the IRRI Biotechnology Program	IRRI	4	4
CGIAR Joint Independent Review and Stakeholders Consultation	IRRI	94	31
5th International Hybrid Rice Symposium	China	445	26
IRRI Board of Trustees Meeting	IRRI	21	12
Workshop: Project Review, Site Visit, and Wrap-up, From Genes to Farmers' Fields: Enchancing and Stabilizing Productivity of Rice in Submergence-Prone Environments	Bangladesh and India	25	5
Inception and Planning Workshop on Reducing Vulnerability of Rice Crops to Preharvest Losses Caused by Planthopper Pest Outbreaks	Vietnam	29	6
Drought Screening for Rice Genetic Improvement + Participatory Varietal Selection	India	12	1
Rice Production Training Course with Emphasis on Rainfed Rice Environments	Bhutan	29	1
National Workshop on the project Improving Knowledge Exchange and Decisionmaking among Rice Stakeholders through ICT-based Technology Promotion and Delivery Systems	IRRI	25	1
Final Meeting and Synthesis Workshop of CPWF-funded Project 7, Development of Technologies to Harness the Productivity Potential of Salt-Affected Areas of the Indo-Gangetic, Mekong, and Nile River Basins	IRRI	50	12
Total		1,687	267

VO Table 2. IRRI visitors, by group, in 2008.

Visitor group	Philippines	Asia	Africa	Australasia	Europe	Latin America	North America	USA	Total
Students	25,164	625	1	13	7		7	35	25,852
Conference participants	148	14							162
Nongovernment organizations	284	7							291
Donors	47	21	2		1			3	74
Government officials/politicians/officers	887	299		6	11			7	1210
Farmers	1,109	198		9				2	1318
Faculty members/parents	1,441	179			4			17	1641
Scientists, researchers	454	241		4	11	7	4	10	731
Private sector	1,035	384	4	29	36	4	10	41	1543
UN agencies, CGIAR, TAC, etc.	4	6	4	3		1		7	25
Diplomatic corps	55	33	7	2	5	2		7	111
Media	81	25		3	30	1	1	6	147
Religious groups	195	45			2			11	253
Tourists	17	49		10	11			20	107
Others	849	103		1	23	1	10	24	1011
Total	31,770	2,229	18	80	141	16	32	190	34,476

Emiko Purdy, USDA agricultural counselor; *Kirk Miller*, USDA Washington, and *Mark Rowse*, USDA, and officials of the Department of Agriculture, 2 May.

Hon. Bruno T. Ramos, mayor, Bay, Laguna, 2 May.

Hon. Procopio Alipon, acting mayor, Los Baños, Laguna, 2 May.

Hon. Ramon Guico, mayor, Binalonan, Pangasinan, 2 May.

Hon. Melchor Nacario, mayor, Calbiga, Samar, 2 May.

Hon. Roque Tiu, mayor, Tanauan, Leyte, 2 May.

Hon. Gerardo Calderon, mayor, Angono, Rizal, 2 May.

Ms. Li-ann de Leon, executive director, League of Municipalities of the Philippines, 2 May.

Dr. Leocadio Sebastian, executive director, Philippine Rice Research Institute, 2 May.

Atty. Ronilo Beronio and party, Philippine Rice Research Institute, 2 May.

Hon. Juan Miguel Zubiri, senator, Republic of the Philippines, 22 May.

H.E. Md. Abdul Aziz, secretary, Ministry of Agriculture, Government of the People's Republic of Bangladesh, 10-13 June.

Hon. Arturo Yap, secretary, Department of Agriculture, 2 May, 17 July, 12 Aug, 19 Sep.

Hon. John Hickey, minister, Department of Agriculture and Livestock, Independent State of Papua New Guinea, and party, 17 June.

EC Review Team, 17 June.

Mr. Jesus Zorilla, head of unit, and *Mr. Constantino Petrides*, international relations-desk officer, Agriculture and Rural Development Unit of the European Commission, 24 June.

Dr. Tashi Samdup, director, council of Renewable Natural Resources, Royal Government of Bhutan, 4 July.

Senior officials, Ministry of Agriculture and Rural Development, Hanoi, Vietnam, 28-29 July.

Hon. Hector Bethmage, minister of agriculture, lands, animal production and health, irrigation and tourism affairs, Western Provincial Council, Sri Lanka, and party, 29 July.

Hon. Paul Tiensten LLM MP, minister, Department of National Planning and District Development, Independent State of Papua New Guinea, 5 Aug.

H.E. Pascal Couchepin, president of the Swiss Confederation, Madame *Brigitte Couchepin,* and party, 12 Aug.

Mr. Camilo Sabio, chairman of the Presidential Commission on Good Government, 12 Aug.

United States House of Representatives staff, 23 Aug.

Dr. Nguyen Danh, member of Parliament, deputy head of Parliament delegation from Gia Lai Province, Vietnam, and party, 11 Sep.

Ms. Claire Young, senior transnational analyst, Australian Office of National Assessments, 22 Sep.

Dr. Sueng-Oh Yoo, Sustainable Agriculture Division, Extension Service Bureau, and *Dr. Sang-guie Lee*, Bio-Agronomy Department, of the National Institute of Agricultural Science and Technology, RDA, Korea, 13 Oct.

Staff of Senate Committee A and *staff* of the office of Senator Miriam Defensor Santiago, 21 Oct.

15 technical staff from Cambodia's Ministry of Agriculture, Forestry, and Fisheries and Department of Industrial Techniques-Ministry of Industry, Mines, and Energy, 23 Oct.

12 delegates from the technical team of the Kingdom of Saudi Arabia, 29 Oct.

Hon. Minister Maithripala Sirisena, Ministry of Agricultural Development and Agrarian Service, Sri Lanka, and party, 29-30 Oct.

Mr. Jay Branegan, staff of Senator Richard G. Lugar, Senate Foreign Relations Committee, United States of America, and party, 11 Nov.

Dr. Frisco Malabanan, director of the Ginintuang Masaganang Ani (GMA) Rice Program, Department of Agriculture, and chief science research specialist, Philippine Rice Research Institute, 10 Dec.

Representatives from various organizations

Prof. Harmut Michel, Nobel Prize winner in chemistry, 11 Jan.

Terry Farris, head, Global Philanthropy, Swiss Bank, UBS, Singapore, 16-17 Jan.

Dr. A.R. Sadananda, global research lead–Rice & Cotton, Advanta India, Ltd, 17-18 Jan.

Dr. Chang Qing, deputy director general, Department of International Cooperation, National Natural Science Foundation of China, and party, 23-24 Jan.

Dr. Chong-Ho Kim, former director general, Honam Agricultural Research Institute, RDA, Korea, 24, Jan.

Dr. Prabhu Pingali, head of agricultural policy and statistics, Bill & Melinda Gates Foundation, 30-31 Jan.

Ms. Bibiana Espinosa Garcia, principal research assistant–wheat collection, International Maize and Wheat Improvement Center (CIMMYT), Mexico, 28 Jan-7 Feb.

Dr. Hubert Zandstra, former IRRI deputy director general for research, 31 Jan-1 Feb.

Mr. Herve Thieblemont, field crop seeds manager–APAC, Syngenta Asia Pacific, Singapore, and *Ms. María Codina Bea*, strategy manager, Syngenta International, Switzerland, 7 Feb.

Dr. Klaus J. Lampe, former IRRI director general, and Mrs. Annemarie Lampe, 6-8 Feb.

Dr. Nanda Shrestha, executive director, Nepal Agricultural Research Council, 8 Feb.

McCann Worldgroup Philippine Team, 8 Feb.

Dr. Joe Tohmé, senior scientist, Centro Internacional de Agricultura Tropical, Colombia, 11-14 Feb.

Dr. Xiamara Sinisterra, biotech advisor, United States Agency for International Development, Washington, D.C., 13 Feb.

Mr. Vincent Tjin A Djie, director, Satrio NV, and party, 15 Feb.

Dr. V. Geethalakshmi, Professor, Agro Climate Research Centre, and *Dr. A Laksmanan*, associate professor, Department of Environmental Sciences, Tamil Nadu Agricultural University, India, 18-20 Feb.

Dr. Shuichi Asanuma, Professor, International Cooperation Center for Agricultural Education, Nagoya University, Japan, and Secretariat of the Japan Capacity Building Program for African Agricultural Researchers, 18-20 Feb.

Dr. Dennis Byron, vice president, crop genetics research and development, Pioneer International Inc., and party, 18-20 Feb, 7 Apr.

Prof. Xiuxin Deng, president, Huazhong Agricultural University, China, and party, 27 Feb.

Dr. Daniel Vincent, Du Pont crop protection global management team, USA, 28 Feb.

Mr. Matthew Brown, project manager of the Scottish Agricultural College International, 28 Feb.

Dr. Victor Kovalev, deputy director for research, All-Russian Rice Research Institute, 28 Feb-4 Mar.

Dr. Richard Ward, coordinator, Global Rust Initiative, CIMMYT, 4 Mar.

Alain Sailland, rice research manager, and *Michiel Van Lookeren Campagne*, head of research, Bayer Bioscience, N.V. Belgium, 10-11 Mar.

Dr. Jungchaee Kang, president, Chonnam National University, South Korea, and party, 17-18 Mar.

Dr. Zhai Huqu, president, Chinese Academy of Agricultural Sciences, and party, 19 Mar.

Dr. Yoshiyuki Shinogi, head, Laboratory of Farmland Engineering, National Institute for Rural Engineering, Japan, 25 Mar.

Mr. Toshinori Yanagiya, special advisor to the CG Director, International Food Policy Research Institute, Washington, D.C., 30-31 Mar.

Dr. Aminul Alam, deputy executive director, Bangladesh Rural Advancement Committee, Bangladesh, 2 Apr.

Dr. Thierry Boegart, chief executive officer (CEO), DevGen Ltd., 3 Apr.

Dr. Bernd Haase, managing director, 5 Prime GmbH, 3 Apr.

Mr. Hari Budianto Darmawan, CEO, Nutrifood, and *Mr. Muhammad Prakosa*, former minister of agriculture and former director of FAO, Indonesia, 3-4 Apr.

Dr. Achmad Suryana, director general, Indonesian Agency for Agricultural Research and Development, Jakarta, Indonesia, 7 Apr.

Dr. Gurjeet Gill, associate professor and head, agricultural and animal science, University of Adelaide, Australia, and party, 6-11 Apr.

Ms. Maylene Ting, senior vice president, Trust International Paper Corporation, 16 Apr.

George and Sarah Liang, investors from Hong Kong, 24 Apr.

Dr. Colin Cavanagh, Commonwealth Scientific and Industrial Research Organisation, Australia, 22-24 Apr.

Tricia Marie Camarillo, AVP-director for business development and corporate affairs, McCann World Group, and *Luigi Avancena*, director for operations, Weber Shandwick, 30 Apr.

Dr. Emil Javier, *Dr. Leonardo Gonzales*, *Dr. Jesus Binamira*, *Mr. Edmund Sana*, *Dr. Santiago Obien*, and *Mr. Ramon Yedra*, DA secretary's Technical Advisory Group, 2 May.

Dr. Sara Boettiger, director, strategic planning and development, Public Intellectual Property Resource. for Agriculture, 6 May.

Ms. Andrea Escalona and *Ms. Mei Parbo*, corporate citizenship, corporate affairs, IBM Philippines, 9 May.

Dr. Jack Bruhn, global technical manager, Du Pont USA, and party, 12 May.

Dr. Ed Roumen, rice breeding and hybrid development manager, Bayer (Southeast Asia) Pte. Ltd., 14-16 May.

Mr. Richard Fuchs, regional director, Southeast and East Asia, International Development Research Centre, 14 May.

Dr. Ed Sarobol, associate professor, Agronomy Department, Faculty of Agriculture, Kasetsart University, Thailand, 15 May.

Dr. Jonathan Walker, assistant professor of geography, coordinator, Asian Studies Program; director of Philippines Mabuhay Study Abroad Program, James Madison University, and party, 15 May, 10 June.

Ms. Cynthia D'Anjou Brown, philanthropy advisor, HSBC Private Bank, 15 May.

Dr. Ren Wang, director, Consultative Group on International Agricultural Research, 23 May.

Mr. Duncan Power, executive director, Charities Aide Foundation, 27 May.

Dr. Ronald Cantrell, former IRRI director general, 28 May.

Mr. U San Hla Baw, deputy general manager, and *Ms. Daw Khin San Win*, assistant manager, national project coordinator, Oil Crops Development Project, Food and Agriculture Organization-Myanmar, 11 June.

Ms. Fumi Tsuno, president, Tsuno Food Industrial Co., Ltd., 20 June.

Top executives, Greenline Onyx Envirotech Phils. Inc. and Veolia, Environment, 20 June.

Mr. Christopher Lavender, director, The Kadoorie Charitable Foundation, and *Mr. Ian Duncan Boyce*, director, Sir Ellv Kadoorie & Sons Limited, 20 June.

Dr. I Made Mahardika, research manager/project finance officer, Indonesian Agency for Agricultural Research and Development, and party, 1 July.

SEA-EU-NET partners, (PT-DLR Germany, CNRS France, NSTDA Thailand, GIGA Germany, and BHC Singapore), 4 July.

Mr. Alberto Lina, chairman, Lina Group of Companies, and party, 7 July.

Mr. C. Lawrence Greenwood, vice president–operations 2, and *Mrs. Ursula Schäfer-Preuss,* vice president, Asian Development Bank, 10 July.

Nuffield Australia, farming scholars, 10-11 July.

Rev. Fr. Reynaldo C. Hayag and *delegates* to the World Youth Day in Australia, 11 July.

Mr. Alex Vion, sales manager*,* Al Rawabe Establishment, and *Mr. William Jack King,* farm manager, Todhia Arable Farm, Saudi Arabia, 21-22 July.

UBS Philanthropy Group, 25 July.

Dr. Vinod Kumar, Asia Pacific R&D manager, India, and *Dr. Lu Ren*, DuPont China, 25 July.

Senior officials from the Ministry of Agriculture and Rural Development, Hanoi, Vietnam, 28-30 July.

Dr. Manuel Logrono, head, B & PD Field Crops, and *Dr. Ish Kumar*, regional head product development, Rice Asia Pacific Syngenta, India, 29-31 July.

Officers from the National Defence College, Bangladesh, and party, 15 Aug.

Dr. Necmi Beser, director, Trakya Agricultural Research Institute, Turkey, 19-22 Aug.

Mr. Kenzo Oshima, senior vice president, Japan International Cooperation Agency, and party, 20 Aug.

Mr. Pham Quang Hung, research and development executive, DuPont Vietnam, and *Mr. Bayu Nugroho*, research and development executive, DuPont, Indonesia, 26 Aug.

Dr. M.S. Swaminathan, former IRRI director general, 31 Aug-1 Sep.

Dr. Dyno Keatinge, director general, AVRDC–The World Vegetable Center, Taiwan, 12 Sep.

Delegation from the Thai Rice Exporters Association, 12 Sep.

Dr. Yo Tiemoko and *Dr. Fatouma D. Seyni*, members of the WARDA (Africa Rice Center) Board of Trustees, 15-16 Sep.

Delegation from the Rice Mills Association of Pakistan, 17 Sep.

Mr. George Camp, independent design professional from Canada, 18 Sep.

Ms. Claire Young, senior transnational analyst, Australian Office of National Assessments, 22 Sep.

Mr. Kazuyuki Tsurumi, FAO representative to the Philippines, 29 Sep.

Dr. Masaru Matsumoto, mycologist and assistant professor, Tropical Agriculture Research Center, Kyushu University, Japan, 29 Sep-3 Oct.

Dr. Papa Seck, director general, and *Dr. Marco Wopereis*, deputy director general, research and development, WARDA, 6-8 Oct.

Dr. Kumleh Abbas Shahdi, director general, Rice Research Institute of Iran, and party, 8 Oct.

Dr. Rob Horsch, deputy director, Ag S&T, Global Development Program, and *Dr. Lawrence Kent*, senior program officer, Ag S&T, Global Development, Bill and Melinda Gates Foundation, 15 Oct.

40 developing member country officials, Asian Development Bank, 18 Oct.

Dr. Yulin Jia, research molecular plant pathologist, ASDA ARS/adjunct associate professor, National Rice Research Center, University of Arkansas, 18-29 Oct.

Eduardo Alejandro Pérez Torres, functional genomics, Biotechnology Laboratory, Centro Regional de Investigación, Quilamapu, Chillán, Chile, 21-31 Oct.

Rice breeders from the Long Ping High-Tech Company, 29 Oct.

Dr. Loretta P. Mayer and *Dr. Cheryl Dyer*, Discovery Research Laboratories, Department of Biological Sciences, Arizona, USA, 30 Oct.

Mr. John Stuermer, Asian Bonds Online–ADB, 31 Oct.

Dr. Thomas Mitchell-Olds, professor of biology, Institute of Genome Sciences and Policy, Duke University, USA, 3-6 Nov.

Mr. Martin Riester, Mariphil, Germany, and party, 5-6 Nov.

Dr. B.K. Thapliyal, professor and head, Center for Agrarian Studies and Disaster Mitigation, National Institute of Rural Development, India, and *Mr. Ali Khosravi*, senior expert of rural ICTs, Department of Extension and Farming Systems, Ministry of Jihad-e-Agriculture, Iran, Centre on Integrated Rural Development for Asia and the Pacific, 6 Nov.

Mr. Michael Brandon Teng, general manager and owner, Benelli & Sons, 10 Nov.

Delegation from Coromandel Fertilizers Ltd., Andhra Pradesh, India, 14 Nov.

Dr. Daniel R. Bush, professor and chair, Department of Biology, Colorado State University, 14 Nov.

Dr. Keitaro Suzuki, National Food Research Institute, Food Resource Division, Cereal Science and Utilization Laboratory, Japan, and *Mr. Pravit Santiwattana*, managing director, Thai Edible Oil Co., Ltd., 19 Nov.

27 international participants in the 18th Project Planning, Development, and Management Course, Asian Institute of Management, 22 Nov.

WARDA scientists and *NARES* from Mali, and Madagascar, 18-22 Nov.

Ms. Pam Castro, program manager, Integrated Farm Systems and Shell Training Farms, Pilipinas Shell Foundation, and party, 3 Dec.

Dr. Piya Abeygunawardena, associate director and *Dr. Ed Runge*, senior adviser, Borlaug Institute for International Agriculture, Texas A&M University, 8-10 Dec.

Dr. Zenaida Nisperos Ganga, secretariat deputy director, the Asia and Pacific Seed Association, 10 Dec.

Mr. Andrew McConville, head of corporate affairs–APAC, Syngenta Asia Pacific Pte. Ltd., 10 Dec.

Dr. Jeffrey Q. Shen, associate professor, University of Nevada, Las Vegas, 11 Dec.

Dr. Hiroshi Kamada, professor, Graduate School of Life and Environmental Sciences, Gene Research Center, University of Tsukuba, Japan, 16 Dec.

25 officials, Bank for Agriculture and Cooperatives of Thailand, 19 Dec.

Members of the diplomatic corps

H.E. Dr. Peter Sutter, ambassador of Switzerland to the Philippines, and *Dr. Felix Gmünder,* representative, Basler and Hofmann/Elchrom Scientific, Switzerland, 26 Feb, 12 Aug.

H.E. Kristie Kenney, ambassador of the United States to the Philippines, and party, 10 Mar.

Mr. Francisco Fernandes, counsellor, Timor-Leste Embassy in Manila, and party, 18 Mar.

H.E. Damien Gamiandu, ambassador of Papua New Guinea to the Philippines, 25 Mar.

H.E. Jorge Rey Jimenez, ambassador of Cuba to the Philippines, 28 Apr.

H.E. Alcides G.R. Prates, ambassador of the Federative Republic of Brazil to the Philippines, 10 June.

Delegation from the Embassy of the Republic of Angola to the Philippines, 27 June.

Dr. Raj Kumar, attaché (admin. & ITEC), and party, Embassy of India, Philippines, 1 July.

Participants in the 4th Ambassadors, Consuls-General, and Tourism Directors Tour, 13 July.

H.E. Curtis S. Chin, U.S. ambassador to the Asian Development Bank and executive director, and party, 23 July.

H.E. Ali Mojtaba Rouzbehani, ambassador of the Islamic Republic of Iran to the Philippines, and *Mr. Hamid Reza Salek*, minister counsellor and deputy chief of minister, Embassy of Iran, 29 July.

H.E. Pierre Combernous, head of the Political Division Asia/Oceania, Swiss Federal Department of Foreign Affairs, 12 Aug.

Mrs. Irene Fluckiger, counsellor and deputy head of mission, 12 Aug.

H.E. Rod Smith, ambassador of Australia to the Philippines, 14 Aug.

Ms. Carolyn Atkinson, first secretary, Embassy of Australia in the Philippines, 28 Oct.

Technical staff, Embassy of Saudi Arabia in the Philippines, 29 Oct.

Media

Mr. Friedemann Hottenbacher, director, German, Swiss, and Austrian science channel “hitec” of the German public channel ZDF, 30 Jan-5 Feb.

Ms. Elizabeth Roxas, executive director, Environmental Broadcast Circle, and party, 22 Feb.

Mr. Cecil Morella, AFP journalist, 13 Mar.

Ms. Nancy Valiente, director, South China Morning Post Group Ltd., Hong Kong, 18 Mar.

Mr. Michael Frantzen, reporter, Deutschlandfunk (National German Radio Network), 19 Mar.

Mr. Lawrence Ong, producer/reporter, and *Mr. Yazid Razali*, cameraman/sound technician, BBC World TV, 1 Apr.

Ms. Leanne Savage, deputy editor, *The Land Newspaper*, NSW, Australia, 7-8 Apr.

Mr. Young-Ho Lee, producer, Munhwa Broadcasting Corporation, South Korea, and *Ms. Kate Jang*, project coordinator in the Philippines, 17 Apr.

Mr. Keith Bradsher, Asia correspondent, *New York Times*, and party, 30 Apr.

Malacañan press corps, 2 May.

AGRIBEAT reporters, 2 May.

Heda Byron, reporter, Voice of America TV, 5 May.

Lena Scherman, special correspondent, Foreign News, Swedish Television, 9 May.

Massimo Agostinis, foreign editor, Swiss National Public Radio, 13 May.

Mr. Sean Murphy, reporter, ABC Television Show "Landline," 18-21 May.

Mr. Anthony Germain, reporter, CBC Radio News, 30 May.

Mr. Hartmut Idzko, reporter, German-French Arte Network, 2 June.

Ms. Karen Eshuis, Dutch journalist, *The Dutch Financial Daily Newspaper*, 3 June.

Mr. Masaki Takakura, staff writer, *The Yomiuri Shimbun*, 12 June.

ZDF German TV, German public TV station, 17 June.

Mr. Brend Musch-Borowska, news reporter, ARD German Radio, 23 June.

Ms. Jacqueline Pietsch, Southeast Asia TV reporter with AFP TV, 30 June.

Mr. Naoki Shoji, staff writer, *The Asahi Shimbun*, 7 July.

Ms. Girlie Linao and *Mr. John Grafilo*, reporters, Deutsche Presse-Agentur (German Press Agency), 9 July.

Mr. Liu Hua, Xinhua News Agency, 17 July.

Mr. Michael Baker, correspondent, BBC Manila, 20 July.

Members of the Thai press, Royal Thai Embassy, 30 July.

The Manila Bureau of TV Asahi, Japanese TV News Agency, 31 July.

3 reporters, Public Television Service, Taiwan TV, and *2 professionals* from National Taiwan University, 27 Aug.

Reporters from ARD German TV, 28 Aug.

Mr. John Stanmeyer, *National Geographic*, 29 Aug.

Reporters from Korean Broadcasting System, Korean TV, 2 Sep, 22 Sep.

Mika Funakoshi, correspondent, Kyodo News Manila Bureau, 4 Sep.

Ms. Hilja Müller, German correspondent, 9 Sep.

Mr. Hauke Goos, reporter, *DER SPIEGEL*, 15 Sep.

Reporters from NBC News team, 16 Sep.

Reporters from Global Initiatives TV, 26 Sep.

Mr. Seng Aung Mai from Myanmar, communicator, and *Mr. Quinton Mtyala* from South Africa, journalist, 30 Sep.

Reporters from *Euronews*, 28 Sep-1 Oct.

Ms. Melissa Alipalo, Sugar Mountain Media, 3 Oct.

Mr. Paul Alexander, Associated Press, 7 Oct.

Ms. Elizabeth Schouten, editor-in-chief, and *Mr. Victor Hugo Supelveda*, photographer, *SAMSAM* (The Youth World Magazine), 21 Oct.

Ms. Ruth Reichstein and *Ms. Caroline Ausserer*, German Public Radio Deutsche Welle/Deutschlandfunk (national economic newspaper), Handelsblatt, 31 Oct.

Reporters from Radio France Internationale, 9 Dec.

INFORMATION TECHNOLOGY SERVICES

The highlight of the activities of the Information Technology Services (ITS) unit was the interconnection of the networks of our landlord, the University of the Philippines Los Baños, and of IRRI. A high-speed link, which provides vastly improved access to each other's resources, was inaugurated. As part of the new connection, IRRI provides transit between the UPLB campus network and the National Research and Education Network (PREGINET) and the Asia Pacific Advanced Network (APAN) for high-performance network applications.

IRRI was invited by IBM to participate in the Nutritious Rice for the World project on the World Community Grid, the largest public-computing grid benefiting humanity. The University of Washington, together with its existing partners and IRRI, collaborates on how to move the project forward using the World Community Grid, focusing specifically on which proteins to target. We used the roll-out of a large batch of new computers to install the World Community Grid client software, which uses computer idle time (normally spent doing nothing) to contribute to scientific computations. We are well on the way to contribute 50 years of runtime (the equivalent of one computer running computations for 50 straight years) well ahead of our 50th anniversary.

The project to make IRRI publications available using Google Books (coordinated by CPS and ITS) yielded fantastic results. During 2008, a total of 137,312 people visited IRRI-published books that are available as full text, and viewed a staggering 1,509,546 pages. Usage increased dramatically once we provided a facility to download complete books in pdf in May 2008. During 2008, 9,469 books were downloaded this way. The 139 countries reached with this partnership between IRRI and Google include places where we previously did not have many book sales, including Iran, Iraq, and Guyana.

Improvements made to IRRI's local networking facilities included the installation of new Wi-Fi access points for wider wireless network coverage and new firewall devices using open-source software running on recycled workstations to improve network security. The use of new monitoring facilities allowed the IRRI ITS team to react faster to alerts, mostly in a pro-active way. Some ITS trivia we collected this way:

- Our Internet connections were down for 35 minutes since we implemented improved monitoring in July 2008.
- Our Internet connections carried 21.45 terabytes of data during 2008, twice the content of the U.S. Library of Congress or about a million YouTube videos.
- The Rice Knowledge Bank Web site (hosted at IRRI) was down for 2 hours and 10 seconds in 2008. This is an up-time percentage of 99.94%.
- On an average day, more than 25,000 virus- infected emails addressed to IRRI staff were quarantined.
- Our anti-virus software detected 679,683 malware threats—that's 1.78 prevented infections per minute.
- Our network printing devices printed 2,787,000 pages, using 14 tons of paper or roughly 334 trees.
- Some 14,066 phone calls were made to external numbers from IRRI telephone extensions for a total call duration of 1,057 hours and 17 minutes (that's more than 44 days).

SEED HEALTH UNIT

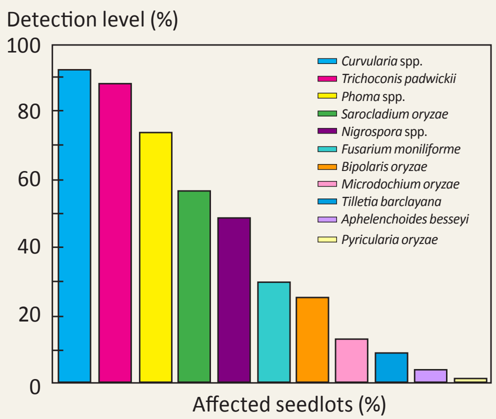
Phytosanitary certification

The Seed Health Unit (SHU) issued 506 phytosanitary certificates covering 118,091 seedlots (3,232.5 kg) and sent to 62 countries worldwide from January to December 2008 (SHU Table 1). By region, East Asia received 85 rice seed shipments (11,610 seedlots weighing 229.0 kg); Europe, 67 shipments (72,236 seedlots, 1,578.0 kg); Latin America, 9 shipments (1,450 seedlots, 28.3 kg); North America, 28 shipments (555 seedlots, 153.5 kg); Oceania,12 shipments (5,162 seedlots, 21.2 kg): South Asia, 108 shipments (10,414 seedlots, 263.3 kg); Southeast Asia, 142 shipments (7,453 seedlots, 681.6 kg); sub-Saharan Africa, 42 shipments (6,597 seedlots, 234.5 kg); West Africa, 4 shipments (2,393 seedlots, 36.4 kg); and West Asia and North Africa, 9 shipments (221 seedlots, 6.9 kg).

Of the 506 shipments exported to different countries worldwide, 437 shipments were rice seeds covering 111,878 seedlots and weighing 2,995.4 kg (SHU Table 2). Other shipments exported were rice/wild rice with a total of 21 shipments covering 1,527 seedlots (15.3 kg); dehulled seeds, 15 shipments (314 seedlots, 2.7 kg); milled rice, 14 shipments (1,945 seedlots, 190.5 kg); wild rice, 10 shipments (2,216 seedlots, 26.3 kg); rice flour, 6 shipments (20 seedlots, 0.2 kg); polished rice, 1 shipment (20 seedlots, 0.2 kg); paddy/milled rice, 1 shipment (6 seedlots, 1.6 kg); and transgenic seeds, 1 shipment (2 seedlots, 0.02 kg).

The exported materials originated from different organizational units: CESD, 14 shipments (532 seedlots weighing 44.025 kg); GRC, 152 shipments (79,937 seedlots, 1,754.9 kg); GQNPC, 22 shipments (890 seedlots, 167.3 kg); and PBGB, 318 shipments (36,732 seedlots, 1,266.3 kg) (SHU Table 3).

The different pathogens detected with corresponding detection level and affected seedlots are shown in SHU Table 4, SHU Fig. 1. Routine seed health tests conducted on 6,435 nontreated outgoing seedlots showed that *Curvularia* spp. affected 92.39% of the seedlots, followed by *Trichoconis padwickii* (88.24%), *Phoma* spp. (73.58%), *Sarocladium oryzae* (56.80%), *Nigrospora* spp. (48.70%), *Fusarium moniliforme* (29.91%), *Bipolaris oryzae* (25.91%),



SHU Fig. 1. Seedborne pathogens detector on nontreated outgoing seeds received by SHU.

Microdochium oryzae (13.21%), *Tilletia barclayana* (9.40%), *Aphelenchoides besseyi* (3.95%), and *Pyricularia oryzae* (1.24%). All exported rice seeds were cleaned for objects of quarantine importance, tested for health, and treated with the prescribed ASEAN standard seed treatment for rice—hot at water 52–57 °C for 15 min. This was followed by fungicide slurry treatment with benomyl and mancozeb, both at 0.1% by seed weight, except for those seeds coming from countries that do not allow seed treatment. Fumigation with phosphine was also administered to all outgoing seeds.

Sixty-seven phytosanitary certificates covering 29,441 seedlots (969.3 kg) were also issued to the International Network for Genetic Evaluation of Rice (INGER) for its nursery rice seed distribution to 32 countries worldwide (SHU Table 5). By region, East Asia received 17 shipments (3,651 seedlots weighing 84.3 kg); Europe, 2 shipments (452 seedlots, 10.7 kg); Latin America, 10 shipments (2,622 seedlots, 65.8 kg); South Asia, 13 shipments (12,410 seedlots, 318.4 kg); Southeast Asia, 14 shipments (6,827 seedlots, 166.8 kg); sub-Saharan Africa, 7 shipments (2,080 seedlots, 50.2 kg); and West Asia and North Africa, 4 shipments (1,399 seedlots, 35.9 kg).

Postentry clearance

One hundred and seven incoming shipments (covering 10,734 seedlots and weighing 736.4 kg) from 26 countries worldwide were also processed for postentry clearance (SHU Table 6). The highest total number of shipments originated from Southeast Asia, with 31 shipments (2,776 seedlots, 160.2 kg), while the highest total number of seedlots originated from East Asia, with 3,821 seedlots weighing 230.4 kg. In terms of total weight, the heaviest volume of materials originated from South Asia, with 233.8 kg for 27 shipments covering 720 seedlots.

Of the 107 incoming shipments, 92 (10,324 seedlots, 671.5 kg) were rice seeds (SHU Table 7). Other incoming shipments were milled rice, 9 shipments (31 seedlots, 22.9 kg); dehulled seeds, 3 shipments (257 seedlots, 37.7 kg); polished rice, 1 shipment (2 seedlots, 3.4 kg); combination of rice and milled rice, 1 shipment (88 seedlots, 0.6 kg); and rice flour, 1 shipment (32 seedlots, 0.3 kg).

The consignees and the nature of incoming shipments are shown in SHU Table 8. PBGB received the highest number of incoming shipments with 75 (7,467 seedlots weighing 572.1 kg), all of which are rice seeds; followed by GQNPC with 19 shipments (729 seedlots, 66.1 kg); CESD with 4 shipments (318 seedlots, 5.8 kg); and GRC with 4 shipments (2,220 seedlots, 92.4 kg).

SHU Tables 9a and 9b show the results of postentry examination conducted on 5,159 incoming seedlots. Of the visually inspected seedlots, none were contaminated with weed seeds or damaged by storage insect pests. In terms of general quality, 2,720 seedlots (52.72%) were under Category 4. The seed health tests on 510 incoming nontreated rice seedlots showed that *Curvularia* spp. affected 90.0%, followed by *Phoma* spp. (73.14%), *T. padwickii* (72.0%), *B. oryzae* (55.7%), *T. barclayana* (43.1%), *F. moniliforme* (38.0%), *S. oryzae* (35.3%), *P. oryzae* (14.3%), *M. oryzae* (13.3%), *A. besseyi* (6.3%), and *Nigrospora* spp. (5.4%) (SHU Table 10). The prescribed ASEAN standard treatments were applied.

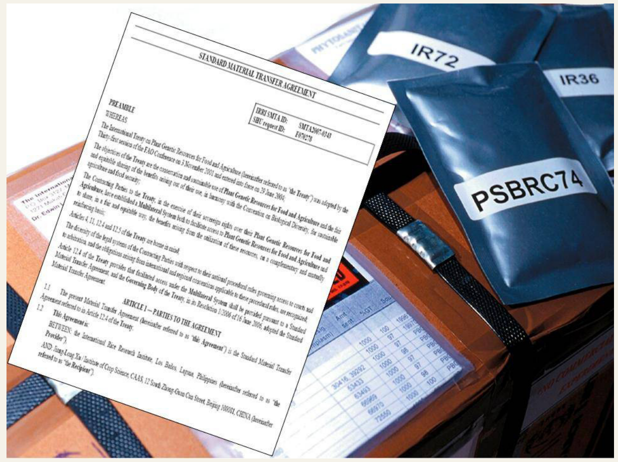
Material Transfer Agreements

Of the 506 rice shipments exported worldwide, 471 shipments covering 37,510 seedlots (1,335.2 kg) were distributed using the standard Material Transfer Agreement (MTA) (SHU Table 11). On the other hand, 61 incoming rice shipments (covering 4,525 seedlots weighing 193.3 kg) from various countries worldwide were accompanied by standard MTAs (SHU Table 12).

Crop health inspection

Crop health inspections were conducted on post-entry quarantine areas and on GRC, PBGB, CESD, and GQNPC seed multiplication plots during the 2008 dry and wet seasons at three different crop stages. SHU Table 13 shows the different diseases observed with corresponding percentage prevalence at different stages of crop growth. For incoming materials planted during the dry season, the most prevalent disease observed at the seedling stage was *Sclerotium* seedling blight (0.3%), whereas the most prevalent disease observed at tillering was tungro (5.4%). The most prevalent disease at maturity was sheath rot (2.1%). During the wet season, the most prevalent disease observed at the seedling stage was again *Sclerotium* seedling blight (17.5%). The most prevalent disease observed during tillering was bacterial leaf streak (41.4%), whereas with mature crops it was tungro (44.4%).

On the other hand, for materials planted in multiplication plots during the dry season, the most prevalent disease observed at the seedling stage



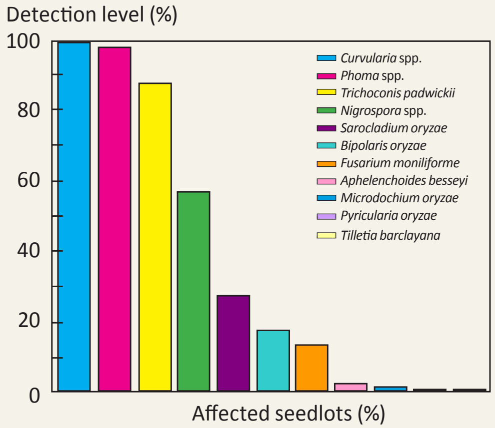
was *Sclerotium* seedling blight (19.1%). The most prevalent disease observed during tillering was tungro (0.9%), while that observed at maturity was sheath rot (0.3%). During the wet season, the most prevalent disease of seedlings was also *Sclerotium* seedling blight (4.3%). The most prevalent disease observed at both tillering and maturity was tungro, 6.5% and 7.0%, respectively.

Advance testing for GRC seeds

A total of 3,840 untreated GRC seedlots were processed for health status before storage. The different fungi detected with corresponding detection level and affected seedlots are shown in SHU Table 14, SHU Fig. 2. Routine seed health testing on these seedlots revealed that *Curvularia* spp. affected 100% of the seedlots, followed by *Phoma* spp. (97.7%), *T. padwickii* (87.5%), *Nigrospora* spp. (56.9%), *S. oryzae* (27.4%), *B. oryzae* (17.3%), *F. moniliforme* (13.5%), *A. besseyi* (2.0%), *M. oryzae* (1.3%), and *P. oryzae* (0.3%). None of the seedlots were infected by *T. barclayana*.

Nonseed biological materials and soil samples

Outgoing (exported). Through the SHU, a total of 68 shipments covering 7,003 samples were processed for phytosanitary certification and sent to 19 countries worldwide (SHU Table 15). By region, East Asia received 18 shipments covering 3,040 samples; Europe got 17 shipments (847 samples); North America, 10 shipments (884 samples); South Asia, 1 shipment (246 samples); Southeast Asia, 15 shipments (122 samples), sub-Saharan Africa, 1 shipment (92 samples); and West Asia and North Africa, 6 shipments (1,772 samples). SHU Table 16 shows the sources and total number of nonseed biological materials and soil samples exported by IRRI. The nature and corresponding number of samples sent by different organizational units are also shown. CESD sent 19 shipments covering 1,949 samples; GQNPC sent 3 shipments covering 30 samples; GRC sent 2 shipments covering 574 samples; and PBGB sent 44 shipments covering 4,450 samples.



SHU Fig. 2. Routine seed health test results of untreated GRC seeds for long-term storage.

Incoming (imported). Seventeen shipments covering 7,228 samples coming from six regions were also processed for postentry clearance (SHU Table 17). The highest number of shipments originated from Europe (six shipments), while the highest number of samples originated from East Asia (3,101 samples). SHU Table 18 shows the recipient organizational unit, nature of incoming materials with corresponding total number of shipments, and total number of samples. The recipients of these incoming materials were CESD with 12 shipments covering 3,313 samples, the majority of which were maize seeds; GQNPC with 2 shipments covering 336 rice leaf and panicle samples; and PBGB with 3 shipments covering 3,579 samples, most of which were DNA extracted from rice.

Workshops, training courses, and visitors

SHU also participated in various training/workshop/orientation programs coordinated by the Training Center: Rice Research to Production Training Course, with 28 participants from 12 countries; Rice Breeding Course: Laying the Foundation for the Second Green Revolution with 13 participants from six countries; Diagnostics on Seedborne Rice Diseases with 11 participants from seven countries; Training of Trainers for the Philippine Self-Sufficiency Plan Course with 36 participants (1st batch), 36 participants (2nd batch), and 35 participants (3rd batch); Upland Rice Variety Selection Techniques (for African countries) with 13 African researchers, 2 Koreans, 1 JICA staff; and orientation activities for 8 interns, 12 scholars, 7 OJTs, 3 resident fellows, and 2 expatriates from PBGB, CESD, GQNPC, GRC, FOH, and IPMO.

The SHU also conducted Training on Identification of Stored Pests of Rice in coordination with the Philippine Plant Quarantine Service (1st batch—5 June, 17 plant quarantine officers; 2nd batch—10 June, 16 plant quarantine officers) as part of its capacity building program.

Visitors included Mr. Ed Paski, RMQA consultant; Ms. Menchu Bernardo, RMQA senior manager; Mr. Joel Rudinas, BPI director; Atty. Ildefonso Jimenez, IRRI legal counsel; 30 members of the Steering Committee and key site coordinators of the Consortium for Unfavorable Rice Environments (CURE); Ms. Yoke Sau, e-learning consultant; members of the Parish Pastoral Council of San Antonio de Padua; Karla Cordero Lara from INIA CRI Quilamapu, Chile; and Mr. Vijaya Kumar, assistant manager of the IRRI-India Office.

GRAIN QUALITY, NUTRITION, AND POSTHARVEST CENTER

Evaluating quality and short-term improvement of the program

Programs 1, 2, and 5

Quality evaluation of materials from Programs 1, 2, and 5 almost doubled from 2007 to 2008. The number of samples submitted in 2008 was 43,657, and these required 99,524 analyses. Of the total, 55.3% were from the Irrigated Rice Program, 16.1% from the Rainfed Lowland and Aerobic Rice Program, 14.3% from Submergence and Flood-Prone, and 10.6% from the Genetic Resources Center.

Projects leading to the improvement of the program include those in the International Network for Quality Rice (INQR) and those operating under GQNPC. Progress of the INQR projects is documented below.

Our research programs have now delivered validated markers for gelatinization temperature, aroma, and amylose content. We genotyped material from the hybridization block (parents used each year) and the genotypes can be found in a growing database in our shareportal and at the INQR site. These data enable breeders to select parents based on the combination of quality alleles that each parent carries. However, in 2008, no breeding programs requested marker data, presumably because of the cost.

Amylose is considered to be the form of starch with the largest contribution to quality, though it is smaller in terms of content. Amylopectin is a much larger component of starch. Thus, the amylopectin structure, on all its levels, presents opportunities for defining new traits of quality. By using genebank material of a number of varieties that do not contain amylose, we determined big differences in cooking properties between varieties. One difference we found is that pastes made from flour from some varieties phase-separated into a viscous liquid and an insoluble paste on heating and shear, while the others did not. We found no differences in chain length distribution of the starch from two varieties, or in the chain length distribution of starch in the paste and the liquid from those that separated, or the branching frequency of the starches. We then used a very new technology to examine the size of the whole molecules—asymmetric flow field fractionation (AF4). This machine is located at the University of Queensland in Australia, where a PhD student, located here, is enrolled. We found that the phase-separating variety had a component of large molecules, which was absent from the variety that did not phase-separate. The structural data are consistent with the supposition that the large molecules cause phase separation by bridging flocculation of colloidal gelatinized particles in the paste, caused by giant amylopectin molecules. This has potential to affect factors such as softness and retrogradation. A paper has been submitted to *Biomacromolecules* and the PhD thesis has been submitted, reviewed, and accepted. Access to this equipment is excellent for analyzing the distribution of whole molecules of starch.

Research with longer term delivery to quality evaluation

Programs 2 and 5

The ACIAR project has components in Programs 2 and 5.

Chalk (Program 2). Chalky areas of rice grains are characterized by partially filled cells, fewer compounds, and smaller individual starch granules relative to the translucent parts of the grains. We have shown that, in high temperature, substrates are supplied to the panicle for a much shorter time, and the duration of grain filling is much shorter. Varieties respond differently to this. Some varieties try to fill every grain, whereas others sacrifice a proportion of spikelets and do not fill them. Both factors lead to a decrease in paddy yield, but varieties that attempted to fill all spikelets had much lighter grains, which were chalky and turned to powder during polishing, whereas in varieties that sacrificed spikelets, the grains that did develop were sound, translucent, and edible (marketable). A manuscript has been submitted to *Functional Plant Biology*.

Chalk is induced by elevated temperatures, and the phenotypes described above explain this. In the chalk project, we are using two sets of two reciprocal introgression lines: one with Lemont and the other with Teqing as the recurrent parent, and one set of recombinant lines from those same parents. Lemont is historically low-chalk and Teqing is high-chalk. The populations have been grown in the field over several seasons, and three sets of chalk data were collected. Chalk did not associate with grain size and was worse in the grains from the dry-season planting, presumably because the plants were undergoing grain filling in the hottest months of the Philippine year. A subset (240) of the populations was grown in the screenhouse until anthesis. Each plant was then moved to one of two phytotrons set to either high temperature (32/26 °C) or control temperature (26/21 °C). Panicle architecture, weight of grain from primary and secondary branches, and chalk value of grain from primary and secondary branches were all measured. The grain weight of seeds from primary branches was higher than that from secondary branches, but chalk values were similar. Chalk values for Lemont and Teqing grown under high temperature were 9% and 45.5%, which decreased to 0.5% and 20.0% under low temperature, respectively. The progeny varied substantially in chalk values from the two treatments. For some, high temperature did not affect the values; for others, the difference was up to 35% more chalk in high temperature. Two mini-subsets of 40 lines, with variability in response to high temperature, were selected for further study.

Chalk (Program 5). The introgression lines were obtained from China, along with a linkage map. However, we rapidly discovered that the genotype of the progeny did not correspond to the genotype given in the map. We then extracted DNA from the subset of 240 and used 140 markers to construct our own map. Using this map, major QTLs were detected on chromosomes 3, 6, and 8; all are in the regions of genes in the pathway of starch synthesis. For all loci, the additive effect of the allele from the recurrent parent Teqing increased by 3.57–7.59% the phenotypic values of chalk. The subset of 240 is currently being sent to about 10 members of the INQR for growing in different countries to test the stability of the QTLs over different environments. Each member will be fully funded to grow the population.

To genotype the traits of grain retention and grain sacrifice in response to environmental conditions, a population is currently being developed for mapping. DNA from parents of the introgression lines and the population has been extracted for analysis on the Cornell SNP chip.

Aroma Program 5 (META-PHOR). Aroma of "fragrant rice" is a trait with clear local and national identity. Many different varieties of jasmine-type rice are consumed in countries of Southeast Asia and many basmati types are consumed in countries of South and Central Asia. The flavor and aroma of these two types of rice can be discriminated easily by consumers, even though the major aromatic component in both types is 2-acetyl-1-pyrroline (2AP). Using a set of aromatic rice accessions from the genebank, we showed that there is no significant difference in the amount of 2AP between jasmine and basmati rice, and no research group has been able to identify the differences that mouths can detect between these two types. One of the reasons could be that most studies use rice bought from the supermarket, which could be a mixture of many and have no history of pre- or postharvest management. Another reason could be that not all volatile compounds have been detected.

The META-PHOR (Metabolomic Technology Applications for Plants, Health, and Outreach) project brings together the world's best plant metabolite expertise and technology. This group of people is the most likely group to determine differences between basmati and jasmine, which would provide markers for programs looking to develop aromatic rice with different parents. Many NARES develop aromatic rice. IRRI is the conduit for collaboration between META-PHOR scientists and the application scientists of the INQR. This enables the best plant metabolite profilers to have access to pure genotypes with known pre- and postharvest management. Thirty-two varieties of aromatic rice, both jasmine and basmati, were supplied from INQR members to META-PHOR. They found more than 400 different volatile compounds in raw grains of basmati and jasmine rice—fourfold more than previously reported, and we have identified a number of these that discriminate the two classes of rice. This work will be advanced by a Malaysian student, in collaboration with META-PHOR scientists, and will be developed into a method to quantify freshness.

The genetic basis of aroma has been shown to be a deletion in a betaine aldehyde dehydrogenase gene. When we genotyped the aromatic material from the genebank, we found 20 aromatic rice accessions that did not carry that deletion. In collaboration with Cornell, we discovered 10 other mutations in that gene that led to the accumulation of 2AP. Different mutations associated with different amounts of 2AP. This is reported in a paper in press with *PNAS*. We also found several varieties that do not carry any mutation in the coding region. F_2 phenotyping and genotyping of progeny from a cross between one of these aromatics and an aromatic carrying the deletion indicates strongly that there are two independent genes for aroma. A PhD student from Laos, funded by META-PHOR, is developing near-isogenic lines to find the other gene. She has two populations, and the parents have unique metabolite profiles. She is at BC_4F_2 now, and the plants are being prepared for the analysis of metabolites, SNPs, and insertion/deletions to select aromatic varieties that are closest metabolically and genetically to the recurrent parent. The student is on the cusp of having the material to find the other gene and to find the pathway of aroma in varieties with the other gene.

Genes for the nutritional value of starch (Program 5). A PhD student, originally from the GQNPC, is located at CSIRO in Australia and co-supervised by the GQNPC head and staff there. Silencing genes of starch synthesis in other cereals leads to higher resistant starch (RS) and lower rates of digestion of the starch (GI). Low-GI starch provides energy for prolonged periods, with benefits of more stable blood sugar levels, resulting in sustained concentration and activity. By using RNAi to silence several genes of starch synthesis, we have now developed candidate genes for low GI and high RS in rice.

We have also investigated a nontransgenic way of lowering GI. GI of rice is reported to be high, but this value was obtained using only temperate japonica lines; diversity had not been examined because a high-throughput tool was not available. This tool is now available at CSIRO and 60 varieties of rice, including mega-varieties, have been analyzed by the machine. GI ranges from low to high and we have been able to associate GI with a trait of quality and the association is very strong. We know the gene controlling that trait, and we know the polymorphisms in the gene that lead to different values for that trait, which associates with different values of GI. Interestingly, many of the mega-varieties have low GI. This means that a cup of rice goes further, and the rice lasts longer in the stomach, so activity and concentration are sustained. A manuscript has been submitted and another invited.

The effect of protein on sensory properties of rice has been determined in collaboration with USDA and a manuscript has been accepted.

Collaboration with NARES through the INQR. INQR members are involved in several large projects, and INQR members are collaborating with many advanced research institutes through the INQR and the externally funded projects operating the GQNPC.

This year, 46 laboratories tested eight methods on 17 varieties of rice. With statistical analysis, we determined the best method to advance, which is quite a bit different from the current method. We have agreement from all members of the INQR that the method will change to the new one. A paper with 31 coauthors has been accepted by *Cereal Chemistry*.

Most ring tests on physical testing are done on subsamples of grain. This means that each participant uses a different grain to do the analysis. In this INQR ring test, we used the FOSS equipment to collect images of 450 grains. We had three workshops for training people to use sorting software (supplied by FOSS), and then everyone sorted the images as they would usually do in their programs. CRIL carried out some clever analyses of how each person classified each grain. Issues came out of this, an online debate occurred along with consultation with breeders, and now everyone is happy with the new definitions that we have agreed to and the priority tree for a grain. At least four groups have bought the instrument, availing of the discount negotiated for INQR members.

Group training courses conducted in 2008.

Course title	Duration	Participants (no.)
International/technical		
Marker-Assisted Selection: Theory, Practice, and Application	21 Jan-1 Feb	24
ICIS Breeders' Training Course	10-14 Mar	22
CIAT-IRRI-WARDA Seed Production Course	10-20 Mar	15
Training Workshop on Participatory Approach to Upscaling the Adoption of Submergence-Tolerant Rice	14-25 Apr	20
Rice: Research to Production	19 May-6 Jun	29
Rice Production and Postharvest Training	23 June-11Jul	26
Rice Breeding Course: Laying the Foundation for the Second Green Revolution	30 July-14 Aug	25
IRIS Workshop for Grain Quality/Chalk Project	20-22 Aug	14
Training Workshop on the Diagnostics of Seedborne Rice Diseases	30 Aug-5 Sep	12
Rice Technology Transfer Systems in Asia	18 Sep-1 Oct	16
Biology of Rice Diseases: Diagnosis and Identification	6-17 Oct	12
Upland Rice Variety Selection Techniques for African Countries	20-31 Oct	14
Marker-Assisted Selection: Theory, Practice, and Application	24 Nov-5 Dec	20
Hands-on Training on Screening Rice Genotypes for Salinity Tolerance	8-10 Dec	8
Subtotal		257
Skills development courses		
Conversational English for Rice Scientists	29 Jan-21 Feb	11
Basic Experimental Design and Data Analysis Using CropStat	18-22 Feb	20
Leadership Course for Asian Women in Agriculture R&D and Extension	3-14 Mar	20
English for Rice Scientists 1	5-28 Aug	13
Mixed Model Analysis Using CropStat	23-25 Sep	12
English for Rice Scientists 2	4-27 Nov	18
Scientific Writing Workshop	11-14 Nov	19
Research Data Management Course	29-31 Jan	10
Research Data Management Course	18-20 Feb	10
Research Data Management Course	26-28 Mar	10
Research Data Management Course	22-24 Apr	10
Research Data Management Course	13-15 May	10
Research Data Management Course	3-5 Jun	11
Research Data Management Course	1-3 Jul	11

Group training courses conducted in 2008.

Course title	Duration	Participants (no.)
Introduction to SAS Enterprise Guide	15-Aug	22
Research Data Management Course	19-21 Aug	9
Research Data Management Course	6-8 Oct	10
Research Data Management Course	2-4 Dec	10
Subtotal		236
In-country/technical		
CESD		
Farmers' Congress in Battambang	23 Jan	51
Combine Harvester Demonstration and Field Day in Battambang	30 Jan	120
Giving Superbags to Households and Explaining Seal Storage	1 Feb	2000
Training on Rice Grain Quality, How to Produce and Manage High-Quality Rice Grain, and Safe Storage of Rice Grain	12 Mar	600
Nutrient Management for Rice and Use of 'Nutrient Manager' Decision Support Tool for Rice	5 May	45
Site-Specific Nutrient Management and Use of the 'Nutrient Manager' Decision Support Tool for Rice	28 May	57
Site-Specific Nutrient Management and Use of the 'Nutrient Manager' Decision Support Tool for Rice	15 July	69
Use of the 'Nutrient Manager' Decision Support Tool for Rice	16 July	49
Rice Specialists' Training Course on the PalayCheck System	24 July	31
Water-Saving Technologies in Rice Production (as part of the Rice Specialists' Training Course on PalayCheck)	25 July	35
Water-Saving Technologies in Rice Production (as part of the Rice Specialists' Training Course on PalayCheck)	30 July	35
Use of 'Nutrient Manager' Decision Support Tool for Rice	20 Aug	19
Water-Saving Technologies in Rice Production	9 Sep	35
Water-Saving Technologies in Rice Production	11 Sep	40
Use of the 'Nutrient Manager' Decision Support Tool for Rice	16 Sep	10
Water-Saving Technologies in Rice Production	23 Sep	39
Water-Saving Technologies in Rice Production	23 Sep	35
Use of the 'Nutrient Manager' Decision Support Tool for Rice	25 Sep	18
Water-Saving Technologies in Rice Production	26 Sep	35
Water-Saving Technologies in Rice Production	27 Sep	40
Training of Agricultural Extension Officers of Two Nam Dinh Communes	27 Sep	50
Introduction and Demonstration of 'Nutrient Manager' for Rice	30 Sep	125

Group training courses conducted in 2008.

Course title	Duration	Participants (no.)
Use of 'Nutrient Manager' Decision Support Tool for Rice	9 Oct	32
Interactive Software on Nutrient and Crop Management in Rice Production	22 Oct	35
Water Saving in Rice Production	18 Nov	35
Use of 'Nutrient Manager' and 'Nutrient Optimizer' as Decision Tools	21 Nov	18
Water Saving in Rice Production	25 Nov	35
Training of Agricultural Extension Officers of Two Long An Communes	27 Nov	50
Establishing a Field School for Rice Millers, Farmers, and Traders	1 Dec	25
Training Course on Rice Postharvest Technology for RUA staff and MAFF	1 Dec	20
Use of 'Nutrient Manager' for Rice and Site-Specific Nutrient Management	3 Dec	40
Water Saving in Rice Production	3 Dec	35
Water Saving in Rice Production	4 Dec	35
Use of 'Nutrient Manager' for Rice and Site-Specific 'Nutrient Management	4 Dec	24
Water Saving in Rice Production	10 Dec	35
Use of 'Nutrient Manager' and 'Nutrient Optimizer' for Rice	11 Dec	47
Use of 'Nutrient Manager' and 'Nutrient Optimizer' for Rice	16 Dec	23
Water-Saving Technologies	25 Jun	25
Water Saving in Rice Production	16 Aug	35
Water Saving in Rice Production	20 Sep	35
Drought Screening for Rice Genetic Improvement + Participatory Varietal Selection	10-15 Nov	26
Using the Dryer for Other Products in Nam Dinh	1-20 Mar	28
Marker-assisted Breeding for Bangladesh	18-27 Nov	16
Support Activities to Farmer Groups in Prey Veng	2007-08	173
Follow-up on Rice Mill Evaluation (Benchmarking) in Prey Veng	2007-08	12
Postharvest Training in Myanmar	23-24 Aug	47
Postharvest Management for Improved Quality of Seeds and Grain	23-24 Aug	47
Postharvest Training in Myanmar	23-24 Aug	47
Postharvest Management for Improved Quality of Seeds and Grain	23-24 Aug	47
Strategic Assessment of Rice-Maize Systems	23-24 Jan & 26-27 Feb	15
Training Course on Dryer Operation and Dryer Technology in Yen Khang	23-24 Oct	20
Rice Production Training Course	23-27 Nov	39
Hermetic Storage (Cocoon) Training and Demonstration in Prey Veng	24-25 Feb	–
Use of "Nutrient Manager" and 'Nutrient Optimizer' for Rice	24-26 Nov	29
Provincial Training of Trainers on Rice Self-Sufficiency plus Vegetable Techno Updates	24-29 Nov	26
Participatory Hermetic Storage Experiment in Long An	25 Oct 2007-25 Apr 2008	8
Farmers' Congress in Battambang	26 Mar-3 May	203

Group training courses conducted in 2008.

Course title	Duration	Participants (no.)
Provincial Training of Trainers on Rice Self-Sufficiency plus Vegetable Techno Updates	2-7 Dec	33
Training on Partial Budget Analysis	28-29 July	20
Training Course on Dryer Operation and Dryer Technology in Yen Phong	28-30 Oct	20
Rice Specialists' Training Course on PalayCheck System	30-31 July	30
Provincial Training of Trainers on Rice Self-Sufficiency plus Vegetable Techno Updates	3-8 Dec	20
Strategic Assessment of Rice-Maize Systems	5-7 Aug	7
Hermetic Storage (Cocoon) Training and Demonstration in Battambang	6-7 Mar	–
Provincial Training of Trainers on Rice Self-Sufficiency plus Vegetable Techno Updates	9-14 Dec	22
Dryer Extension in Long An Province	Aug-Nov	35
IFWM Training Course	15-23 Dec	30
IFWM Training Course	19-22 Dec	30
Support to Dryer Installation in Prey Veng	Jan- Mar	
Trade-off Analysis Training on Poverty, Access to Water, and Livelihood Strategies	30-31 July	10
Water Saving in Rice Production	4-6 June	40
Hands-on Activities to Improve Farmers' Granaries in Battambang	Mar-July	65
Hands-on Activities to Improve Farmers' Granaries in Prey Veng	Mar-July	50
Aerobic Rice Systems	14-15 Oct	40
Water Saving in Rice Production	18-19 Oct	35
Training of Extension Staff on Natural Resource Management for Increasing Rice Productivity	20-21 and 23-24 Oct	89
Understanding QC of ASL Data	Jan-Mar	–
IPMO		
Condensed RTTS Course for China	12-14 Dec	25
TC		
GMA RiceTraining of Trainers, Batch 1	11-22 Aug	33
GMA Rice Training of Trainers, Batch 2	15-26 Sep	34
GMA Rice Training of Trainers, Batch 3	10-21 Nov	31
CRIL		
Introduction to Computers, Excel, Experimental Designs, and Data Analysis	14-18 Jan	22
ICIS Developers' Mini Workshop	14-15 Apr	8
Statistics Training Course, Nepal	1-5 Dec	13
Statistics Training Course, India	8-12 Dec	13

Group training courses conducted in 2008.

Course title	Duration	Participants (no.)
PBGB		
In-country Training on Breeding for Salinity and Submergence Tolerance in Rice (Myanmar)	7-11 Jan	32
GCP Training Workshop: Marker-assisted Breeding for Bangladesh	18-27 Nov	16
Rice Production Training Course with Emphasis on Rainfed Rice Environments (Bhutan)	24-28 Nov	29
SSD		
GIS and Modeling	14-15 Jan	24
Participatory Varietal Selection	5-7 May	23
Participatory Varietal Selection (Thailand)	1-4 June	11
Workshop on Data Validation and Analysis of Baseline Survey Results (Lao PDR)	14-18 Sep	4
Survey Design and Data Collection (India)	16-18 Oct	15
Participatory Varietal Selection and Socioeconomic Component for Experimental Sites (India)	21-23 May	21
Participatory Varietal Selection (Indonesia)	22-24 May	15
Participatory Varietal Selection (Vietnam)	24-27 Jun	16
GIS and Modeling (Indonesia)	26-27 Feb	20
Participatory Varietal Selection and Socioeconomic Component for Experimental Sites (India)	26-28 May	18
Participatory Varietal Selection (Lao PDR)	28 Apr-1 May	12
Participatory Varietal Selection and Socioeconomic Component for Experimental Sites (Bangladesh)	30 Jun-2 July	24
GIS and Modeling (Thailand)	4-5 Feb	27
GIS and Modeling (Lao PDR)	4-5 Mar	19
Data Management and Analysis of Baseline Surveys	4-6 Nov	2
Training Cum Workshop on Gender Analysis and Its Application in Sustainable Rural Livelihood Security (India)	5-7 Sep	31
Data Management and Analysis (Thailand)	6-8 Apr	7
Data Validation and Analysis of Baseline Survey Results (Vietnam)	8-14 Nov	3
Africa		
ESA Regional Officeffice		
Training Workshop on Impact Assessment	12-16 May	15
Participatory Varietal Selection Workshop	17-21 Nov	25
Training Workshop on Seed Production	18-22 Aug	22
Use of Marker-Assisted Selection in Rice Breeding	29 Sep-8 Oct	11
Total		6,102

Scholars on board in 2008, by country and type.

Country		Type	
Africa		**Type I - PhD & MS scholars, thesis research at IRRI**	
Ghana	1		
Asia		PhD	35
Bangladesh	5	MS	16
China	11		
India	8	**Type II - PhD & MS scholars, coursework and thesis research at IRRI**	
Indonesia	2		
Iran	2		
Japan	3	PhD	6
Korea	3	MS	9
Lao PDR	2		
Myanmar	2		
Nepal	2	**Type III - OJT/nondegree**	
Philippines	32		
Thailand	1	OJT/nondegree and interns	11
Vietnam	6		
		Japan-CGIAR fellows	2
North America			
United States	1	**India-IRRI resident fellows**	2
Total	81	**Total**	81

Scholars, by country and type, who completed their training in 2008.

Country		Type	
Africa		**Type I - PhD & MS scholars, thesis research at IRRI**	
Burundi	1		
Ghana	1	PhD	23
Nigeria	1	MS	13
Asia		**Type II - PhD & MS scholars, coursework and thesis research at IRRI**	
Bangladesh	5		
Bhutan	1		
China	10	PhD	10
India	14	MS	3
Indonesia	4		
Iran	2	**Type III - OJT/nondegree**	
Japan	4		
Korea	5	OJT/nondegree and interns	52
Lao PDR	2		
Myanmar	3	**GCP fellows**	3
Nepal			
Philippines	34	**Japan-CGIAR fellows**	2
Sri Lanka	1		
Thailand	3	**India-IRRI resident fellows**	5
Vietnam	6		
		Total	**111**
Europe			
Belgium	2		
England	1		
France	1		
Germany	1		
North America			
Canada	2		
United States	5		
South America			
Ecuador	1		
Peru	1		
Total	**111**		

Weather Summary

Annual rainfall for 2008 was 1,929 mm for the IRRI dryland (upland) site and 1,793 mm for the wetland (lowland) site (Table 1). These values were 134 and 197 mm lower than the long-term average rainfall for the dryland and wetland site, respectively. In terms of monthly rainfall, Los Baños experienced exceptionally high rainfall (more than twice that of the long-term average) in January and February and exceptionally low rainfall (more than half of the average) in July (Fig. 1). The wettest day at IRRI was on 21 June with more than 200 mm rainfall per day due to the passing of typhoon Frank. The longest recorded continuous wet spell was 14 d (24 Oct–6 Nov) at the dryland and 10 d (31 Oct–9 Nov) at the wetland site. The longest continuous dry spell was 18 d (28 Feb–16 Mar) at the dryland and wetland sites.

Mean monthly solar radiation reached a peak in March (more than 18 MJ m^{-2} d^{-1}); the lowest record of 10 MJ m^{-2} d^{-1} was noted in December (Fig. 2). February and December had exceptionally low records of solar radiation. The annual average duration of bright sunshine was about 5.7 h d^{-1} (Table 1). The highest monthly mean value was 8.2 h d^{-1} in March, declining to a low value of 3.1 h d^{-1} in December. The longest record of sunshine at Los Baños was on 5 May with 12.2 h of bright sunshine.

Maximum temperature reached its highest monthly mean value (Fig. 3) in April (32.7 °C at the dryland site and 32.1 °C at the wetland site), whereas lowest monthly mean values were recorded in December (27.9 °C) at the dryland site and in February (27.5 °C) at the wetland site. The hottest day in 2008 was 9 April, with 35.5 °C recorded at the dryland site; the maximum temperature at the wetland site, 34.7 °C, was observed on 2 May. The seasonal pattern of minimum temperatures was more stable than that of maximum temperatures. The coldest day in 2008 was 17 December (20.2 °C at the dryland site and 20.0 °C at the wetland site).

Midday vapor pressure deficit was consistently lower at the dryland site than at the wetland site (Fig. 4). Mean early morning relative humidity ranged from 82 to 90% at the dryland site and from 82 to 88% at the wetland site (Table 1).

Daily mean windspeed (measured at 2-m height) was 1.6 m s^{-1} at the dryland site and 1.3 m s^{-1} at the wetland site (Table 1). Windspeed was generally low (<2.0 m s^{-1}), except during typhoons. The highest windspeed was recorded during Typhoon Cosme (5.2 m s^{-1} at the dryland site on 17 May), which exceeded the windspeed of typhoon Frank on 21 Jun (2.6 m s^{-1} at the dryland site and 3.9 at the wetland site).

Because of a slightly higher air temperature, higher amount of rainfall, and lower vapor pressure deficit at midday, free water evaporation at the dryland site was slightly higher than that at the wetland site (Table 1). Open-pan evaporation totals were 1,621 mm at the dryland site and 1,517 mm at the wetland site. These values were 214 mm lower than the long-term evaporation total at the dryland site and 159 mm lower at the wetland site (Table 1).

Twenty-one cyclones (including 12 typhoons) passed through the Philippines' area of responsibility (PAR) in 2008. These included two events with two overlapping cyclones entering the PAR—typhoon Lando (14–20 May) and tropical storm Dindo (15–18 May) as well as tropical depression Siony (12–13 Nov) and tropical storm Tonyo (13–15 Nov). Three typhoons directly affected Los Baños: Cosme (14–20 May), Frank (18–23 Jun), and Pablo (Sep 29–Oct 2). Typhoon Frank brought about higher accumulated rainfall total in Los Baños.

Weather Summary

Table 1. Monthly weather data for IRRI dryland (14° 08′ N, 121° 15′ E) and wetland sites (14° 11′ N, 121° 15′ E), 2008; long-term averages for dryland and wetland sites from 1979 to 2007.

Site		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual total or average
							Rainfall (mm mo^{-1})							Sum (mm yr^{-1})
IRRI, dryland site		179	62	5	45	244	373	94	242	161	176	150	199	1929
Long-term average		41	26	41	42	145	234	322	252	248	290	245	177	2063
IRRI, wetland site		173	60	7	54	199	294	162	227	131	156	153	178	1793
Long-term average		42	26	40	39	135	225	304	234	240	300	238	168	1990
							Evaporation (mm mo^{-1})							Sum (mm yr^{-1})
IRRI, dryland site		111	95	178	177	149	169	139	134	134	126	114	96	1621
Long-term average		133	155	202	217	201	158	144	142	132	125	115	111	1835
IRRI, wetland site		105	89	170	166	140	160	127	123	123	117	107	92	1517
Long-term average		119	137	175	193	181	149	139	133	123	118	107	102	1676
							Temperature (°C)							Av (°C)
IRRI, dryland site	Max	28.9	28.0	31.1	32.7	32.0	32.6	31.8	31.2	31.7	31.4	30.6	27.9	30.8
	Min	22.9	22.9	23.2	24.4	24.1	23.9	23.9	23.3	24.0	24.4	24.6	23.6	23.8
Long-term average	Max	29.5	30.6	32.1	34.0	34.2	33.0	31.9	31.6	31.7	31.2	30.4	29.1	31.6
	Min	22.0	21.9	22.5	23.8	24.4	24.2	23.7	23.8	23.7	23.7	23.5	22.7	23.3
IRRI, wetland site	Max	28.5	27.5	30.4	32.1	31.7	32.1	31.5	31.1	31.6	31.4	30.3	27.8	30.5
	Min	23.1	23.0	23.3	24.5	24.5	24.5	24.6	24.0	24.5	24.7	24.7	23.6	24.1
Long-term average	Max	28.4	29.1	30.4	32.4	33.0	32.3	31.3	31.1	31.2	30.6	29.9	28.4	30.7
	Min	22.0	21.9	22.6	23.8	24.6	24.6	24.2	24.2	24.0	23.9	23.6	22.7	23.5
							Relative humidity (%)							Av (%)
IRRI, dryland site		87	86	82	82	87	83	86	90	87	87	86	85	86
Long-term average		85	83	80	78	79	83	85	86	87	86	86	85	84
IRRI, wetland site		86	86	83	82	85	82	85	88	86	87	85	84	85
Long-term average		84	84	81	79	79	82	84	85	86	85	85	85	83
							Windspeed (m s^{-1})							Av (m s^{-1})
IRRI, dryland site		1.8	1.9	1.9	1.7	1.4	1.5	1.5	1.2	1.4	1.3	1.5	2.0	1.6
Long-term average		1.7	1.7	1.8	1.6	1.5	1.4	1.4	1.5	1.3	1.3	1.5	1.7	1.5
IRRI, wetland site		1.7	1.5	1.5	1.5	1.1	1.3	1.1	0.9	1.0	1.1	1.5	1.9	1.3
Long-term average		1.8	1.7	1.7	1.6	1.4	1.3	1.3	1.3	1.1	1.2	1.5	1.8	1.5
							Solar radiation (MJ m^{-2} d^{-1})							Daily av (MJ m^{-2})
IRRI, dryland site		12.7	11.7	18.6	18.1	15.8	17.0	15.5	15.2	15.9	14.8	13.0	10.0	14.9
Long-term average		14.4	17.4	19.9	21.7	19.8	17.7	16.5	15.9	16.0	15.1	13.9	12.6	16.7
IRRI, wetland site		12.2	11.3	18.2	17.6	15.3	16.7	14.9	14.8	15.6	14.6	12.7	9.6	14.5
Long-term average		14.1	17.4	20.1	21.9	19.9	17.7	16.5	15.8	16.0	15.0	13.5	12.2	16.7
							Sunshine (h d^{-1})							Daily av (h)
IRRI, wetland site		5.2	3.6	8.2	8.0	5.6	7.3	5.0	5.1	5.3	6.4	5.3	3.1	5.7
Long-term average		5.5	7.2	8.0	9.0	7.6	6.0	5.1	4.8	4.8	5.1	5.3	4.4	6.1

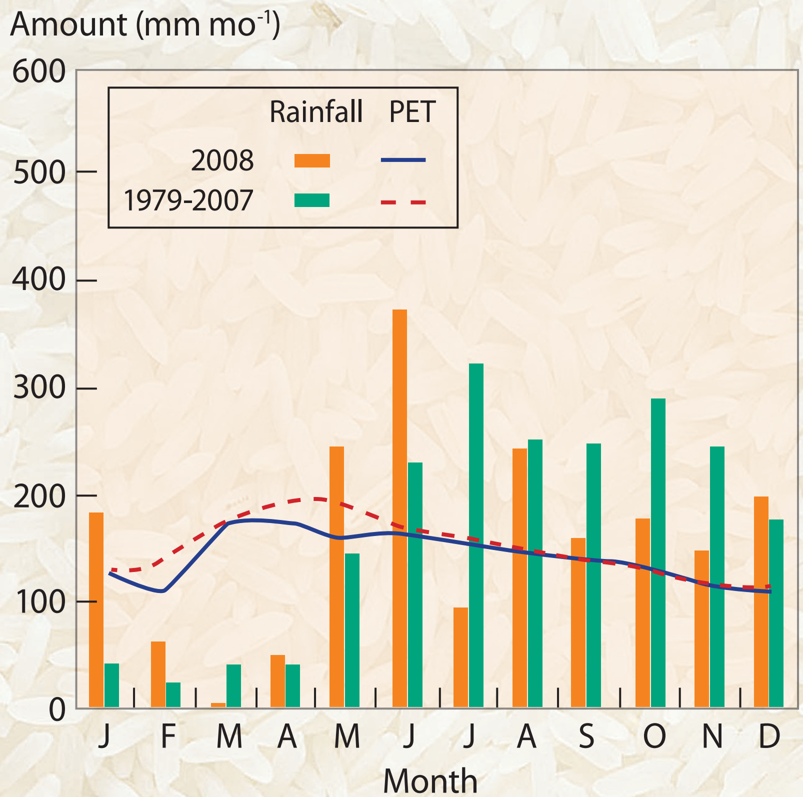


Fig. 1. Monthly rainfall and potential evapotranspiration in 2008 and long-term averages.

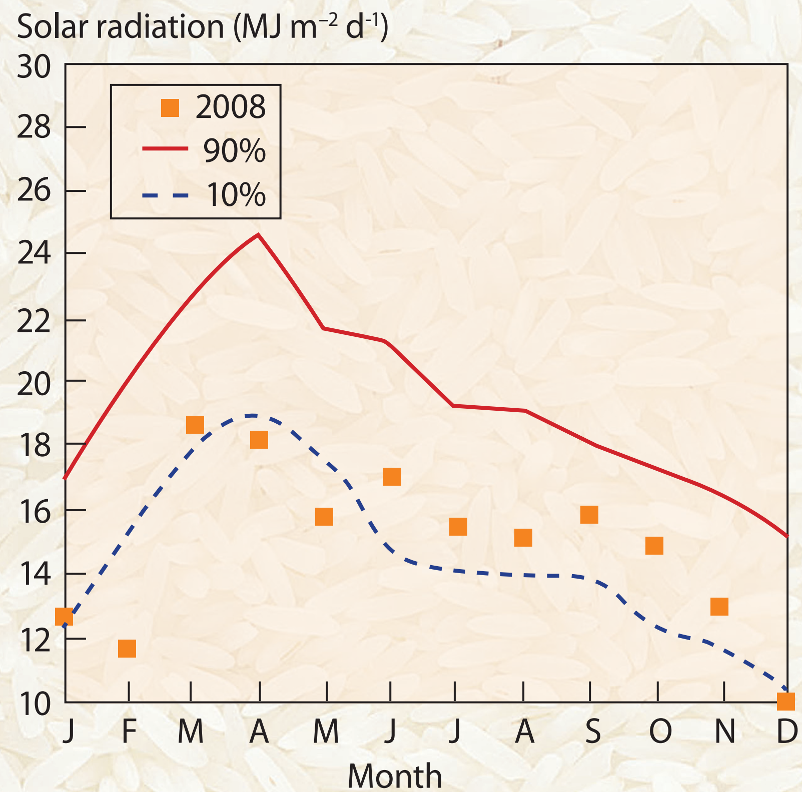


Fig. 2. Mean monthly solar radiation with 10 and 90% probability of occurrence derived from long-term averages. IRRI, 2008.

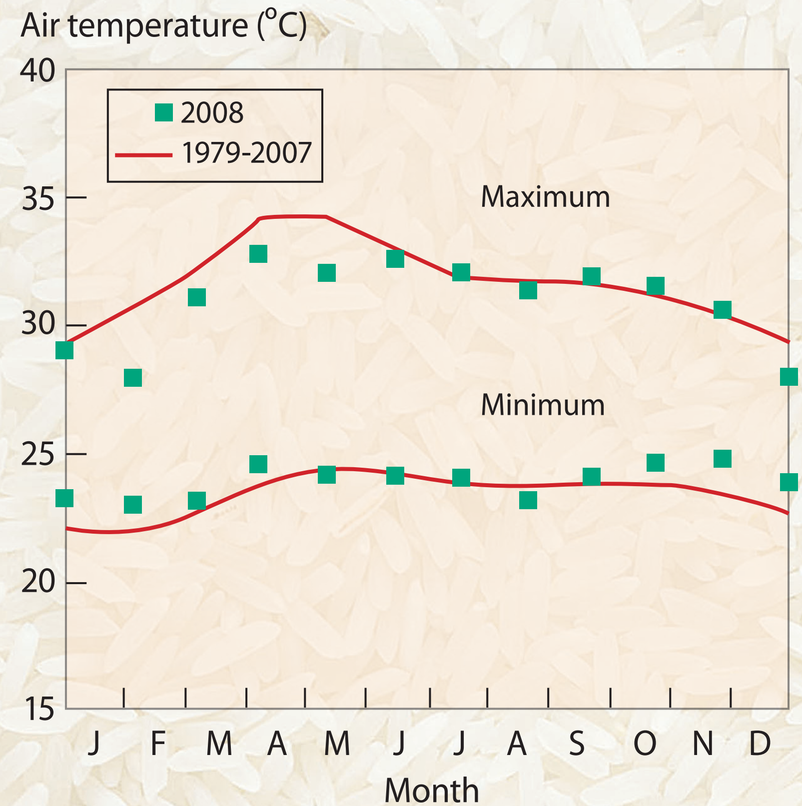
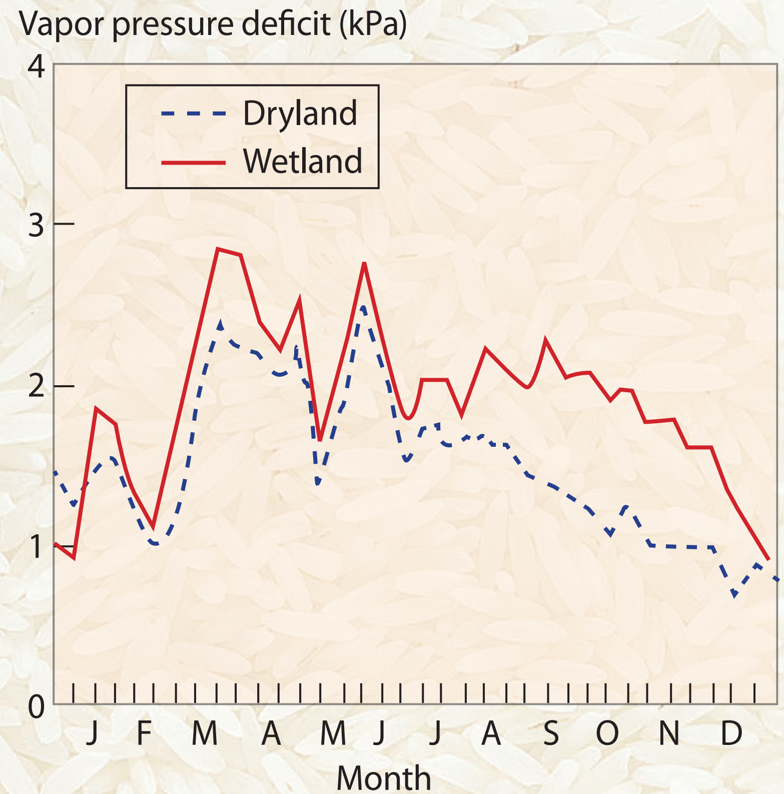


Fig. 3. Monthly maximum and minimum air temperature in 2008 and long-term averages. IRRI, 2008.



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Pampolino MF. Nutrient and crop managers: interactive computer-based modules for facilitating dissemination of SSNM and ICM for rice. Presented at the Indonesian Soil Research Institute, Bogor, Indonesia, 13 Mar.

Peng S. 2008. Introduction on IRRI and its research—with focus on genetic improvement in WUE and NUE. Presented at the Fujian Academy of Agricultural Sciences, Fuzhou, China, 1 Aug.

Peng S. 2008. New techniques of rice nitrogen management. Presented at Huazhong Agricultural University, Wuhan, China, 11 Jun.

Peng S. 2008. Nitrogen management strategies for improving rice NUE. Presented at the IPNI-China Program and Institute of Agricultural Resources and Regional Planning, Chinese Academy of Agricultural Sciences, Beijing, China, 2 June.

Peng S. 2008. Progress of aerobic rice research at IRRI. Presented at the Shanghai Agrobiological Gene Center, Shanghai, China, 18 Apr.

Peng S. 2008. Rice crop physiology research in the face of global climate change. Presented at Liaoning Academy of Agricultural Sciences, Shenyang, China, 23 Sep; Shenyang Agricultural University, Shenyang, China, 26 Sep; and South China Agricultural University, Guangzhou, China, 29 Sep.

Serraj R, Hervé P. 2008. Screening and physiological characterization of drought resistance in transgenic lowland rice at IRRI. Presented at the 1st Annual Meeting of the MAFF-funded Project “Promotion of Research Targeting Stable Supply of Global Food,” JIRCAS, Tsukuba, Japan, 16-18 Jan.

Serraj R. 2008. Drought resistance in rice: phenotyping and trait-based selection. Presented at the Research Centre for Biotechnology, Indonesian Institute of Sciences, Bogor, Indonesia, 9 Jan.

Serraj R. 2008. Drought resistance in rice: towards integration of physiology, breeding, and functional genomics. Presented at CIRAD, Montpellier, France, 25 June.

Serraj R. 2008. Drought screening protocols for upland environments. Presented at the training course “Drought Screening for Rice Genetic Improvement,” Birsa Agricultural University, Ranchi, Jharkhand, India, 10-15 Nov.

Serraj R. 2008. Identifying genes responsible for failure of grain formation in rice and wheat under drought. Presented at the Annual Research Meeting of the Generation Challenge Program, Bangkok, Thailand, 16-20 Sep.

Serraj R. 2008. Improvement of drought resistance in rice. Presented at the National Center for Genetic Engineering and Biotechnology, Thailand Science Park, Klong Luang, Thailand, 2 Apr.

Serraj R. 2008. An integrated strategy for drought resistance improvement in rice. Presented at the National Center of Biotechnology, IARI, New Delhi, India, 2 Oct.

Serraj R. 2008. Overview of drought resistance component traits and trait-based selection. Presented at the training course “Drought Screening for Rice Genetic Improvement,” Birsa Agricultural University, Ranchi, Jharkhand, India, 10-15 Nov.

Serraj R. 2008. Overview of soil-plant-water relations and drought stress physiology. Presented at the training course "Drought Screening for Rice Genetic Improvement," Birsa Agricultural University, Ranchi, Jharkhand, India, 10-15 Nov.

Serraj R. 2008. Phenotyping and breeding for drought resistance improvement. Presented at the STRASA-BMGF Project Inception Meeting, Dhaka, Bangladesh, 30-31 Mar.

Serraj R. 2008. Phenotyping reproductive-stage traits and processes under drought. Presented at the training course "Drought Screening for Rice Genetic Improvement," Birsa Agricultural University, Ranchi, Jharkhand, India, 10-15 Nov.

Singleton GR. 2008. Ecology-based management of rodents: the good, the bad, and hindi masyadong pangit. Presented at the Institute of Biology, College of Arts and Sciences, University of the Philippines, Diliman, Quezon City, 7 July.

Singleton GR. 2008. Improving rice productivity in South Sulawesi. Presented at the Assessment Institute for Agricultural Technology, Maros, South Sulawesi, 2 Apr.

Singleton GR. 2008. Improving rice productivity in Southeast Sulawesi. Presented at the Assessment Institute for Agricultural Technology, Kendari, Southeast Sulawesi, 4 Apr.

Singleton GR. 2008. The Irrigated Rice Research Consortium: platform for research to impact. Presented at the IRRC Phase IV Stakeholder Meeting, Vientiane, Lao PDR, 13 June; Rice Department of Thailand, Bangkok, Thailand, 11 Jan; and the Philippine Rice Research Institute, Muñoz, Nueva Ecija, Philippines, 4 Feb.

Tuong TP. 2008. IRRI research—with focus on water management. Presented at the National Institute of Rural Engineering, Tsukuba, Japan, 17 June.

Tuong TP. 2008. Technologies for efficient utilization of water in rice production Presented at the Bangladesh Rice Research Institute, Gazipur, Bangladesh, 10 Aug.

Tuong TP. 2008. Water-saving technologies in rice production. Presented at the Department of Agriculture and Rural Development, An Giang, Vietnam, 19 Nov.

Vergara GV. 2008. Analysis of data in designed experiments. Presented at the IRRI Training Center, Los Baños, Philippines, 22 Apr.

Vergara GV. 2008. Background on *Sub1* and types of flooding. Presented at the IRRI-DA Forum, Iloilo City, Philippines, 23 May.

Vergara GV. 2008. Enhancing productivity of rice in submergence-prone environments. Presented at the Indonesian Center for Food Crops Research and Development, Indonesia, 19 Feb.

Vergara GV. 2008. New directions in flooding tolerance. Presented at the BMZ project review, site visit, and wrap-up, India, 7 Nov.

Plant Breeding, Genetics, and Biotechnology Division

Brar DS. 2008. Genomics in crop breeding. Presented at the Chinsurah Rice Research Station, West Bengal, India, 14 Nov.

Brar DS. 2008. Plant breeding in the genomics era. Lee Memorial Lecture. Academia Sinica, 8 Oct, Taipei, Taiwan.

Brar DS. 2008. Transgenic rice and biosafety protocols at IRRI. Presented at the Workshop on Biosafety Regulations: Experiences in Implementation, 23-24 Oct, UPLB, Los Baños, Laguna.

Heuer S. 2008 Major QTLs and candidate genes for P uptake in rice: *phosphate uptake 1* (*Pup1*). Presented at the workshop on "Marker-Assisted Selection (MAS) in Rice: Theory, Practice, and Application," International Rice Research Institute, Los Baños, Philippines, Jan.

Kohli A. 2008. Developing improved and non-toxic *Jatropha* varieties. Presented at the Jatropha International Congress, Singapore, 17-18 Dec.

Kohli A. 2008. The food and fuel research paradigm: systems approaches to rice and *Jatropha* improvement. Presented at the Temasek LifeScience Laboratories, Singapore, 8 May.

Kohli A. 2008. Research methods in *Jatropha* improvement. Presented at the Barwale Research Foundation and Knowledge Centre, Jalna, India, 12-15 Jan.

Lee KS. 2008. Current research activities and status of IRRI. Presented at the workshop for liaison scientists of RDA in seven CG centers and two countries, Rural Development Administration, Korea, 17 Sep.

Lee KS. 2008. Research achievement and prospects of IRRI. Presented at the National Institute of Crop Science, RDA, Korea, 21 Sep.

Mackill DJ. 2008. Flooding tolerance in rice: one solution for the rice crisis. Presented at the Indian Merchants' Chamber, Mumbai, India, 20 Nov.

Redoña ED. 2008. Breeding heat-tolerant rice. Presented at the Rice Research Institute, Anhui Academy of Agricultural Sciences, Hefei, Anhui, China, 20 Oct.

Redoña ED. 2008. Germplasm exchange and INGER. Presented at the Rice Research to Production Training Course, IRRI, Los Baños, Philippines, 2 June.

Redoña ED. 2008. INGER and germplasm exchange. Presented at the Food Crop Research Institute, Hanoi, Vietnam, 27 Jan.

Redoña ED. 2008. INGER and international germplasm sharing. Presented at the Department of Agricultural Research, Yezin, Myanmar, 23 Sep.

Redoña ED. 2008. INGER, the International Treaty on Plant Genetic Resources for Food and Agriculture, and the Standard Material Transfer Agreement. Presented at the Rice Research Institute of Iran, Rasht, Iran, 25 Aug.

Redoña ED. 2008. INGER and the new rules on germplasm exchange. Presented at the Rice Research Institute, Batalagoda, Sri Lanka, 25 Jan.

Redoña ED. 2008. Planning rice breeding programs. Presented at the Rice Breeding Course, IRRI, Los Baños, Philippines, 30 July.

Redoña ED. 2008. Rice diversity and germplasm exchange. Presented at the Rice Production and Postharvest Training Course, IRRI, Los Baños, Philippines, 24 June.

Redoña ED. 2008. The International Network for Genetic Evaluation of Rice (INGER). Presented at the 2008 Rice Breeding Course, IRRI, Los Baños, Philippines, 6 Aug.

Redoña ED. 2008. The International Network for Genetic Evaluation of Rice (INGER) and germplasm exchange. Presented at the training course on Biology of Rice Diseases: Diagnosis and Identification, IRRI, Los Baños, Philippines, 16 Oct.

Redoña ED. 2008. The International Network for Genetic Evaluation of Rice (INGER). Presented at the Upland Rice Variety Selection Techniques for African Countries Training Course, IRRI, Los Baños, Philippines, 29 Oct.

Singh RK. 2008. Problems, progress, and prospects of breeding salt-tolerant rice varieties for Asia and Africa. Presented at WARDA, Benin and St. Louis, 3 & 5 Sep, respectively.

Singh RK. 2008. Problems, progress, and prospects in developing salt-tolerant rice varieties for Asia and Africa. Presented at the African Japanese Plenary Workshop on Sustainable Rice Production, Alexandria, Egypt, 23-25 Aug.

Singh RK. 2008. Progress of rice breeding for salt tolerance at IRRI. Presented at Mekong University, Vietnam, 30 Sep.

T.T. Chang Genetic Resources Center

McNally KL. 2008. Discovery of genome-wide SNPs in diverse rice—a foundation for whole-genome association studies. Presented at IRRI, Los Baños, Philippines, 8 May.

McNally KL. 2008. Discovery of genome-wide SNPs in diverse rice—a foundation for whole-genome association studies. Presented at Plant Breeding Department, Cornell University, Ithaca NY, 20 May.

McNally KL. 2008. Discovery of genome-wide SNPs in diverse rice—a foundation for whole-genome association studies. Presented at the Center for Genomics and Systems Biology, New York University, NY, 29 May.

International Programs Management Office

Ladha JK. 2008. International agronomy. Presented at the American Society of Agronomy Board Retreat, Chicago, USA, 14-16 Apr.

Ladha JK. 2008. Role of biological nitrogen fixation in replenishing soil nitrogen in cropping system. Presented at the Department of Crop and Soil Sciences, Colorado State University, Fort Collins, USA, 9 May.

Pathak H. 2008. Global climate change and Indian agriculture. Presented at Humboldt Kolleg, Puri, Orissa, 11-14 Dec.

Pathak H. 2008. Global climate change and its impact on agro-ecosystems. Presented at the Indian Institute of Science, Bangalore, 5-6 Nov.

Seed Health Unit

Gonzales P. 2008. Rice seed health testing at IRRI. Presented at WARDA station, International Institute of Tropical Agriculture, Ibadan, Nigeria, 23 Apr.

Office of the Director General

Zeigler RS. 2008. Challenges of the global food crisis. Presented at the Asia Society, Washington, D.C., 3 Nov.

Zeigler RS. 2008. IRRI's rice action plan. Presented at the 30th AMAF Meeting, Hanoi, Vietnam, 22 Oct.

Zeigler RS. 2008. The rice crisis: strategic solutions and the investments needed. Presented at the National Taiwan University–World Rice Development: The NTU-IRRI Partnership, Taiwan, ROC, 9 Oct.

Zeigler RS. 2008. Re-shaping agricultural policy. Presented at the Committing Science to Global Development Workshop, Lisbon, Portugal, 29-30 Sep.

Zeigler RS. 2008. Plant diseases and the world's dependence on rice. Presented at the 9th International Congress of Plant Pathology, Turin, Italy, 24-29 Aug.

Zeigler RS, Dobermann A, Mackill D. 2008. Rice science: key to food security and environmental health in a changing world. Presented at the 5th International Crop Science Congress, Jeju, Korea, 13-15 Apr.

Office of the Deputy Director General for Operations and Support Services

Padolina WG. 2008. Biotechnology, agriculture development, and biosecurity in Asia—challenges and opportunities. Presented at the 5th Asian Conference on Food and Nutrition Safety, Cebu City, Philippines, 3 Nov.

Padolina WG. 2008. Biotechnology and food security. Presented at the National Defense College of the Philippines, Camp General Emilio Aguinaldo, Quezon City, Philippines, 28 Mar.

Padolina WG. 2008. Challenges to development. Presented at the National Defense College of the Philippines, Camp General Emilio Aguinaldo, Quezon City, Philippines, 19 June.

Padolina WG. 2008. Food security and rice. Presented at the Understanding Choices Forum, Eduardo Aboitiz Development Studies Center, Cebu City, Philippines, 13 June.

Padolina WG. 2008. Food security and rice. Presented at the World Knowledge Forum, Seoul, Korea, 16 Oct.

Padolina WG. 2008. IRRI and food security. Presented at the World Food Crisis Forum, Jeju, Korea, 17 Oct.

Padolina WG. 2008. Population and rice. Presented at the 2008 World Population Day Forum on Population and the Millennium Development Goals, Mandaluyong City, Philippines, 11 July.

Padolina WG. 2008. Report and recommendations of the COMSTE Agriculture and Food Panel. Presented at the Innovation Summit organized by DOST, Sofitel Philippine Plaza, Pasay City, Philippines, 26 Nov.

Padolina WG. 2008. Report and recommendations of the COMSTE Agriculture and Food Panel. Presented at the Research & Development Conference, University of the Philippines Diliman, Quezon City, 15 Dec.

Thursday rice research seminars

Drought tolerance and synthetic apomixes: odd bedfellows or a perfect match? Dr. John Bennett, 10 January, Audio and powerpoint.

Luck is the residue of design. Video of Pioneer Interview of Dr. Peter Jennings, IRRI's first plant breeder. 17 January, Video.

A scientist's insights as a farmer. Dr. Cezar Mamaril, PhilRice consultant and Laguna farmer, 24 January, Audio and powerpoint.

Transformation of food systems in the developing world: implications for research and policy. Dr. Prabhu Pingali, head of Agricultural Policy and Statistics Division, Bill and Melinda & Gates Foundation, 31 January.

GMO another day. What would change if GMO would be everywhere? Dr. Philippe Hervé, 7 February, Audio and powerpoint.

Keeping up in Latin America: rice strategic research from Colombia. Dr. Joe Tohmé, geneticist, Agrobiodiversity and Biotechnology project leader, International Center for Tropical Agriculture, Colombia, 14 February

Partnerships for change. Dr. Deborah Templeton, 28 February, Audio and powerpoint.

Video on the Svalbard Seed Vault. Mr. Gene Hettel.

The Worldfish Center Philippines Office: What is the impact of biodiversity informatics on food security, poverty, and hunger alleviation? Mr. Nicolas Bailly, FishBase project leader, Worldfish Center, 3 April.

IRRI.ORG—pathways to new web presence. Mr. David Foote, FBM eServices, 17 April.

Reflections and projections: the rice crisis, past and present. Dr. Randolph Barker, 24 April, Audio and powerpoint.

IRRI's response to the rice crisis. Panel of IRRI staff, 29 April Audio.

Discovery of genome-wide SNPs in diverse rice—a foundation for whole-genome association studies. Dr. Kenneth McNally. 8 May. Audio and powerpoint.

What it takes to translate genomics into efficient breeding. Dr. Hei Leung, 22 May. Audio and powerpoint.

Plant breeding in the genomics era. Dr. Darshan Brar. 29 May. Audio and powerpoint.

The geography of poverty: its nature, causes, and implications. Dr. Robert Hijmans. 12 June. Audio and powerpoint.

The Greener Revolution: more than rice itself. Dr. Gary Jahn, 26 June. Audio and powerpoint.

Sena's heritage and its new challenges: salinity and biofortification in South Korea. Dr. K.S. Lee, 27 June. Audio and powerpoint.

Making the Philippines self-sufficient in rice: the role of IRRI. Dr. Leocadio Sebastian, former PhilRice executive director, 7 August.

Reaching 300,000 in 3 years: stress-tolerant rice for the poorest farmers of South Asia. Dr. Uma Shankar Singh, 14 August, Audio and powerpoint.

Rice prices have started to fall—does this mean that the rice crisis is over? An update and outlook. Dr. Sushil Pandey, 14 August Audio and powerpoint.

Impacts of climate change on rice production in the mega-deltas of Asia: a case study of the Mekong Delta affected by sea-level rise. Dr. Reiner Wassmann, 28 August Audio and powerpoint

Ecological management of rodents—the good, the bad, and hindi masyadong pangit! Dr. Grant Singleton, 4 September, Audio and powerpoint.

Why do planthopper outbreaks occur? Dr. K.L. Heong, 11 September, Audio and powerpoint.

How can breeders help rice to live with an enemy? Dr. R.K. Singh, 25 September, Audio and powerpoint.

GreenPhylDB: a comparative genomics platform to drive functional genomics in plants. Mr. Matthieu Conte, 20 October, Audio and powerpoint.

Improving rice production in sub-Saharan Africa: joint IRRI-WARDA strategy. Panel of IRRI and WARDA staff. 7 October, Powerpoint.

The rice crisis, the media, and you. Mr. Adam Barclay, 16 October, Audio and powerpoint.

The makings of C4 rice. Ms. Jacqueline Dionora, 23 October, Audio and powerpoint.

Integration of physiological modeling and genetic analysis to study crop genotype-to-phenotype relationships. Dr. Yin Xinyou, 6 November.

One year of seeding and seven years of weeding. Dr. David Johnson, 18 November, Audio and powerpoint

Public-private sector partnerships for bringing new technologies to farmers. Dr. Achim Dobermann, 20 November, Audio and powerpoint.

Nutrient management for drought-prone lowlands: principles and options. Dr. Stephan Haefele 27 November. Audio and powerpoint

IRRI on YouTube. Mr. Gene Hettel, 4 December.

End-of-year and mid-year addresses to staff. Dr. Robert Zeigler, 11 December, Audio and powerpoint.

Division seminars

Crop and Environmental Sciences

Sustainable rice production in Indian Punjab: issues and approaches. Dr. Gulshan Mahajan, rice agronomist, Punjab Agricultural University, Ludhiana, India.

Productivity, sulfur dynamics, and sustainable management for rice-maize (*Oryza sativa* L.-*Zea mays* L.) as compared to rice-rice cropping patterns. Ms. Su Su Win.

Direct drilling wheat into rice residues in the north-west Indo-Gangetic Plains. Dr. Elizabeth Humphreys.

Nutrient and crop managers: interactive computer-based decision tools for facilitating dissemination of integrated nutrient and crop management. Dr. Roland Buresh.

New practical techniques to reduce water consumption and greenhouse gas emission in paddy fields. Dr. Yuichiro Furukawa.

Managing rice landscapes in the uplands for improvement of livelihoods and conserving resources. Dr. Benjamin K. Samson.

Leaf carbon gain and water use efficiency in tropical rice: interactions and directions for improvement. Dr. Erik Murchie, lecturer in Crop Physiology Division, Agricultural and Environmental Science, School of Biosciences, Sutton Bonington Campus, University of Nottingham, UK.

Characterization of the microclimate within the rice canopy in flooded and non-flooded rice fields (using eddy covariance method). Ms. Maricar Alberto.

One decade of research on improving rice nitrogen fertilization through site-specific nitrogen management in China. Dr. Shaobing Peng.

Integrated pest management in sustainable agricultural systems. Dr. Serge Savary.

Yield constraint analysis of rainfed lowland rice in Southeast Asia. Dr. Anita Boling.

Application of GC/MS on environmental samples and pesticide analysis: latest trends, advances, and innovations. Dr. Novalina Lingga, deputy manager for applications, Shimadzu Asia Pacific, Singapore.

Practical and cost-effective solution to CESD's potential bombs. Ms. Lily R. Molina.

The burning of a little straw may hide the stars. Dr. Sarah E.J. Beebout.

Biochemical adaptation of purple nutsedge (*Cyperus rotundus* L.) to lowland conditions. Mr. Rolly G. Fuentes, Division of Natural Sciences and Mathematics, University of the Philippines in the Visayas–Tacloban College.

A colorimetric method for the determination of Zn in rice plants and inorganic fertilizers. Mr. Jack Deodato Jacob.

On-the-go soil sensing systems. Dr. Viacheslav I. Adamchuk, associate professor, Biological Systems Engineering Department, University of Nebraska–Lincoln, NE, USA.

Addressing pH-associated yield constraints in aerobic rice. Mr. Van Ryan Haden, affiliate PhD scholar, Cornell University.

AquaCrop–a new model for crop prediction under water deficit conditions—a first attempt of calibration for rice. Ms. Gabriella Izzi, consultant, Food and Agriculture Organization of the United Nations, Rome, Italy.

The fine art of agricultural innovation: where scientists and farmers meet. Prof. Cees Leeuwis, Communication and Innovation Studies, University of Wageningen (joint seminar with SSD).

High amylase activity and high ethylene production in rice tolerant of flooding at germination and early seedling stage. Ms. Evangelina S. Ella.

Measurement of heat, water vapor, and carbon dioxide exchanges between the atmosphere and terrestrial ecosystems using the eddy covariance technique. Dr. Takashi Hirano, professor of environmental informatics research, Faculty of Agriculture, Hokkaido University, Sapporo, Hokkaido, Japan.

Early, complete, and prolonged flooding stress: genetic diversity and physiological adaptations. Dr. Georgina V. Vergara.

Spatial prediction of ecosystem services by means of easily available geoinformation. Dr. Kay Sumfleth.

Conflicting experiences with permanent raised bed rice-wheat systems. Dr. Elizabeth Humphreys.

Climate change—has climate become more favorable for growing corn over the past century? Dr. Edward C.A. Runge, professor, and Billie B. Turner, chair in production agronomy, Texas A&M University, Department of Soil and Crop Sciences.

ASL: meeting the needs of agronomists, breeders, and entomologists in rice research. Ms. Lily R. Molina.

Plant Breeding, Genetics, and Biotechnology

Molecular mapping for resistance genes of brown planthopper in rice. Dr. Suk-Man Kim.

Gene bank management in the context of GM crops. Dr. Ruaraidh Sackville Hamilton.

Epoxide hydrolase genes of *Nicotiana benthamiana* as disease response (DR) genes and quantification of foliar diseases. Dr. Paul Goodwin, Department of Environmental Biology, University of Guelph, Canada.

Breeding varieties resistant to rice virus diseases in Korea. Mr. Do-Yeon Kwak.

Development of near-isogenic lines for blast resistance and their application in rice breeding. Dr. Nobuya Kobayashi.

Genome resources for gene identification in wheat. Dr. Colin Cavanagh, Cereal Quality Group, CSIRO Plant Industry, Canberra ACT, Australia.

Identification and characterization of QTL for drought resistance. Mr. Jerome Bernier.

Integrated pest management in sustainable agricultural systems. Dr. Serge Savary.

Epidemiology of plant diseases: processes, scales, and implications for breeding host plant resistance in rice. Dr. Laetitia Willocquet.

An analytical approach for making selection decisions on rice flavor. Prof. Stanley J. Kays and Dr. Dong-Sik Yang, University of Georgia, USA.

Genetics of sterility in hybrids between wild and cultivated rice strains. Dr. Yohei Koide.

Signaling in the rice and *Rhizoctonia* pathosystem. Dr. Yulin Jia, National Rice Research Center, University of Arkansas, USA.

Advances in biotic and abiotic stress tolerance. Dr. Thomas Mitchell-Olds, Department of Biology, Institute of Genome Science and Policy, Duke University, USA.

Plant sugar and amino acid transporters: from structure and function to regulating resource allocation and multicellular growth. Dr. Daniel R. Bush, Department of Biology, Colorado State University, USA.

Genome analysis and molecular cytogenetics of *Oryza* species. Dr. Mei-Chu Chung, Institute of Plant and Microbial Biology, Academia Sinica, Taipei, Taiwan.

Genetic variation and submergence tolerance of rice varieties from flood-prone areas. Dr. Abu Shaker Masuduzzaman.

Social Sciences

Mapping rice submergence: where are we? Dr. Yann Chemin.

Micro-credit for poverty reduction: evaluation of WAVE Foundations's microfinance program in Bangladesh. Ms. Catalina Diaz.

Poverty, water, and livelihoods: a case of two upper-catchment villages in the northern Lao PDR. Dr. Hari Gurung.

Prospect for the green revolution in Africa. Dr. Yujiro Hayami, advisor, Graduate Program, GRIPS/FASID Joint Programme, Tokyo, Japan.

Using advanced climate information for agriculture and water management. Dr. Amor V.M. Ines, International Research Institute for Climate and Society, The Earth Institute at Columbia University, New York, USA.

Developments in rice science: questions to history and challenges for the future. Mr. Harro Maat, university lecturer, Technology and Agrarian Development, Wageningen University, The Netherlands (joint seminar with CESD).

Modeling food supply and demand and building a potential hunger map for Asia. Dr. Kan ichiro Matsumura, associate professor, Kwansei Gakuin University, Japan.

High commodity prices: just a bad dream or a wake-up call? Dr. Samarendu Mohanty.

Expiring temporary safeguards on apparel trade: implications on U.S. cotton. Dr. Maria Erlinda Mutuc, postdoctoral/research associate, Department of Agricultural and Applied Economics, Texas Tech University, Lubbock, Texas.

An echo seminar on SEARCA training course on impact assessment of anti-poverty programs: focus on technology and capacity development. Ms Josephine Narciso and Ms. Ma. Shiela Valencia.

The role of censoring in farm-level impact assessments of *Bt* corn: evidence from the Philippines. Dr. Rod Rejesus, assistant professor, North Carolina State University, USA.

The social capital formation for common pool resource management. Ms. Gerlie Tatlonghari.


Proceedings of the Second
Temperate Rice Conference
RICE GENETICS
Rice Genetics II
Rice Genetics IV
IMPACT OF RICE RESEARCH
Rice Science: Innovations
and Impact for Livelihood
PARENTAGE OF IRRI CROSSES IR1-IR 50,000
NATIONAL RICE SUMMIT PROCEEDINGS
RICE IN ASIA
AINFED RICE

National agricultural research and extension systems

Bangladesh

Agricultural Advisory Society
Bangladesh Academy for Rural Development
Bangladesh Agricultural Research Council
Bangladesh Agricultural Research Institute
Bangladesh Agricultural University
Bangladesh Fisheries Research Institute
Bangladesh Institute of Nuclear Agriculture
Bangladesh Rice Research Institute
Bangladesh Water Development Board
Department of Agricultural Extension
Department of Agriculture -Kamal
Government of Bangladesh
Health Education and Economic Development
Local Government Engineering Department
Rural Development Academy
University of Dhaka

Benin

National Institute of Agricultural Research of Benin

Brazil

Empresa Brasileira de Pesquisa Agropecuária

Burundi

Government of the Republic of Burundi
University of Burundi

Cambodia

Cambodia Agricultural Research and Development Institute
Department of Agricultural Extension
Ministry of Agriculture, Forestry and Fisheries
Prek Leap National School of Agriculture
Prey Veng Provincial Department of Agriculture
Royal University of Agriculture

China

Anhui Academy of Agricultural Sciences
China Agricultural University
China National Rice Research Institute
Chinese Academy of Agricultural Sciences
Fudan University
Guangdong Academy of Agricultural Sciences
Guangxi Academy of Agricultural Sciences
Huazhong Agricultural University
Hunan Agricultural University
Institute of Insect Sciences, Zhejiang University
Jiangxi Academy of Agricultural Sciences
Lixiahe Agricultural Research Institute
Ministry of Agriculture of the People's Republic of China

Nanjing Agricultural University
National Natural Science Foundation of China
Northeast Agricultural University
Peking University
Sichuan Academy of Agricultural Sciences
Wuhan University
Yangzhou University
Yunnan Academy of Agricultural Sciences
Yunnan Agricultural University
Zhejiang Academy of Agricultural Sciences
Zhejiang University

Cuba

Instituto de Investigaciones del Arroz

Egypt

Agricultural Research Center
Egypt Rice Research Center
Rice Research and Training Center

Gambia

Gambia Horticultural Enterprises

Ghana

Crops Research Institute

Guatemala

Instituto de Ciencia y Tecnologia Agricolas

India

Acharya NG Ranga Agricultural University
Anand Agricultural University
Assam Agricultural University
Banaras Hindu University
Birsa Agricultural University
CCS Haryana Agricultural University, Rice Research Station, Kaul (Kaithal), India
Central Rainfed Upland Rice Research Station (Hazaribag)
Central Rice Research Institute
Central Soil Salinity Research Institute
Chandra Shekhar Azad University of Agriculture and Technology
Chinsurah Rice Research Station
College of Agriculture, REWA
Department of Agricultural Research and Education
Department of Agriculture and Cooperation
Directorate of Rice Research
Dr. B. Sawani Konkan Krishi Vidyapeeth
Govind Ballabh Pant University of Agriculture and Technology
Indian Agricultural Research Institute
Indian Council of Agricultural Research
Indira Gandhi Agricultural University
Jawaharlal Nehru Krishi Vishwa Vidyalaya
Krishi Vigyan Kendra-Ara
Krishi Vigyan Kendra-Jamui
Krishi Vigyan Kendra-Nawada
Maharana Pratap University of Agriculture & Technology
Narendra Dev University of Agriculture and Technology
Orissa University of Agricultural Technology
Pandit Jawarharlal Nehru College of Agriculture & Research Institute
Punjab Agricultural University
Raja Dinesh Singh Krishi Vigyan Kendra
Rajendra Agricultural University
Sardar Vallabh Bhai Patel University of Agriculture and Technology
Tamil Nadu Agricultural University
Tata Energy Research Institute
University of Agricultural Sciences
University of Calcutta
West Bengal Directorate of Agriculture

Indonesia

AIAT-South Sumatra
BPTP Sulawesi Selatan
Indonesian Agency for Agricultural Research and Development
Indonesian Center for Agricultural Biotechnology and Genetic Resources and Research Development
Indonesian Center for Agricultural Land Resources Research and Development
Indonesian Center for Agricultural Post Harvest Research and Development
Indonesian Center for Food Crop Research and Development
Indonesian Centre for Rice Research
Indonesian Institute of Sciences
Kuvempu University
Rice Research Institute

Iran

Agricultural Biotechnology Research Institute of Iran

Rice Research Institute of Iran

Shahid Bahonar University of Kerman

University of Mazandaran

Lao PDR

National Agriculture and Forestry Research Institute

Ministry of Agriculture and Forestry

Malaysia

Malaysian Agricultural Research and Development Institute

Mali

Institut d'Economie Rurale

Mozambique

Government of the Republic of Mozambique

National Institute of Agricultural Research

Myanmar

Department of Agricultural Research

Myanma Agriculture Service

Nepal

Department of Agriculture

Nepal Agricultural Research Council

Regional Agriculture Station, Bhairahwa

Tribhuvan University

Pakistan

National Agricultural Research Centre

National Institute for Biotechnology and Genetic Engineering

On-Farm Water Management

Pakistan Agricultural Research Council

Philippines

Agricultural Productivity Center for Bohol for the Visayas

Agricultural Training Institute (ATI)-VII Central Visayas

Bohol Agricultural Promotion Center

Bulacan Agricultural State College

Bureau of Agricultural Research

Central Luzon State University

Department of Environment and Natural Resources

National Irrigation Administration

Pampanga Agricultural College

Philippine Rice Post-Production Consortium

Philippine Rice Research Institute

University of Southern Mindanao

University of the Philippines System

Visayas State University

Western Mindanao State University

West Visayas State University

Russia

All Russian Rice Research Institute

Rwanda

Institut des sciences agronomiques du Rwanda

Senegal

Institut Sénégalais de recherches agricoles

Sri Lanka

Department of Agriculture

Rice Research and Development Institute

Tanzania

Government of the United Republic of Tanzania

Taiwan, China

Academia Sinica

National Taiwan University

Thailand

Bureau of Rice Research and Development

Chainat Rice Research Center

Chainat Rice Seed Center

Chiang Mai University

Department of Rice

Khon Kaen Plant Material and Technical Service Center

Khon Kaen University

National Center for Genetic Engineering and Biotechnology

Rice Research Institute

Ubon Ratchathani Rice Research Center

Vietnam

An Giang University

Bac Lieu People's Committee

Can Tho University

Cuu Long Delta Rice Research Institute

Department of Agriculture and Rural Development-Bac Lieu Province
Food Crops Research Institute (Gia Loc)
Hanoi Agricultural University
Hue University of Agriculture and Forestry
Integrated Resource Mapping Center
Mekong Delta Development Research Institute
Ministry of Agriculture and Rural Development
National Agricultural Extension Center
National Institute of Plant Protection
National Institute of Soils and Fertilizers
Nong Lam University
Plant Protection Department
Research Institute for Aquaculture No. 2
Southern Plant Protection Center
Sub-Institute of Water Resource Planning
Thai Nguyen University
Vietnam Agricultural Science Institute
Vietnam Institute Agricultural Engineering and Post-Harvest Technology
Vietnamese Academy of Agricultural Science

Advanced research institutes

Australia

Charles Sturt University
Commonwealth Scientific and Industrial Research Organisation
Curtin University of Technology
Department of Agriculture, Fisheries and Forestry - Commonwealth
New South Wales Department of Primary Industries-Agriculture
Rural Industries Research and Development Corporation
The University of Queensland
The University of Sydney

Belgium

Universite Catholique de Louvain-Unite de Physiologie Vegetale
Ghent University

Canada

University of Alberta
University of Toronto

France

Centre de coopération internationale en recherche agronomique pour le développement
Institut de recherche pour le développement
Institut national de la recherche agronomique

Germany

Christian Albrecht University-Kiel
Forschungszentrum Karlsruhe GMBH
Max Planck Institute
University of Freiburg
University of Hohenheim

Japan

Chiba University
Foundation for Advanced Studies in International Development
Japan International Cooperation Agency
Japan International Research Center for Agricultural Sciences
Ministry of Agriculture, Forestry and Fisheries
Nagoya University
National Agricultural Research Center
National Institute of Agrobiological Sciences
Plantech Research Institute

Korea

Chonnam National University
Honam Agricultural Research Institute (formerly National Honam Agricultural Experiment Station-Under the National Institute for Crop Science)
National Institute of Crop Science (formerly NCES)
Pohang University of Science and Technology
Rural Development Administration
Yeongnam Agricultural Research Institute (formerly National Yeongnam Agricultural Experiment Station)

Netherlands

Plant Research International
Wageningen University and Research Centre

Singapore

National University of Singapore

Sweden

Swedish International Development Cooperation Agency

Switzerland

Swiss Federal Institute of Technology

United Kingdom

Department for International Development
European Bioinformatics Institute
John Innes Centre
University of Aberdeen
University of Cambridge
University of Dundee
University of Oxford
University of Sheffield

United States of America

Clemson University
Colorado State University
Cornell University
National Center for Genome Resources
Ohio State University
Pennsylvania State University
Purdue University
United States Department of Agriculture
- Agricultural Research Service
- National Agricultural Library

University of Arizona
University of Arkansas
University of California-Berkeley
University of California-Davis
University of California-Riverside
University of Florida
University of Maine
University of Minnesota
University of Missouri
University of Washington
Virginia Polytechnic Institute and State University
Western Michigan University
Yale University

International centers/organizations

Africa Rice Center
Association for Strengthening Agricultural Research in Eastern and Central Africa
Bioversity International
Centro Internacional de Agricultura Tropical
Centro Internacional de Mejoramiento de Maíz y Trigo
CGIAR Challenge Program on Water and Food
Food and Agriculture Organization of the United Nations
International Atomic Energy Agency
International Center for Agricultural Research in the Dry Areas
International Center for Biosaline Agriculture
International Center for Research in the Semi-Arid Tropics
International Food Policy Research Institute
International Institute of Tropical Agriculture
International Livestock Research Institute
International Plant Nutrition Institute
International Potato Center
International Water Management Institute
Plan International
SEAMEO Regional Center for Graduate Study and Research in Agriculture
World Agroforestry Center
WordFish Center
World Vegetable Center

Nongovernment organizations

Bangladesh

Bangladesh Rural Advancement Committee (BRAC)
Rangpur-Dinajpur Rural Services
Shushilan
WAVE Foundation

Cambodia

Federation of Cambodia Rice Millers Association
Srer Khmer

India

Barwale Foundation
MS Swaminathan Research Foundation
Nadia Zilla Farmers' Development Organization
Nand Educational Foundation For Rural Development
SAMRUDHI

Myanmar

Myanmar Rice and Paddy Traders Association

Philippines

Infanta Integrated Community Development Assistance, Inc.
University of the Philippines Los Baños Foundation, Inc.

Thailand

Chamnien Saranaga Foundation

Thai Rice Foundation

United States of America

American Society of Agronomy

Ohio State University Research Foundation

Public Intellectual Property Resource for Agriculture

The Samuel Roberts Noble Foundation, Inc.

Vietnam

World Vision Vietnam

Private organizations

Bangladesh

Lal Teer Seed Limited

Socioconsult Ltd.

Belgium

Devgen nb

Bolivia

Agricom Seeds S.R.L.

Cambodia

Crenn and Associates

Small and Medium Enterprises Cambodia

China

Yuang Longping High-Tech Agriculture Co., Ltd.

Denmark

FOSS

Germany

Bayer CropScience

Japan

Domer, Inc.

India

Ankur Seeds Pvt. Ltd.

Association for Integrated Development

DCM Shriram Consolidated Ltd.

Ganga Kaveri Seeds Pvt. Ltd.

Indo American Hybrid Seeds (I) Pvt. Ltd.

JK Agri Genetics Ltd.

Maharashtra Hybrid Seed Company

Metahelix Life Sciences Private Limited

Nuziveedu Seeds Ltd.

Safal Seeds and Biotech Ltd.

Seedworks India Pvt. Ltd.

Tata Energy Research Institute

Vibha Agrotech Ltd.

Indonesia

PT BISI International Tbk

Ireland

Google

Malaysia

Sime Darby Technology Centre Sdn. Bhd. Malaysia

United Kingdom

National Institute of Agricultural Botany

United States of America

AWHERE Inc.

CGN Business Performance Consulting

Exelixis Plant Sciences

Perlegen Sciences, Inc.

Pioneer Hi-Bred International, Inc. (A Du Pont Company)

Rice Tec Inc.

Vietnam

Voice of Ho Chi Minh Radio Broadcasting

Australia

- Australian Centre for International Agricultural Research (ACIAR). Variation No. 2 relating to ACIAR-funded project *Impact of migration and/or off-farm employment on roles of women and appropriate technologies in Asian and Australian mixed farming systems* (DPPC2001-06). 17 Jan 2008
- Australian Centre for International Agricultural Research (ACIAR). Variation No. 3 relating to ACIAR Project No. CIM/2002/106 *Fertilization-independent formation of embryo, endosperm, and pericarp for apomictic hybrid rice* (DPPC2001-07). 28 July 2008
- Australian Centre for International Agricultural Research (ACIAR). Amendment to the Agreement between ACIAR and IRRI for the project *Implementation of rodent management in intensive irrigated rice production systems in Indonesia and Vietnam* (DPPC2005-67). 28 Apr 2008
- Australian Centre for International Agricultural Research (ACIAR). Project Agreement between ACIAR and IRRI relating to ACIAR Project No. SMAR/2007/216 *Improving rice productivity in South and Southeast Sulawesi* (DPPC2007-125). 9 Apr 2008
- Australian Centre for International Agricultural Research (ACIAR). Amendment to the Deed of Agreement between ACIAR and IRRI for the project *Fine-tuning the "Happy Seeder" technology for adoption in Northwest India* (DPPC2007-49). 13 Oct 2008
- Australian Centre for International Agricultural Research (ACIAR). Project Agreement between ACIAR and IRRI relating to ACIAR Project No. CIM/2007/122 *Sustainable intensification of rice-maize production systems in Bangladesh* (joint project with CIMMYT) (DPPC2008-04). 28 Oct 2008

- Department of Agriculture, Fisheries, and Forestry (DAFF). Consultancy Agreement between DAFF and IRRI for logistical coordination and delivery of *Workshop on Diagnostic of Seed-borne Rice Diseases*. 15 Aug 2008–31 Oct 2008
- University of Queensland (UQ). Extension of Memorandum of Agreement for academic cooperation between UQ and IRRI. 11 Dec 2008–11 Dec 2013

Bangladesh

- Bangladesh Agricultural Research Institute (BARI). Letter of Agreement between BARI and IRRI for the USAID-funded project *Revitalizing the rice-wheat cropping systems of the Indo-Gangetic Plains: adaptation and adoption of resource-conserving technologies in India, Bangladesh, and Nepal* (DPPC2007-100). 6 June 2008
- Bangladesh Agricultural Research Institute (BARI). Letter of Agreement between BARI and IRRI for the World Bank-funded project *CGIAR Systemwide Ecoregional Program: funding to the Rice and Wheat Consortium (RWC)* (DPPC2008-39). 24 July 2008
- Bangladesh Agricultural Research Institute (BARI). Letter of Agreement between BARI and IRRI for the USAID-funded project *Accelerating adoption of resource-conserving technologies in South Asia* under the umbrella *of the Cereal Systems Initiative for South Asia* (DPPC2008-89). 4 Nov 2008
- Bangladesh Rice Research Institute (BRRI). Letter of Agreement between BRRI and IRRI for membership in the *Hybrid Rice Research and Development Consortium (HRDC)* for Public Sector Member (DPPC2008-49). 28 Feb 2008
- Bangladesh Rice Research Institute (BRRI). Letter of Agreement between BRRI and IRRI for the GCP-funded project *Enhancing MAS capacity for salt-stress rice breeding in Bangladesh* (DPPC2008-50). 27 Mar 2008
- Bangladesh Rice Research Institute (BRRI). Letter of Agreement between BRRI and IRRI for the CPWF-funded project *Development of technologies to harness the productivity potential of salt-affected areas of the Indo-Gangetic, Mekong, and Nile River basins* (DPPC2003-21). 13 Oct 2008
- Bangladesh Rice Research Institute (BRRI). Letter of Agreement between BRRI and IRRI for the purpose of implementing the research activities of the Labor Productivity Working Group (LPWG) under the *Irrigated Rice Research Consortium (IRRC) Phase III* (DPPC2004-30). 17 Mar 2008
- Bangladesh Rice Research Institute (BRRI). Amendment to the Letter of Agreement between BRRI and IRRI for the Labor Productivity Working Group (LPWG) of the *Irrigated Rice Research Consortium (IRRC) Phase III* (DPPC2004-30). 8 Dec 2008
- Bangladesh Rice Research Institute (BRRI). Letter of Agreement between BRRI and IRRI for the BMZ-funded project *Enhancing and stabilizing the productivity of salt-affected areas by incorporating genes for tolerance of abiotic stresses in rice* (DPPC2007-09). 16 May 2008
- Bangladesh Rice Research Institute (BRRI). Letter of Agreement between BRRI and IRRI for the USAID-funded project *Revitalizing the rice-wheat cropping systems of the Indo-Gangetic Plains: adaptation and adoption of resource-conserving technologies in India, Bangladesh, and Nepal* (DPPC2007-100). 6 June 2008
- Bangladesh Rice Research Institute (BRRI). Letter of Agreement between BRRI and IRRI for the GCP-funded project *Speeding the development of salt-tolerant rice varieties through marker-assisted selection and their dissemination in salt-affected areas of Bangladesh* (DPPC2007-104). 19 May 2008
- Bangladesh Rice Research Institute (BRRI). Letter of Agreement between BRRI and IRRI for the BMGF-funded project *Stress-tolerant rice for poor farmers in Africa and South Asia* (DPPC2007-73). 12 June 2008
- Bangladesh Agricultural University (BAU). Letter of Agreement between BAU and IRRI for membership in the *Hybrid Rice Research and Development Consortium (HRDC)* for Public Sector Member (DPPC2008-49). 28 Feb 2008
- Bangladesh Institute of Nuclear Agriculture (BINA). Letter of Agreement between BINA and IRRI for the GCP-funded project *Speeding the development of salt-tolerant rice varieties through marker-assisted selection and their dissemination in salt-affected areas of Bangladesh* (DPPC2007-104). 19 May 2008
- Bangladesh Institute of Nuclear Agriculture (BINA). Letter of Agreement between BINA and IRRI for the BMGF-funded project *Stress-tolerant rice for poor farmers in Africa and South Asia* (DPPC2007-73). 10 June 2008
- Bangladesh Rural Advancement Committee (BRAC). Letter of Agreement between BRAC and IRRI for membership in the *Hybrid Rice Research and Development Consortium (HRDC)* for Private Sector Primary Member (DPPC2008-49). 10 Jan 2008
- Bangladesh Rural Advancement Committee (BRAC). Memorandum of Understanding between BRAC and IRRI for collaboration in rice and rice-based farming systems research. 8 June 2008–7 June 2013
- Bangladesh Rural Advancement Committee (BRAC). Letter of Agreement between BRAC and IRRI regarding the importation of leaf color charts (LCC). 9 Nov 2008

- Bureau of Socioeconomic Research and Training (BSERT), Bangladesh Agricultural University (BAU). Letter of Agreement between BSERT-BAU and IRRI for the BMGF-funded project *Stress-tolerant rice for poor farmers in Africa and South Asia* (DPPC2007-73). 23 Nov 2008
- Department of Agricultural Extension (DAE). Letter of Agreement between DAE and IRRI regarding the importation of leaf color charts (LCC). 18 Mar 2008
- Department of Agricultural Extension (DAE). Letter of Agreement between DAE and IRRI for the USAID-funded project *Revitalizing the rice-wheat cropping systems of the Indo-Gangetic Plains: adaptation and adoption of resource-conserving technologies in India, Bangladesh, and Nepal* (DPPC2007-100). 6 June 2008
- Department of Agricultural Extension (DAE). Memorandum of Agreement between DAE and IRRI for scientific and technical collaboration in rice and rice-based farming systems research and extension. 21 July 2008–20 July 2013
- Department of Agricultural Extension (DAE). Letter of Agreement between DAE and IRRI for the USAID-funded project *Accelerating adoption of resource-conserving technologies in South Asia* under the umbrella of the *Cereal Systems Initiative for South Asia* (DPPC2008-89). 4 Nov 2008
- Dhaka University (DU). Letter of Agreement between DU and IRRI for the GCP-funded project *Speeding the development of salt-tolerant rice varieties through marker-assisted selection and their dissemination in salt-affected areas of Bangladesh* (DPPC2007-104). 22 May 2008
- Lal Teer Seed Limited (LTSL). Letter of Agreement between LTSL and IRRI for membership in the *Hybrid Rice Research and Development Consortium (HRDC)* for Private Sector Promotional Member (DPPC2008-49). 11 Sep 2008
- Rangpur Dinajpur Rural Services (RDRS). Letter of Agreement between RDRS and IRRI for the BMGF-funded project *Stress-tolerant rice for poor farmers in Africa and South Asia* (DPPC2007-73). 10 June 2008
- Shushilan. Letter of Agreement between Shushilan and IRRI for the BMGF-funded project *Stress-tolerant rice for poor farmers in Africa and South Asia* (DPPC2007-73). 10 June 2008

Belgium

- Devgen N.V. Letter of Agreement between Devgen N.V. and IRRI for membership in the *Hybrid Rice Research and Development Consortium (HRDC)* for Private Sector Primary Member (DPPC2008-49). 10 July 2008
- University of Ghent (UG). Memorandum of Agreement between UG and IRRI for collaboration in agricultural research and training. 15 Dec 2008–14 Dec 2011

Benin

- Africa Rice Center (WARDA). Letter of Agreement between WARDA and IRRI for the BMGF-funded project *Stress-tolerant rice for poor farmers in Africa and South Asia* (DPPC2007-73). 1 Feb 2008

Bolivia

- Agricomseeds S.R.L. Letter of Agreement between Agricomseeds S.R.L. and IRRI for membership in the *Hybrid Rice Research and Development Consortium (HRDC)* for Private Sector Promotional Member (DPPC2008-49). 10 July 2008

Burundi

- Government of the Republic of Burundi. Memorandum of Understanding between the Government of the Republic of Burundi and IRRI for enhancing the national capability in research on rice and rice-based cropping systems in Burundi. 1 Mar 2008–28 Feb 2013

Cambodia

- Cambodian Rice Millers Association (CRMA). Letter of Agreement between CRMA and IRRI for the ADB-funded project *Improving poor farmers' livelihood through postharvest technology* (DPPC2002-37). 27 Nov 2008
- Plan International. Amendment to the Service Agreement among Plan International, Cambodian Agricultural Research and Development Institute (CARDI), and IRRI for the project *Poverty reduction options validated in drought environments (PROVIDE)—Phase 2* (DPPC2007-97). 22 Feb 2008
- Plan International. Service Agreement among Plan International, Cambodian Agricultural Research and Development Institute (CARDI), and IRRI for the project *Poverty reduction options validated in drought environments (PROVIDE)—Phase 3* (DPPC2008-71). 2 May 2008
- Royal University of Agriculture (RUA). Letter of Agreement between RUA and IRRI for the ADB-funded project *Improving poor farmers' livelihood through postharvest technology* (DPPC2002-37). 27 Nov 2008

Canada

- University of Toronto. Letter of Agreement between University of Toronto and IRRI for the BMGF-funded project *Creating the second Green Revolution by supercharging photosynthesis: C_4 rice* (DPPC2008-78). 5 Dec 2008

China

- Anhui Academy of Agricultural Sciences (AAAS). Letter of Agreement between AAAS and IRRI for membership in the *Hybrid Rice Research and Development Consortium (HRDC)* for Public Sector Member (DPPC2008-49). 10 Jan 2008
- China Agricultural University (CAU). Memorandum of Agreement between CAU and IRRI to promote research, training, and exchange of information and technology in areas of mutual concern related to rice and rice-based farming systems. 22 Oct 2008–21 Oct 2011
- China National Rice Research Institute (CNRRI). Letter of Agreement between CNRRI and IRRI for membership in the *Hybrid Rice Research and Development Consortium (HRDC)* for Public Sector Member (DPPC2008-49). 3 Mar 2008
- China National Rice Research Institute (CNRRI). Work Order Agreement between CNRRI and IRRI regarding the *Provision of genotyping support services* funded by GCP (DPPC2008-26). 31 Mar 2008
- Huazhong Agricultural University (HAU). Memorandum of Agreement between HAU (on behalf of the National Center for Crop Molecular Breeding and Crop Physiology and Production Center) and IRRI for collaboration in agricultural research. 27 Feb 2008–26 Feb 2018
- Huazhong Agricultural University (HAU). Letter of Agreement between HAU and IRRI for the GCP-funded project *Validation of drought-response/resistance pathway genes by phenotypic analysis of mutants* (DPPC2008-29). 23 Sep 2008
- Huazhong Agricultural University (HAU). Letter of Agreement between HAU and IRRI for the BMGF-funded project *Durable rust resistance in wheat* (led by Cornell University) (DPPC2007-71). 17 Oct 2008
- Hunan Rice Research Institute (HRRI). Letter of Agreement between HRRI and IRRI for membership in the *Hybrid Rice Research and Development Consortium (HRDC)* for Public Sector Member (DPPC2008-49). 17 Mar 2008
- Jiangsu Academy of Agricultural Sciences (JAAS). Letter of Agreement between JAAS and IRRI for membership in the *Hybrid Rice Research and Development Consortium (HRDC)* for Public Sector Member (DPPC2008-49). 27 Feb 2008
- *Liaoning Rice Research Institute (LRRI)*. Letter of Agreement between LRRI and IRRI for the RDA-funded project *Temperate Rice (Japonica) Research Consortium (TRRC)* (DPPC2007-13). 2 July 2008
- Sichuan Academy of Agricultural Sciences (SAAS). Letter of Agreement between SAAS and IRRI for membership in the *Hybrid Rice Research and Development Consortium (HRDC)* for Public Sector Member (DPPC2008-49). 3 Mar 2008
- Wuhan University. Letter of Agreement between Wuhan University and IRRI for the project *Study on greenhouse gas emission under irrigated rice conditions in China* (DPPC2008-77). 30 June 2008
- Yuan Longping High-Tech Agriculture Co. Ltd. Letter of Agreement between Yuan Longping High-Tech Agriculture Co. Ltd. and IRRI for membership in the *Hybrid Rice Research and Development Consortium (HRDC)* for Private Sector Primary Member (DPPC2008-49). 10 Jan 2008

Colombia

- Centro Internacional de Agricultura Tropical (CIAT). Amendment No. 3 to Contract No. C-071-05 on the 12-month extension with no additional cost of the project *Developing biofortified iron-dense rice for India* (DPPC2004-43). 17 Jan 2008
- Centro Internacional de Agricultura Tropical (CIAT). Amendment No. 1 to Contract No. C-082-07 on the 12-month extension with no additional cost of the project *Good practices for managing research data* (DPPC2007-66). 27 Nov 2008
- Centro Internacional de Agricultura Tropical (CIAT) and International Food Policy Research Institute (IFPRI) on behalf of the HarvestPlus Challenge Program. Amendment No. 6 to HarvestPlus Agreement No. 5007-A relative to the increase in contract value and extension of project end date of the project *Micronutrient-dense rice to reduce malnutrition:* (DPPC2003-70). 2 May 2008
- Centro Internacional de Agricultura Tropical (CIAT) and International Food Policy Research Institute (IFPRI) on behalf of the HarvestPlus Challenge Program. Amendment No. 7 to HarvestPlus Agreement No. 5007-B relative to the increase in contract value and extension of project end date of the project *Micronutrient-dense rice to reduce malnutrition: transgenics* (DPPC2003-70). 2 May 2008
- Centro Internacional de Agricultura Tropical (CIAT) and International Food Policy Research Institute (IFPRI) on behalf of the HarvestPlus Challenge Program. Amendment No. 7 to HarvestPlus Agreement No. 7007 relative to the no-cost extension of the project *Assessing the potential of biofortification to address micronutrient malnutrition in rice-based cropping systems of South and Southeast Asia* (DPPC2004-16). 28 Apr 2008

Cuba

- Instituto de Investigaciones del Arroz (IIArroz). Memorandum of Understanding between IIArroz and IRRI for scientific and technical relations. 28 Apr 2008–27 Apr 2013

Egypt

- Egypt Rice Research Center (ERRC). Letter of Agreement between ERRC and IRRI for membership in the *Hybrid Rice Research and Development Consortium (HRDC)* for Public Sector Member (DPPC2008-49). 24 Jan 2008
- Field Crops Research Institute (FCRI). Letter of Agreement between FCRI and IRRI for membership in the *Hybrid Rice Research and Development Consortium (HRDC)* for Public Sector Member (DPPC2008-49). 24 Jan 2008

France

- French Embassy, Manila. Letter of Agreement between the French Embassy and IRRI for the project *Increasing water saving in irrigated rice in Central Luzon* (DPPC2008-32). 3 Apr 2008

Germany

- Albert Ludwig University of Freiburg (ALUF). Extension of subcontract between ALUF and IRRI for the Grand Challenges in Global Health project *Engineering rice for high beta-carotene, vitamin E, and enhanced iron and zinc bioavailability* (DPPC2004-91). 23 May 2008
- Deutsche Gesselschaft für Technische Zusammenarbeit (GTZ) GmbH. Grant Agreement between GTZ and IRRI for the project *Rice and global climate change: candidate genes for preventing heat- and drought-induced yield losses due to spikelet sterility* (DPPC2008-75). 16 Sep 2008

Ghana

- Crops Research Institute (CRI). Work Order Agreement between CRI and IRRI regarding the *Provision of genotyping support services* funded by GCP (DPPC2008-26). 28 May 2008

India

- Advanta India Ltd. Letter of Agreement between Advanta India Ltd. and IRRI for membership in the *Hybrid Rice Research and Development Consortium (HRDC)* for Private Sector Primary Member (DPPC2008-49). 18 Jan 2008
- Anand Agricultural University (AAU). Letter of Agreement between AAU and IRRI for the BMGF-funded project *Stress-tolerant rice for poor farmers in Africa and South Asia* (DPPC2007-73). 10 June 2008
- Assam Agricultural University (AAU). Letter of Agreement between AAU and IRRI for the BMGF-funded project *Stress-tolerant rice for poor farmers in Africa and South Asia* (DPPC2007-73). 10 June 2008
- Banaras Hindu University (BHU). Letter of Agreement between BHU and IRRI for the USAID-funded project *Accelerating adoption of resource-conserving technologies in South Asia* under the umbrella of the *Cereal Systems Initiative for South Asia* (DPPC2008-89). 7 Nov 2008
- Barwale Foundation (BF). Letter of Agreement between BF and IRRI for the RF- and GCP-funded project *Developing and disseminating resilient and productive rice varieties for drought-prone environments in India* (DPPC2004-32). 2 July 2008
- Barwale Foundation (BF). Letter of Agreement between BF and IRRI for the BMGF-funded project *Stress-tolerant rice for poor farmers in Africa and South Asia* (DPPC2007-73). 2 July 2008
- Birsa Agricultural University (BAU). Letter of Agreement between BAU and IRRI for the BMGF-funded project *Stress-tolerant rice for poor farmers in Africa and South Asia* (DPPC2007-73). 10 June 2008
- Birsa Agricultural University (BAU). Letter of Agreement between BAU and IRRI for the GCP-funded project *Connecting performance under drought with genotypes through phenotype associations* (DPPC2007-122). 17 Oct 2008
- Central Rice Research Institute (CRRI). Letter of Agreement between CRRI and IRRI for the BMZ- and Eiselen-funded project *Enhancing and stabilizing the productivity of salt-affected areas by incorporating genes for tolerance of abiotic stresses in rice* (DPP2007-09). 16 May 2008
- Central Soil Salinity Research Institute (CSSRI). Letter of Agreement between CSSRI and IRRI for the BMZ- and Eiselen-funded project *Enhancing and stabilizing the productivity of salt-affected areas by incorporating genes for tolerance of abiotic stresses in rice* (DPP2007-09). 16 May 2008
- Chandra Shekhar Azad University of Agriculture and Technology (CSAUAT). Letter of Agreement between CSAUAT and IRRI for the USAID-funded project *Revitalizing the rice-wheat cropping systems of the Indo-Gangetic Plains: adaptation and adoption of resource-conserving technologies in India, Bangladesh, and Nepal* (DPPC2007-100). 30 May 2008
- Chandra Shekhar Azad University of Agriculture and Technology (CSAUAT). Letter of Agreement between CSAUAT and IRRI for the USAID-funded project *Accelerating adoption of resource-conserving technologies in South Asia* under the umbrella of the *Cereal Systems Initiative for South Asia* (DPPC2008-89). 1 Dec 2008

- Chinsurah Rice Research Station (CRRS). Letter of Agreement between CRRS and IRRI for the BMGF-funded project *Stress-tolerant rice for poor farmers in Africa and South Asia* (DPPC2007-73). 10 June 2008
- DCM Shiram Consolidated Ltd. Letter of Agreement between DCM Shiram Consolidated Ltd. and IRRI for membership in the *Hybrid Rice Research and Development Consortium (HRDC)* for Private Sector Primary Member (DPPC2008-49). 10 July 2008
- Dr. B. Sawani Konkan Krishi Vidyapeeth (DBSKKV). Letter of Agreement between DBSKKV and IRRI for the BMGF-funded project *Stress-tolerant rice for poor farmers in Africa and South Asia* (DPPC2007-73). 21 July 2008
- Indian Agricultural Research Institute (IARI), Directorate of Rice Research (DRR). Letter of Agreement with IARI and DRR for the USAID-funded project *The development of adapted germplasm for India with high levels of provitamin carotenoids* (a collaboration to accelerate the pace of the Golden Rice project for India) (DPPC2005-23). 4 Dec 2008
- Indian Council of Agricultural Research (ICAR). Letter of Agreement between ICAR and IRRI for the USAID-funded project *Revitalizing the rice-wheat cropping systems of the Indo-Gangetic Plains: adaptation and adoption of resource-conserving technologies in India, Bangladesh, and Nepal* (DPPC2007-100). 5 Feb 2008
- Indian Council of Agricultural Research (ICAR). Letter of Agreement between ICAR and IRRI for the BMGF-funded project *Stress-tolerant rice for poor farmers in Africa and South Asia* (DPPC2007-73). 3 Nov 2008
- Indian Council of Agricultural Research (ICAR) Research Complex for Eastern Region (RCER). Letter of Agreement between ICAR-RCER and IRRI for the USAID-funded project *Accelerating adoption of resource-conserving technologies in South Asia* under the umbrella of the *Cereal Systems Initiative for South Asia* (DPPC2008-89). 4 Nov 2008
- Indira Gandhi Agricultural University (IGAU). Letter of Agreement between IGAU and IRRI for the BMGF-funded project *Stress-tolerant rice for poor farmers in Africa and South Asia* (DPPC2007-73). 10 June 2008
- JK Agri Genetics Ltd. Letter of Agreement between JK Agri Genetics Ltd. and IRRI for membership in the *Hybrid Rice Research and Development Consortium (HRDC)* for Private Sector Primary Member (DPPC2008-49). 8 Feb 2008
- *Krishi Vigyan Kendra (KVK)*, Ara. Letter of Agreement between KVK, Ara, and IRRI for the USAID-funded project *Accelerating adoption of resource-conserving technologies in South Asia* under the umbrella of the *Cereal Systems Initiative for South Asia* (DPPC2008-89). 17 Nov 2008
- Krishi Vigyan Kendra (KVK), Nawada. Letter of Agreement between KVK, Nawada, and IRRI for the USAID-funded project *Accelerating adoption of resource-conserving technologies in South Asia* under the umbrella of the *Cereal Systems Initiative for South Asia* (DPPC2008-89). 4 Nov 2008
- Krishi Vigyan Kendra (KVK), Pratapgarh. Letter of Agreement between KVK, Pratapgarh, and IRRI for the USAID-funded project *Accelerating adoption of resource-conserving technologies in South Asia* under the umbrella of the *Cereal Systems Initiative for South Asia* (DPPC2008-89). 4 Nov 2008
- Maharashtra Hybrid Seeds Company Limited (MAHYCO). Letter of Agreement between MAHYCO and IRRI for membership in the *Hybrid Rice Research and Development Consortium (HRDC)* for Private Sector Primary Member (DPPC2008-49). 10 July 2008
- Metahelix Life Sciences Private Limited. Letter of Agreement between Metahelix Life Sciences Private Limited and IRRI for membership in the *Hybrid Rice Research and Development Consortium (HRDC)* for Private Sector Primary Member (DPPC2008-49). 6 Feb 2008
- *Nadia Zilla Farmer's Development Organization (NZFDO*). Letter of Agreement between NZFDO and IRRI for a *Study on diffusion of rice varieties* under the HarvestPlus-funded project *Assessing the potential of biofortification to address micronutrient malnutrition in rice-based cropping systems of South and Southeast Asia* (DPPC2004-16). 11 Apr 2008
- *Nadia Zilla Farmers' Development Organization (NZFDO)*. Letter of Agreement between NZFDO and IRRI for the BMGF-funded project *Stress-tolerant rice for poor farmers in Africa and South Asia* (DPPC2007-73). 3 July 2008
- Nadia Zilla Farmer's Development Organization (NZFDO). Amendment to the Letter of Agreement between NZFDO and IRRI for the BMGF-funded project *Stress-tolerant rice for poor farmers in Africa and South Asia* (DPPC2007-73). 2 Dec 2008
- Nand Educational Foundation for Rural Development (NEFORD). Letter of Agreement between NEFORD and IRRI for the BMGF-funded project *Stress-tolerant rice for poor farmers in Africa and South Asia* (DPPC2007-73). 3 July 2008
- Nand Educational Foundation for Rural Development (NEFORD). Letter of Agreement between NEFORD and IRRI for the DFID-funded project *Poverty alleviation through rice innovation systems (PARIS)* (DPPC2007-118). 23 July 2008

- Narendra Dev University of Agriculture and Technology (NDUAT). Letter of Agreement between NDUAT and IRRI for the BMZ- and Eiselen-funded project *Enhancing and stabilizing the productivity of salt-affected areas by incorporating genes for tolerance of abiotic stresses in rice* (DPP2007-09). 16 May 2008
- Narendra Dev University of Agriculture and Technology (NDUAT). Letter of Agreement between NDUAT and IRRI for the USAID-funded project *Accelerating adoption of resource-conserving technologies in South Asia* under the umbrella of the *Cereal Systems Initiative for South Asia* (DPPC2008-89). 4 Nov 2008
- Narendra Dev University of Agriculture and Technology (NDUAT). Letter of Agreement between NDUAT and IRRI for the BMGF-funded project *Stress-tolerant rice for poor farmers in Africa and South Asia* (DPPC2007-73). 10 June 2008
- Nuziveedu Seeds Ltd. Letter of Agreement between Nuziveedu Seeds Ltd. and IRRI for membership in the *Hybrid Rice Research and Development Consortium (HRDC)* for Private Sector Primary Member (DPPC2008-49). 10 Jan 2008
- Orissa University of Agriculture and Technology (OUAT). Letter of Agreement between OUAT and IRRI for the BMGF-funded project *Stress-tolerant rice for poor farmers in Africa and South Asia* (DPPC2007-73). 10 June 2008
- Pandit Jawaharlal Nehru College of Agriculture and Research Institute (PAJANCOA). Letter of Agreement between PAJANCOA and IRRI for the BMGF-funded project *Stress-tolerant rice for poor farmers in Africa and South Asia* (DPPC2007-73). 20 May 2008
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- Safal Seeds and Biotech Ltd. Letter of Agreement between Safal Seeds and Biotech Ltd. and IRRI for membership in the *Hybrid Rice Research and Development Consortium (HRDC)* for Private Sector Promotional Member (DPPC2008-49). 10 July 2008
- SAMRUDHI. Letter of Agreement between SAMRUDHI and IRRI for a *Study on diffusion of rice varieties in Orissa* under the HarvestPlus-funded project *Assessing the potential of biofortification to address micronutrient malnutrition in rice-based cropping systems of South and Southeast Asia* (DPPC2004-16). 21 Jan 2008
- SAMRUDHI. Letter of Agreement between SAMRUDHI and IRRI for the BMGF-funded project *Stress-tolerant rice for poor farmers in Africa and South Asia* (DPPC2007-73). 13 Nov 2008
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- Tamil Nadu Agricultural University (TNAU). Letter of Agreement between TNAU and IRRI for membership in the *Hybrid Rice Research and Development Consortium (HRDC)* for Public Sector Member (DPPC2008-49). 5 Mar 2008
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- Tamil Nadu Agricultural University (TNAU). Letter of Agreement between TNAU and IRRI for the BMGF-funded project *Stress-tolerant rice for poor farmers in Africa and South Asia* (DPPC2007-73). 10 June 2008
- University of Agricultural Sciences (UAS). Letter of Agreement between UAS and IRRI for the project *Developing and disseminating resilient and productive rice varieties for drought-prone environments in India* (DPPC2004-32). 7 July 2008
- University of Agricultural Sciences (UAS). Letter of Agreement between UAS and IRRI for the BMGF-funded project *Stress-tolerant rice for poor farmers in Africa and South Asia* (DPPC2007-73). 7 July 2008
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- Vibha Agrotech Ltd. Letter of Agreement between Vibha Agrotech Ltd. and IRRI for membership in the *Hybrid Rice Research and Development Consortium (HRDC)* for Private Sector Primary Member (DPPC2008-49). 24 Jan 2008
- West Bengal Department of Agriculture (WBDA). Letter of Agreement between WBDA and IRRI for the USAID-funded project *Revitalizing the rice-wheat cropping systems of the Indo-Gangetic Plains: adaptation and*

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Indonesia

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- Indonesian Center for Rice Research (ICRR). Letter of Agreement between ICRR and IRRI regarding support to farmers' participatory variety selection in the uplands of Indonesia under the CURE project. 25 Mar 2008
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- Indonesian Center for Agricultural Land Resources Research and Development (ICALRD). Letter of Agreement between ICALRD and IRRI for the SDC-funded collaborative project *Documentation of the SSNM dissemination process in Indonesia within the framework of ICM* under the Productivity and Sustainability Work Group of the Irrigated Rice Research Consortium (DPPC2004-30). 11 Apr 2008
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- Indonesia Institute of Sciences (Lembaga Ilmu Pengetahuan Indonesia–LIPI). Memorandum of Agreement between LIPI and IRRI for collaboration in agricultural research. 28 Apr 2008–27 Apr 2011
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Iran

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- Shahid Bahonar University of Kerman (SBUK). Memorandum of Agreement between SBUK and IRRI for collaborative graduate program to accelerate and further promote rice and rice-based farming systems research. 29 July 2008–28 July 2013

Italy

- Bioversity International. Letter of Agreement between Bioversity International and IRRI for the project *Collective action for the rehabilitation of global public goods in the CGIAR genetic resources system: Phase 2 (GPG2)* (DPPC2008-126). 11 Dec 2008
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- Global Crop Diversity Trust (GCDT). Grant Agreement between GCDT and IRRI for the project *Heat-tolerant rice to combat global warming* (DPPC2007-123). 2 May 2008
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- Graduate School of Bioagricultural Sciences, Nagoya University (BSNU). Memorandum of Agreement between BSNU and IRRI for the promotion of cooperation in both academic research and enhancing educational opportunities for researchers and graduate students. 12 Feb 2008–11 Feb 2012
- International Cooperation Center for Agricultural Education (ICCAE), Nagoya University. Amendment to the Letter of Agreement between ICCAE-NU and IRRI for the project *Development of breeding materials for rice blast resistance—phenotypic evaluation and marker-assisted selection to develop near-isogenic lines for rice blast resistance* under the Japan Capacity Building Program (DPPC2007-80). 18 Jan 2008
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- Japan International Research Center for Agricultural Sciences (JIRCAS). Letter of Agreement between JIRCAS and IRRI for the GCP-funded project *Application and validation of the major QTL* phosphate uptake 1 (Pup1) (DPPC2008-42). 29 Apr 2008
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- Japan International Research Center for Agricultural Sciences (JIRCAS). Letter of Agreement between JIRCAS and IRRI for the GCP-funded project *Revitalizing marginal lands: discovery of genes for tolerance of saline and phosphorus-deficient soils to enhance and sustain productivity* (DPPC2004-26). 30 May 2008
- Japan International Research Center for Agricultural Sciences (JIRCAS). Letter of Agreement between JIRCAS and IRRI for the GCP-funded project *Drought from a different perspective: improved tolerance through phosphorus acquisition* (DPPC2008-38). 17 Nov 2008

Kenya

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Korea

- Chonnam National University (CNU). Memorandum of Agreement between CNU and IRRI for the promotion of research, training, and exchange of information and technology. 18 Mar 2008–17 Mar 2013
- Honam Agricultural Research Institute (HARI). Agreement between HARI and IRRI on cooperative research project *Development of submergence-tolerant japonica rice varieties* (DPPC2008-06). 12 June 2008
- Liaoning Rice Research Institute (LRRI). Letter of Agreement between LRRI and IRRI for the collaborative project *"Development of superior temperate rice cultivars with high yield potential and grain quality"* under Work Group 1 of the *Temperate Rice Research Consortium (TRRC)* (DPPC2007-13). 31 Oct 2008
- National Institute of Crop Science (NICS). Letter of Agreement between NICS and IRRI for the collaborative project *Breeding for cold tolerance* under Work Group 3 of the *Temperate Rice Research Consortium (TRRC)* (DPPC2007-13). 13 June 2008

Lao PDR

- National Agriculture and Forestry Research Institute (NAFRI). Letter of Agreement between NAFRI and IRRI for successful implementation of research activities in the CURE working group on upland systems. 16 July 2008
- National Agriculture and Forestry Research Institute (NAFRI). Letter of Agreement between NAFRI and IRRI for the collaborative project *Postproduction Work*

Group activities in Lao PDR under the *Irrigated Rice Research Consortium (IRRC) Phase III* (DPPC2004-30). 31 July 2008

Malaysia

- Malaysian Agricultural Research and Development Institute (MARDI). Amendment to the Letter of Agreement between MARDI and IRRI for the collaborative project *Evaluation of the effects of crop establishment practices on weed rice infestation and seed bank study on weedy rice* under the Labor Productivity Work Group of the *Irrigated Rice Research Consortium (IRRC) Phase III* (DPPC2004-30). 8 Dec 2008
- Malaysian Agricultural Research and Development Institute (MARDI). Letter of Agreement between MARDI and IRRI for membership in the *Hybrid Rice Research and Development Consortium (HRDC)* for Public Sector Member (DPPC2008-49). 10 Jan 2008
- Sime Darby Technology Centre Sdn. Bhd. Letter of Agreement between Sime Darby Technology Centre Sdn. Bhd. and IRRI for membership in the *Hybrid Rice Research and Development Consortium (HRDC)* for Private Sector Primary Member (DPPC2008-49). 10 July 2008

Mexico

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- Centro Internacional de Mejoramiento de Maíz y Trigo (CIMMYT). Award letter between CIMMYT (on behalf of the Generation Challenge Program) and IRRI for the 2008 GCP-commissioned research project *Transcriptome analysis of near-isogenic rice lines to identify expression signatures and gene combination conferring stress tolerance* (DPPC2007-119). 14 Feb 2008
- Centro Internacional de Mejoramiento de Maíz y Trigo (CIMMYT). Award letter between CIMMYT (on behalf of the Generation Challenge Program) and IRRI for the 2008 GCP-commissioned research project *Connecting performance under drought with genotypes through phenotype associations* (DPPC2007-122). 14 Feb 2008
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- Centro Internacional de Mejoramiento de Maíz y Trigo (CIMMYT). Award letter between CIMMYT (on behalf of the Generation Challenge Program) and IRRI for the 2008 GCP-commissioned research project *Development of Generation CP domain models and ontology* (DPPC2007-128). 14 Feb 2008
- Centro Internacional de Mejoramiento de Maíz y Trigo (CIMMYT). Award letter between CIMMYT (on behalf of the Generation Challenge Program) and IRRI for the 2008 GCP-commissioned research project *GCP quality management and data quality improvement* (DPPC2007-130). 14 Feb 2008
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- Centro Internacional de Mejoramiento de Maíz y Trigo (CIMMYT). Award letter between CIMMYT (on behalf of the Generation Challenge Program) and IRRI for the 2008 GCP-commissioned research project *Development of an integrated GCP platform* (DPPC2007-138). 14 Feb 2008
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- Centro Internacional de Mejoramiento de Maíz y Trigo (CIMMYT). Award letter between CIMMYT (on behalf

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- Centro Internacional de Mejoramiento de Maíz y Trigo (CIMMYT). Award letter between CIMMYT (acting as host agent for the Generation Challenge Program) and IRRI for the GCP competitive program titled *Drought from a different perspective: improved tolerance through phosphorus acquisition* (DPPC2008-38). 19 Nov 2008
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- Centro Internacional de Mejoramiento de Maíz y Trigo (CIMMYT). Amendment to Article 39.7 of the Generation Challenge Program Consortium Agreement (DPPC2005-51). 25 Nov 2008
- Centro Internacional de Mejoramiento de Maíz y Trigo (CIMMYT). Letter of Agreement between CIMMYT and IRRI for the ACIAR-funded project *Sustainable intensification of rice-maize production systems in Bangladesh* (DPPC2008-04). 16 Dec 2008
- Centro Internacional de Mejoramiento de Maíz y Trigo (CIMMYT). Letter of Agreement between CIMMYT and IRRI for the USAID-funded project *Accelerating adoption of resource-conserving technologies in South Asia* under the umbrella of the *Cereal Systems Initiative for South Asia* (DPPC2008-89). 9 Dec 2008
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Myanmar

- Department of Agricultural Research (DAR). Letter of Agreement between DAR and IRRI for the successful implementation of research activities in the CURE Working Group 2 (WG2), submergence-prone environments. 24 Nov 2008
- Myanma Agriculture Service (MAS). Letter of Agreement between MAS and IRRI for the collaborative project *Development and promotion of the Irrigated Rice Research Consortium (IRRC) technologies in rice production* (DPPC2004-30). 21 Aug 2008
- Myanmar Rice and Paddy Traders Association (MRPTA). Letter of Agreement between MRPTA and IRRI for the collaborative project on *Rice postharvest systems development—Myanmar 2008* under the *Irrigated Rice Research Consortium (IRRC) Phase III* (DPPC2004-30). 23 May 2008

Nepal

- Department of Agriculture (DoA). Letter of Agreement between DoA and IRRI for the USAID-funded project *Accelerating adoption of resource-conserving technologies in South Asia* under the umbrella of the *Cereal Systems Initiative for South Asia* (DPPC2008-89). 6 Nov 2008
- Institute of Agricultural and Animal Sciences (IAAS). Letter of Agreement between IAAS and IRRI for the BMGF-funded project *Stress-tolerant rice for poor farmers in Africa and South Asia* (DPPC2007-73). 10 June 2008
- National Agricultural Research Council (NARC). Letter of Agreement between NARC and IRRI for the USAID-funded project *Revitalizing the rice-wheat cropping systems of the Indo-Gangetic Plains: adaptation and adoption of resource-conserving technologies in India, Bangladesh, and Nepal* (DPPC2007-100). 22 May 2008
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- National Agricultural Research Council (NARC). Letter of Agreement between NARC and IRRI for the World Bank-funded project *CGIAR Systemwide Ecoregional Program: funding to the Rice and Wheat Consortium (RWC)* (DPPC2008-39). 24 July 2008
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Pakistan

- Agricultural Farm Services, Seed Division. Letter of Agreement between Agricultural Farm Services and IRRI for membership in the *Hybrid Rice Research and Development Consortium (HRDC)* for Private Sector Promotional Member (DPPC2008-49). 10 July 2008
- Pakistan Agricultural Research Council (PARC). Letter of Agreement between PARC and IRRI for the World Bank-funded project *CGIAR Systemwide Ecoregional Program: funding to the Rice and Wheat Consortium (RWC)* (DPPC2008-39). 24 July 2008

Papua New Guinea

- Government of Papua New Guinea, represented by the Department of Agriculture and Livestock (PNG). Memorandum of Understanding between PNG and IRRI for scientific and technical cooperation in research and training on rice and rice-based farming systems. 17 June 2008–16 June 2013

Peru

- International Potato Center (CIP). Letter of Agreement between CIP and IRRI for the part-time assignment of Mr. Denis Díaz Maco to support the *High-performance computing project* at IRRI. 17 June 2008–16 Sep 2008
- International Potato Center (CIP). Letter of Agreement between CIP and IRRI for the part-time assignment of Mr. Denis Díaz Maco to support the *High-performance computing project* at IRRI. 15 Nov 2008–16 Feb 2009

Philippines

- Asian Development Bank (ADB). Technical Assistance Agreement (RETA 6489) between ADB and IRRI for the project *Bringing about a sustainable agronomic revolution in rice production in Asia by reducing preventable pre- and postharvest losses* (DPPC2008-74). 6 Nov 2008
- Bohol Agricultural Promotion Center (BAPC). Letter of Agreement between BAPC and IRRI for the collaborative project *Demonstration of direct-seeded rice establishment under an integrated weed management system, Bohol, Philippines,* through the Labor Productivity Work Group of the *Irrigated Rice Research Consortium (IRRC) Phase III* (DPPC2004-30). 31 Jan 2008
- Bulacan Agricultural State College (BASC). Letter of Agreement between BASC and IRRI for the collaborative project *Irrigated Rice Research Consortium (IRRC) Water-Saving Work Group* (DPPC2004-30). 29 Apr 2008
- Bulacan Agricultural State College (BASC). Amendment to the Letter of Agreement between BASC and IRRI for the collaborative project *Irrigated Rice Research Consortium (IRRC) Water-Saving Work Group* (DPPC2004-30). 24 July 2008
- Bureau of Plant Industry (BPI). Memorandum of Agreement between BPI and IRRI on quarantine services for incoming and outgoing seeds, nonseed biological materials, and soil samples. 18 Mar 2008
- *Bureau of Postharvest Research and Extension (BPRE)*. Amendment to the Letter of Agreement between BPRE and IRRI for the project *Establishment of baseline data for aflatoxin contamination in rice in different postharvest operations under Philippine condition* (DPPC2007-88). 2 June 2008
- Central Luzon State University (CLSU). Letter of Agreement between CLSU and IRRI for the collaborative project *Irrigated Rice Research Consortium (IRRC) Water-Saving Work Group* (DPPC2004-30). 29 Apr 2008
- Department of Agriculture (DA). Memorandum of Agreement between DA and IRRI on *Accelerating rice production in the Philippines*. 2 May 2008–1 May 2013
- FBM eServices. Agreement between FBM eSerrices and IRRI to assist IRRI in devising World Wide Web content management implementation. 18 Mar 2008–17 Mar 2009
- National Irrigation Administration (NIA). Letter of Agreement between NIA and IRRI for the JIRCAS-funded project *Experimental introduction of volumetric irrigation fee scheme* (DPPC2008-117). 21 Oct 2008
- Pampanga Agricultural College (PAC). Letter of Agreement between PAC and IRRI for the DA-BAR-funded project *Improving knowledge exchange and decisionmaking among rice stakeholders through ICT-based technology promotion and delivery systems* (DPPC2005-27). 31 July 2008
- Philippine Rice Research Institute (PhilRice). Letter of Agreement between PhilRice and IRRI for the FAO-funded project *The role of crop management technologies in rapid rice yield growth in the Philippines* (DPPC2007-126). 7 Jan 2008

- Philippine Rice Research Institute (PhilRice). Letter of Agreement between PhilRice and IRRI for the project *Breeding rice for heat tolerance* (DPPC2008-02). 24 Jan 2008
- Philippine Rice Research Institute (PhilRice). Letter of Agreement between PhilRice and IRRI for the project *Hybrid nucleus and breeder seed production* (DPPC2003-73). 25 Jan 2008
- Philippine Rice Research Institute (PhilRice). Letter of Agreement between PhilRice and IRRI for membership in the *Hybrid Rice Research and Development Consortium (HRDC)* for Public Sector Member (DPPC2008-49). 27 Mar 2008
- Philippine Rice Research Institute (PhilRice). Letter of Agreement between PhilRice and IRRI for the implementation of the research project *Adaptation trials of different storage systems for rice seeds in the Philippines* under the Postproduction Work Group (PPWG) of the *Irrigated Rice Research Consortium (IRRC) Phase III* (DPPC2004-30). 31 Mar 2008
- Philippine Rice Research Institute (PhilRice). Letter of Agreement between PhilRice and IRRI for the collaborative project *Irrigated Rice Research Consortium (IRRC) Water-Saving Work Group* (DPPC2004-30). 29 Apr 2008
- Philippine Rice Research Institute (PhilRice). Letter of Agreement between PhilRice and IRRI for the project *Development of rice with elevated iron and zinc in the polished grain: Phase 1—understand and exploit G × E interactions for high iron/zinc in the polished grain* under the HarvestPlus-funded project *Micronutrient-dense rice to reduce malnutrition* (Challenge Program on Biofortified Crops for Improved Human Nutrition) (DPPC2003-70). 27 May 2008
- Philippine Rice Research Institute (PhilRice). Letter of Agreement between PhilRice and IRRI for the project *Field performance evaluation and selection of GUVA elite lines in the tropics* (DPPC2006-39). 7 July 2008
- Philippine Rice Research Institute (PhilRice). Letter of Agreement between PhilRice and IRRI on the *Implementation of the 2009-2010 Rice Self-Sufficiency Plan (RSSP) of the Gintong Masaganang Ani (GMA) Rice Program* (DPPC2008-88). 9 July 2008
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- Philippine Rice Research Institute (PhilRice). Memorandum of Agreement between PhilRice and IRRI regarding the National Cooperative Testing (NCT) Project. 3 Aug 2008–2 Aug 2013
- Philippine Rice Research Institute (PhilRice). Amendment to the Letter of Agreement between PhilRice and IRRI for the collaborative project *Irrigated Rice Research Consortium (IRRC) Water-Saving Work Group* (DPPC2004-30). 5 Aug 2008
- Philippine Rice Research Institute (PhilRice). Letter of Agreement between PhilRice and IRRI for the DA-BAR-funded project *Improving knowledge exchange and decisionmaking among rice stakeholders through ICT-based technology promotion and delivery systems* at PhilRice-Negros (DPPC2005-27). 6 Aug 2008
- Philippine Rice Research Institute (PhilRice). Letter of Agreement between PhilRice and IRRI for the implementation of the adaptive research project *Initiating the transfer and adaptation of improved drying technology from Vietnam to the Philippines* under the Postproduction Work Group (PPWG) of the *Irrigated Rice Research Consortium (IRRC) Phase III* (DPPC2004-30). 8 Dec 2008
- Philippine Society for the dvancement of Genetics, Inc. (PhilSAGEN). Letter of Agreement between PhilSAGEN and IRRI for the purpose of organizing and holding a seminar on *Biofortification of rice and other approaches to address micronutrient malnutrition* and the *10th National Genetics Symposium* on 19-22 Nov 2008 at the Mindanao State University-Iligan Institute of Technology (MSU-IIT), Iligan City, Lanao del Norte, under the USAID-funded project *Development of rice biotechnology products for Asia: technical and pre-regulatory components* (DPPC2004-17). 8 Nov 2008
- Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA). Letter of Agreement between SEARCA and IRRI for the implementation of research on *Impact of climate change on the Philippine rice sector: supply/demand projections and policy* (DPPC2007-26). 23 June 2008
- University of Southeastern Philippines (USEP). Letter of Agreement between USEP and IRRI for the collaborative project *Development of water management of irrigated rice e-learning module* under the *Irrigated Rice Research Consortium (IRRC) Water-Saving Work Group* (DPPC2004-30). 31 July 2008
- University of Southeastern Philippines (USEP). Letter of Agreement between USEP and IRRI for the BAR-DA-funded project *Improving knowledge exchange and decisionmaking among rice stakeholders through*

ICT-based technology promotion and delivery systems (DPPC2005-27). 31 July 2008

- University of Southern Mindanao (USM). Letter of Agreement between USM and IRRI for the USAID-funded project *Ecologically based participatory IPM for Southeast Asia* (DPPC2005-73). 28 Mar 2008
- University of Southern Mindanao (USM). Letter of Agreement between USM and IRRI for the successful implementation of research activities in the CURE working group on upland systems. 16 July 2008
- University of Southern Mindanao (USM). Letter of Agreement between USM and IRRI for the DA-BAR-funded project *Improving knowledge exchange and decisionmaking among rice stakeholders through ICT-based technology promotion and delivery systems* (DPPC2005-27). 31 July 2008
- Visayas State University (VSU). Letter of Agreement between VSU and IRRI for the project *Assessing the impact of communication campaigns and radio soap operas on farmers' pest management decision making in Vietnam* (DPPC2008-05). 6 Feb 2008
- Visayas State University (VSU). Letter of Agreement between VSU and IRRI for the collaborative project *Assessing the impact of pesticide information in print advertisements on rice farmers in the Philippines*. 1 Dec 2008–30 Jun 2009
- West Visayas State University (WVSU). Letter of Agreement between WVSU and IRRI for the collaborative project *Facilitating the dissemination of improved nutrient management for rice-based systems in Iloilo province* under the IFA/IPI/PPI-funded project for the Productivity and Sustainability Work Group of the *Irrigated Rice Research Consortium (IRRC) Phase III* (DPPC2005-02). 28 May 2008
- West Visayas State University (WVSU). Letter of Agreement between WVSU and IRRI for the collaborative project *Training workshop on computer-based decision tools for soil science curriculum of universities and colleges in the Visayas* under the IFA/IPI/PPI-funded project for the Productivity and Sustainability Work Group of the *Irrigated Rice Research Consortium (IRRC) Phase III* (DPPC2005-02). 29 Sep 2008
- West Visayas State University (WVSU). Letter of Agreement between WVSU and IRRI for the project *Assessing the impact of pesticide information in print advertisements on rice farmers in the Philippines* (DPPC2008-138). 24 Nov 2008

Russia

- All Russian Rice Research Institute (ARRRI). Memorandum of Understanding between ARRRI and IRRI for scientific and technical cooperation on rice research and training. 28 Feb 2008–27 Feb 2013

Singapore

- Bayer (South East Asia) Pte. Ltd. Letter of Agreement between Bayer (South East Asia) Pte. Ltd. and IRRI for membership in the *Hybrid Rice Research and Development Consortium (HRDC)* for Private Sector Primary Member (DPPC2008-49). 10 July 2008
- Syngenta Asia Pacific Pte. Ltd. Letter of Agreement between Syngenta Asia Pacific Pte. Ltd. and IRRI for membership in the *Hybrid Rice Research and Development Consortium (HRDC)* for Private Sector Primary Member (DPPC2008-49). 14 Feb 2008

Sri Lanka

- International Water Management Institute (IWMI). Letter of Agreement between IWMI (on behalf of the Challenge Program for Water and Food) and IRRI relative to the CPWF Inception Meeting and Annual Stakeholders Workshop held in Dhaka, Bangladesh (DPPC2008-31). 19 Feb 2008
- International Water Management Institute (IWMI). Letter of Agreement between IWMI (on behalf of the Challenge Program for Water and Food [CPWF]) and IRRI for the provision of funds for the implementation of the activity titled *Theme Leader* to be carried out under the auspices of the CPWF Consortium (DPPC2003-87). 4 Apr 2008
- International Water Management Institute (IWMI). Memorandum of Agreement between IWMI and IRRI regarding the formation of a strategic alliance to share facilities with CIP at the IWMI-Delhi office. 1 May 2008–30 Apr 2010
- International Water Management Institute (IWMI). Letter of Agreement between IWMI and IRRI to implement the subproject *Livelihood enhancement through improved management of water and land resources in northeast India* under the IFAD-funded project *Accelerating agricultural technology adoption to enhance rural livelihoods in disadvantaged districts of India* (DPPC2006-79). 15 May 2008
- International Water Management Institute (IWMI). Letter of Agreement between IWMI and IRRI to implement the subproject *Sustainable livelihood improvement through need-based integrated farming system models in disadvantaged districts of Bihar* under the IFAD-funded project *Accelerating agricultural technology adoption to enhance rural livelihoods in disadvantaged districts of India* (DPPC2006-79). 9 Sep 2008
- Rice Research and Development Institute (RRDI). Amendment to the Letter of Agreement between RRDI

and IRRI for the collaborative project *Development of direct seeding and weed management options* under the *Irrigated Rice Research Consortium (IRRC) Phase III* (DPPC2004-30). 8 Dec 2008

- Rice Research and Development Institute (RRDI). Letter of Agreement between RRDI and IRRI for membership in the *Hybrid Rice Research and Development Consortium (HRDC)* for Public Sector Member (DPPC2008-49). 5 Mar 2008

Switzerland

- Swiss Agency for Development and Cooperation (SDC). Amendment to the Agreement between SDC and IRRI for the project *The Irrigated Rice Research Consortium (IRRC) Phase III* (DPPC2004-30). 23 Sep 2008

Syria

- International Center for Agricultural Research in the Dry Areas (ICARDA). Letter of Agreement between ICARDA and IRRI for the project *Establishment of the global crop registers for rice and wheat* (DPPC2008-48). 21 May 2008

Taiwan

- National Taiwan University (NTU). Memorandum of Agreement between NTU and IRRI to promote research, training, and exchange of information and technology in areas of mutual concern related to rice and rice-based farming systems. 9 Oct 2008–8 Oct 2011
- World Vegetable Center (AVRDC). Letter of Agreement between AVRDC and IRRI regarding the part-time assignment of Mr. Rogelio Alvarez, Jr. to upgrade the global IT infrastructure and services of the Center. 14 Jan 2008–31 Mar 2008, 28 Apr 2008–19 May 2008, and 17 Nov 2008–17 Dec 2008

Tanzania

- Ministry of Agriculture, Food Security, and Cooperatives. Memorandum of Understanding between the Ministry of Agriculture, Food Security, and Cooperatives on scientific and technical cooperation in research on rice and rice-based cropping systems. 29 July 2008–28 July 2013

Thailand

- Bureau of Rice Research and Development (BRRD). Letter of Agreement between BRRD and IRRI for membership in the *Hybrid Rice Research and Development Consortium (HRDC)* for Public Sector Member (DPPC2008-49). 6 May 2008
- Khon Kaen University (KKU). Letter of Agreement between KKU and IRRI on the *Study on strategic analysis of diversification in rice-growing areas of Thailand, with focus on rainfed rice area systems.* 1 Dec 2008–31 Mar 2009
- Ubon Ratchathani Rice Research Center (URRRC). Letter of Agreement between URRRC and IRRI for the BMGF-funded project *Stress-tolerant rice for poor farmers in Africa and South Asia* (DPPC2007-73). 15 May 2008
- Ubon Ratchathani Rice Research Center (URRRC). Letter of Agreement between URRRC and IRRI for the successful implementation of research activities in the CURE working group on drought. 17 July 2008

United Kingdom

- Biotechnology and Biological Sciences Research Council (BBSRC), Department for International Development (DFID). Joint Award Agreement between BBSRC/DFID and IRRI for the project *Characterizing genetic and soil-induced variation in arsenic uptake, translocation, and metabolism in rice to mitigate arsenic contamination in Asia* (DPPC2006-106). 22 Apr 2008
- British Embassy, Manila. Bilateral Programme Budget Grant Contract between the British Embassy and IRRI for the project *Rice and climate change: towards an informed Philippine policy* (DPPC2008-91). 20 Oct 2008
- Natural Resources International Limited (NR International). Agreement between NR International and IRRI relative to "assistance to Nand Educational Foundation for Rural Development (NEFORD) with invoicing" for the project *Poverty alleviation through rice innovation systems* (DPPC2007-118). 15 Sep 2008
- University of Cambridge. Letter of Agreement between University of Cambridge and IRRI for the BMGF-funded project *Creating the second Green Revolution by supercharging photosynthesis: C_4 rice* (DPPC2008-78). 5 Dec 2008
- University of Nottingham. Letter of Agreement between the University of Nottingham and IRRI for the BMGF-funded project *Creating the second Green Revolution by supercharging photosynthesis: C_4 rice* (DPPC2008-78). 5 Dec 2008

USA

- AWhere Inc. Letter of Agreement between AWhere Inc. and IRRI for the BMGF-funded project *Cereal Systems Initiative for South Asia (CSISA)* (DPPC2008-100). 19 Dec 2008
- Bill & Melinda Gates Foundation (BMGF). Grant Agreement between BMGF and IRRI for the project *Creating the second Green Revolution by supercharging photosynthesis: C_4 rice* (DPPC2008-78). 14 Oct 2008
- Bill & Melinda Gates Foundation (BMGF). Grant Agreement between BMGF and IRRI for the project *Cereal*

Systems Initiative for South Asia (CSISA) (DPPC2008-100). 19 Nov 2008

- Clemson University (CU). Subaward Modification No. 2 between CU and IRRI for the USAID-funded project *Ecologically based participatory IPM for Southeast Asia* (DPPC2005-73). 27 Feb 2008
- College of Agriculture and Life Sciences (CALS), Cornell University. Memorandum of Understanding between CALS and IRRI to facilitate international academic exchange, to develop academic and scientific relationships, and to support collaborative research activities. 3 Mar 2008–2 Mar 2013
- Cornell University (Cornell). Subcontract Agreement between Cornell and IRRI for the BMGF-funded project *Durable rust resistance in wheat (DRRW)* (DPPC2007-71). 29 July 2008
- Cornell University (Cornell). Task Order No. 1 to Subcontract Agreement between Cornell and IRRI for the BMGF-funded project *Durable rust resistance in wheat (DRRW)* (DPPC2007-71). 11 Aug 2008
- Exelixis Plant Sciences. Letter of Agreement between Exelixis Plant Sciences and IRRI for membership in the *Hybrid Rice Research and Development Consortium (HRDC)* for Private Sector Promotional Member (DPPC2008-49). 10 July 2008
- International Food Policy Research Institute (IFPRI). Letter of Agreement between IFPRI and IRRI to implement the subproject *Linking smallholders in Bihar to emerging value chains* under the IFAD-funded project *Accelerating agricultural technology adoption to enhance rural livelihoods in disadvantaged districts of India* (DPPC2006-79). 9 Oct 2008
- Louisiana State University (LSU) Agricultural Center. Letter of Agreement between LSU Agricultural Center and IRRI for membership in the *Hybrid Rice Research and Development Consortium (HRDC)* for Public Sector Member (DPPC2008-49). 8 Feb 2008
- Ohio State University Research Foundation (OSURF). Letter of Agreement between OSURF and IRRI for the collaborative project *Breeding for blast resistance* under Work Group 2 of the *Temperate Rice Research Consortium (TRRC)* (DPPC2007-13). 18 July 2008
- Pioneer Hi-Bred International, Inc. Letter of Agreement between Pioneer Hi-Bred International, Inc. and IRRI for membership in the *Hybrid Rice Research and Development Consortium (HRDC)* for Private Sector Primary Member (DPPC2008-49). 15 Feb 2008
- Pioneer Overseas Corporation (PIONEER). Research Collaboration Agreement between PIONEER and IRRI on the implementation of research projects under a *Scientific Know-how and Exchange Program (SKEP)* (DPPC2008-41). 21 Nov 2008
- RiceTec, Inc. Letter of Agreement between RiceTec, Inc. and IRRI for membership in the *Hybrid Rice Research and Development Consortium (HRDC)* for Private Sector Primary Member (DPPC2008-49). 10 Jan 2008
- Rockefeller Foundation (RF). Grant Agreement between RF and IRRI for the project *Golden rice product development and deployment* (DPPC2008-115). 24 Oct 2008
- United States Department of Agriculture (USDA). Amendment No. 2 to Specific Cooperative Agreement between USDA and IRRI for the project *Enabling open access to IRRI-assisted theses and dissertations funding proposal* (DPPC2006-72). 11 Apr 2008
- University of California, Davis (UC-Davis). Subaward Agreement between UC-Davis and IRRI for the USDA-funded project *Tilling and ecotilling resources for Japonica and Indica rice* (DPPC2003-50). 20 Feb 2008
- Washington State University (WSU). Letter of Agreement between WSU and IRRI for the BMGF-funded project *Creating the second Green Revolution by supercharging photosynthesis: C_4 rice* (DPPC2008-78). 5 Dec 2008
- Western Michigan University (WMU) and Calvin College. Novation Agreement among WMU, Calvin College, and IRRI for the USAID-funded project *Modeling the impacts of* Bt *transgene flow on lepidopteran food web structure and stability on wild rice in Vietnam* (DPPC2006-70). 23 June 2008
- World Vision, Inc. (WVUS). Subgrant Agreement between WVUS and IRRI for the USAID-funded project *Partnership for innovation and knowledge in agriculture (PIKA)* (DPPC2008-81). 1 Oct 2008

Vietnam

- An Giang University (AGU). Amendment to the Letter of Agreement between AGU and IRRI for the ADB-funded project *Improving poor farmers' livelihoods through rice information technology (Linking Extension and Research Needs through Information Technology-LEARN IT)* (DPPC2002-36). 3 June 2008
- An Giang Department of Agriculture and Rural Development. Letter of Agreement between An Giang Department of Agriculture and Rural Development and IRRI for the collaborative project *Development and promotion of the Irrigated Rice Research Consortium (IRRC) technologies in rice production* under the IRRC Country Outreach Programs (ICOPs) (DPPC2004-30). 8 Aug 2008
- Agricultural Sciences Institute of Southern Central Coast (ASISOV). Letter of Agreement between ASISOV and IRRI on the collaborative project *Development, evaluation, and dissemination of site-specific nutrient management (SSNM) for rice in Central Vietnam* under

the IFA/IPI/PPI-funded project for the Productivity and Sustainability Work Group of the *Irrigated Rice Research Consortium (IRRC) Phase III* (DPPC2005-02). 3 Jan 2008

- Cuu Long Delta Rice Research Institute (CLRRI). Letter of Agreement between CLRRI and IRRI for the BMZ-funded project *Enhancing and stabilizing the productivity of salt-affected areas by incorporating genes for tolerance of abiotic stresses in rice* (DPPC2007-09). 16 May 2008
- Cuu Long Delta Rice Research Institute (CLRRI). Letter of Agreement between CLRRI and IRRI for the CPWF-funded project *Development of technologies to harness the productivity potential of salt-affected areas of the Indo-Gangetic, Mekong, and Nile River basins* (DPPC2003-21). 6 Oct 2008
- Field Crops Research Institute (FCRI). Letter of Agreement between FCRI and IRRI for membership in the *Hybrid Rice Research and Development Consortium (HRDC)* for Public Sector Member (DPPC2008-49). 25 Mar 2008
- Field Crops Research Institute (FCRI). Letter of Agreement between FCRI and IRRI for the purpose of implementing the alternate wetting and drying water savings experiment of the *Irrigated Rice Research Consortium–Water-Saving Work Group* (DPPC2004-30). 1 Sep 2008
- Hanoi Agricultural University (HAU). Amendment to the Letter of Agreement between HAU and IRRI for the ADB-funded project *Improving poor farmers' livelihoods through rice information technology (Linking Extension and Research Needs through Information Technology-LEARN IT)* (DPPC2002-36). 3 June 2008
- National Agricultural Extension Center (NAEC). Amendment to the Letter of Agreement between NAEC and IRRI for the ADB-funded project *Improving poor farmers' livelihoods through rice information technology (Linking Extension and Research Needs through Information Technolog -LEARN IT)* (DPPC2002-36). 3 June 2008
- Nong-Lam University (NLU). Letter of Agreement between NLU and IRRI for the purpose of implementing a training on laser leveling in Lao PDR as part of the research project *Rice postharvest systems development* under the SDC-funded project *The Irrigated Rice Research Consortium (IRRC), Phase III* (DPPC2004-30). 4 Jan 2008
- Nong-Lam University (NLU). Amendment to the Letter of Agreement between NLU and IRRI for the purpose of lending some additional equipment needed for implementing the activities of the research project *Rice postharvest systems development* under the SDC-funded project *The Irrigated Rice Research Consortium (IRRC), Phase III* (DPPC2004-30). 20 Jan 2008
- Nong-Lam University (NLU). Letter of Agreement between NLU and IRRI for the purpose of laser leveling promotion activities in Lao PDR as part of the research project *Rice postharvest systems development in Lao PDR* under the SDC-funded project *The Irrigated Rice Research Consortium (IRRC), Phase III* (DPPC2004-30). 31 Jan 2008
- Nong-Lam University (NLU). Letter of Agreement between NLU and IRRI for the purpose of implementing a training on postharvest and mini-combine operation, maintenance, and repair in Lao PDR as part of the research project *Rice postharvest systems development in Lao PDR* under the SDC-funded project *The Irrigated Rice Research Consortium (IRRC), Phase III* (DPPC2004-30). 31 July 2008
- Northern Mountainous Agriculture and Forestry Science Institute (NOMAFSI). Scientific Collaboration Contract between NOMAFSI and IRRI for the IFAD-funded project *Managing rice landscapes in the marginal uplands for household food security and environmental sustainability* (DPPC2003-08). 12 June 2008
- World Vision Vietnam (WV-V). Amendment to the Letter of Agreement between WV-V and IRRI for the ADB-funded project *Improving poor farmers' livelihoods through rice information technology (Linking Extension and Research Needs through Information Technology-LEARN IT)* (DPPC2002-36). 3 June 2008
- Vietnam Institute of Agricultural Engineering and Postharvest Technology (VIAEP). Letter of Agreement between VIAEP and IRRI for the purpose of market information collection and dissemination; farmers' lessons learned meetings; and rice husk furnace installation for farmers' dryers as part of the ADB-funded project *Improving poor farmers' livelihood through postharvest technology* (DPPC2002-37). 25 June 2008

Financial Support

Summary of financial support to IRRI research agenda (in US$000)

	2008	2007
5 Prime	484	–
Aquifer Limited	30	166
Asian Development Bank	994	1,081
Australia	1,351	1,113
Bill & Melinda Gates Foundation	5,705	189
Bangladesh	135	100
Canada		
Canadian International Development Agency	1,397	1,200
Centro Internacional de Agricultura Tropical (CIAT)	29	4
Challenge Programs		
Generation	1,494	1,456
HarvestPlus	382	839
Water and Food	920	3,098
China	170	154
European Commission	1,752	3,565
Food and Agriculture Organization of the United Nations (FAO)	51	20
Foundation for Advanced Studies on Agricultural Development (FASID)	22	48
France	353	401
Germany		
Federal Ministry for Economic Cooperation	537	388
Federal Ministry for Economic Cooperation/ German Agency for Technical Cooperation	549	469
Global Crop Diversity Trust	328	234
Grand Challenges in Global Health through Albert Ludwig University of Freiburg	483	139
India	594	650
International Atomic Energy Association (IAEA)	17	17
International Fertilizer Industry Association (IFA), International Plant Nutrition Institute (IPNI), International Potash Institute (IPI)	121	61
International Fund for Agricultural Development (IFAD)	1,368	596
International Fund for Agricultural Research (IFAR)	11	19
Iran	165	92
Japan	4,712	3,504
Korea	825	891
Malaysia	18	44
Monsanto Fund	–	46
Norway	382	334
Nunza BV	29	26
Philippines	178	133
Plan International Cambodia	7	42
Portugal	58	200
Rockefeller Foundation	116	616
Sweden	516	555
Switzerland	1,335	1,745
Thailand	40	40
United Kingdom	2,128	2,431
United States of America		
United States Agency for International Development (USAID)	4,867	3,412
United States Department of Agriculture (USDA)	101	29
Vietnam	15	15
World Bank	1,836	2,122
Others	663	104
Total	**37,268**	**32,389**

Australian Centre for International Research

- Improving rice productivity in South and Southeast Sulawesi under the Support for Market-driven Adaptive Research (SMAR) (DPPC2007-125), 3/1/2008–2/28/2011
- Sustainable intensification of rice-maize production systems in Bangladesh (joint project with CIMMYT) (DPPC2008-04), 7/1/2008–6/30/2013
- Molecular marker technologies for faster wheat breeding in India (led by the University of Sydney) (DPPC2008-09), 6/26/2008–4/30/2012

Asian Development Bank

- Bringing about a sustainable agronomic revolution in rice production in Asia by reducing preventable pre- and postharvest losses (DPPC2008-74), 10/1/2008–10/31/2010

Bill & Melinda Gates Foundation

- Cereal Systems Initiative for South Asia (CSISA) (DPPC2008-100), 12/1/2008–11/30/2011
- Creating the second Green Revolution by supercharging photosynthesis: C_4 rice (DPPC2008-78), 10/15/2008–10/31/2011

Department for International Development and Biotechnology and Biological Sciences Research Council

- Characterizing genetic- and soil-induced variation in arsenic uptake, translocation, and metabolism in rice to mitigate arsenic contamination in Asia (led by the University of Aberdeen) (DPPC2006-106), 1/1/2008–12/31/2010

Department for International Development

- Poverty alleviation through rice innovation systems under DfID's Research into Use Program (led by NEFORD) (DPPC 2007-118), 3/1/2008–2/1/2011

Bioversity International

- Collective action for the rehabilitation of global public goods in the CGIAR genetic resources system: phase 2 (GPG2) (DPPC2008-126), 10/1/2008–12/31/2009

Bundesministerium für Wirtschaftliche Zusammenarbeit und Entwicklung (German Federal Ministry for Economic Cooperation and Development)

- Rice and global climate change: candidate genes for preventing heat- and drought-induced yield losses due to spikelet sterility (DPPC2008-75), 11/1/2008–10/31/2010

Bundesministerium für Wirtschaftliche Zusammenarbeit und Entwicklung (German Federal Ministry for Economic Cooperation and Development) and Eiselen Foundation

- Enhancing and stabilizing the productivity of salt-affected areas by incorporating genes for tolerance of abiotic stresses in rice (CFP2007) (DPPC2007-09), 1/1/2008–12/31/2010

British Embassy

- Rice and climate change: towards an informed Philippine policy (DPPC2008-91), 8/1/2008–3/31/2009

Chinese Academy of Agricultural Sciences

- “Green super rice” for the resource-poor of Africa and Asia (DPPC2008-66), 11/1/2008–10/31/2011

Systemwide Genetic Resources Program and Bioversity International

- Internal financial audits in the 11 CGIAR center partners in the World Bank-funded project “Collective action for the rehabilitation of global public goods in the CGIAR genetic resources system: phase 2” (GPG2) (DPPC2008-43), 4/1/2008–5/31/2010
- Compile, review, and update standard operating procedures (sub-activity under “Collective action for the rehabilitation of global public goods in the CGIAR genetic resources system: phase 2” [GPG2]) (DPPC2008-47), 3/1/2008–7/15/2008

Challenge Program on Water and Food (CPWF)

- CPWF Inception Meeting and Annual Stakeholders Workshop (DPPC2008-31), 2/26/2008–2/28/2008

Cornell University

- Durable rust resistance in wheat (DPPC2007-71), 2/1/2008–1/31/2011

Foundation for Advanced Studies in International Development (FASID)

- FASID-IRRI loop survey-research on agricultural transformation in Central Luzon and Laguna (DPPC2008-65), 5/15/2008–12/15/2008

FOSS

- Improving the capacity of indica rice breeding programs to measure the traits of physical quality of grain (DPPC2007-39), 1/1/2008–12/31/2010

Global Crop Diversity Trust

- Heat-tolerant rice to combat global warming (DPPC2007-123), 1/1/2008–12/31/2009
- Establishment of the Global Crop Registers for Rice and Wheat (DPPC2008-48), 1/1/2008–12/31/2009

Generation Challenge Programme (GCP)

- Speeding the development of salt-tolerant rice varieties through marker-assisted selection and their dissemination in salt-affected areas of Bangladesh (DPPC2007-104), 1/1/2008–12/31/2008
- Transcriptome analysis of near-isogenic rice lines to identify expression signatures and gene combinations conferring stress tolerance (DPPC2007-119), 1/1/2008–12/31/2008
- Connecting performance under drought with genotypes through phenotype associations (DPPC2007-122), 1/1/2008–12/31/2008
- Population development to underpin gene discovery and allele validation in rice: the multiparent advanced generation inter-crosses (MAGIC) (DPPC2007-124), 1/1/2008–12/31/2008
- Development of Generation CP domain models and ontology (DPPC2007-128), 1/1/2008–12/31/2008
- GCP quality management and data quality improvement (DPPC2007-130), 1/1/2008–12/31/2008
- Data analysis support for existing projects in SP2 with emphasis on integrating results from microarray and mapping experiments (DPPC2007-131), 1/1/2008–12/31/2008
- Large-scale phylogenomic analyses to gene function prediction for GCP crops (led by Bioversity) (DPPC2007-132), 1/1/2008–12/31/2008
- Development of tools and technology to increase the functionality of the GCP information platform (DPPC2007-137), 1/1/2008–12/31/2008

- Development of an integrated GCP platform (DPPC2007-138), 1/1/2008–12/31/2008
- Provision of genotyping support services (DPPC2008-26), 3/7/2008–3/6/2009
- Implementation of web services technology in the Generation Challenge Program Consortium (DPPC2008-27), 1/1/2008–12/31/2008
- High-performance computing facilities for the GCP platform (DPPC2008-28), 1/1/2008–12/31/2008
- Validation of drought-response/resistance pathway genes by phenotypic analysis of mutants (led by Virginia Polytechnic and State University) (DPPC2008-29), 8/1/2008–7/31/2009
- Targeting drought-avoidance root traits to enhance rice productivity under water-limited environments (DPPC2008-34), 11/1/2008–10/31/2011
- Drought from a different perspective: improved tolerance through phosphorus acquisition (DPPC2008-38), 11/1/2008–10/31/2011
- Application and validation of the major QTL *phosphate uptake 1* (*Pup1*) (DPPC2008-42), 1/1/2008–12/31/2008
- Enhancing MAS capacity for salt-stress rice breeding in Bangladesh (led by BRRI)-GCP Capacity Building Program (DPPC2008-50), 3/31/2008–4/30/2009

International Fund for Agricultural Development

- Reducing risks from arsenic contamination for poor people (DPPC2008-07), 10/31/2008–12/31/2010

Japan International Cooperation Agency

- Area-focused training program on upland rice variety selection techniques (for African countries) (DPPC2008-109), 10/7/2008–11/17/2008

Japan International Research Center for Agricultural Sciences

- Experimental introduction of volumetric irrigation fee scheme (DPPC2008-117), 9/1/2008–10/31/2010
- Transformation of lowland rice and evaluation of transformed rice for environmental stress tolerance (DPPC2008-25), 5/1/2008–2/27/2009

Philippine Rice Research Institute

- Implementation of the 2009-2010 Rice Self-Sufficiency Plan of the GMA Rice Program (DPPC2008-88), 7/9/2008–12/31/2008

Pioneer Hi-Bred International, Inc.

- Scientific Know-how and Exchange Program between IRRI and Pioneer Hi-Bred International, Inc. (DuPont) (DPPC2008-41), 7/16/2008–7/15/2011

Plan International

- Poverty Reduction Options Validated in Drought Environments (PROVIDE)—Phase 3 (DPPC2008-71), 5/2/2008–2/28/2009

Rural Development Administration

- Development of submergence-tolerant japonica rice varieties (IRRI-RDA collaboration) (DPPC2008-06), 4/1/2008–3/31/2011

United States Agency for International Development

- Partnership for Innovation and Knowledge in Agriculture (PIKA) (led by World Vision) (DPPC2008-81), 10/1/2008–9/30/2010
- Accelerating adoption of resource-conserving technologies in South Asia under the umbrella of the Cereal Systems Initiative for South Asia (DPPC2008-89), 9/26/2008–11/25/2011

United States Department of Agriculture

- Identification of genes that control biomass production using rice as a model system (led by Colorado State University) (DPPC2008-03), 12/1/2008–8/31/2011

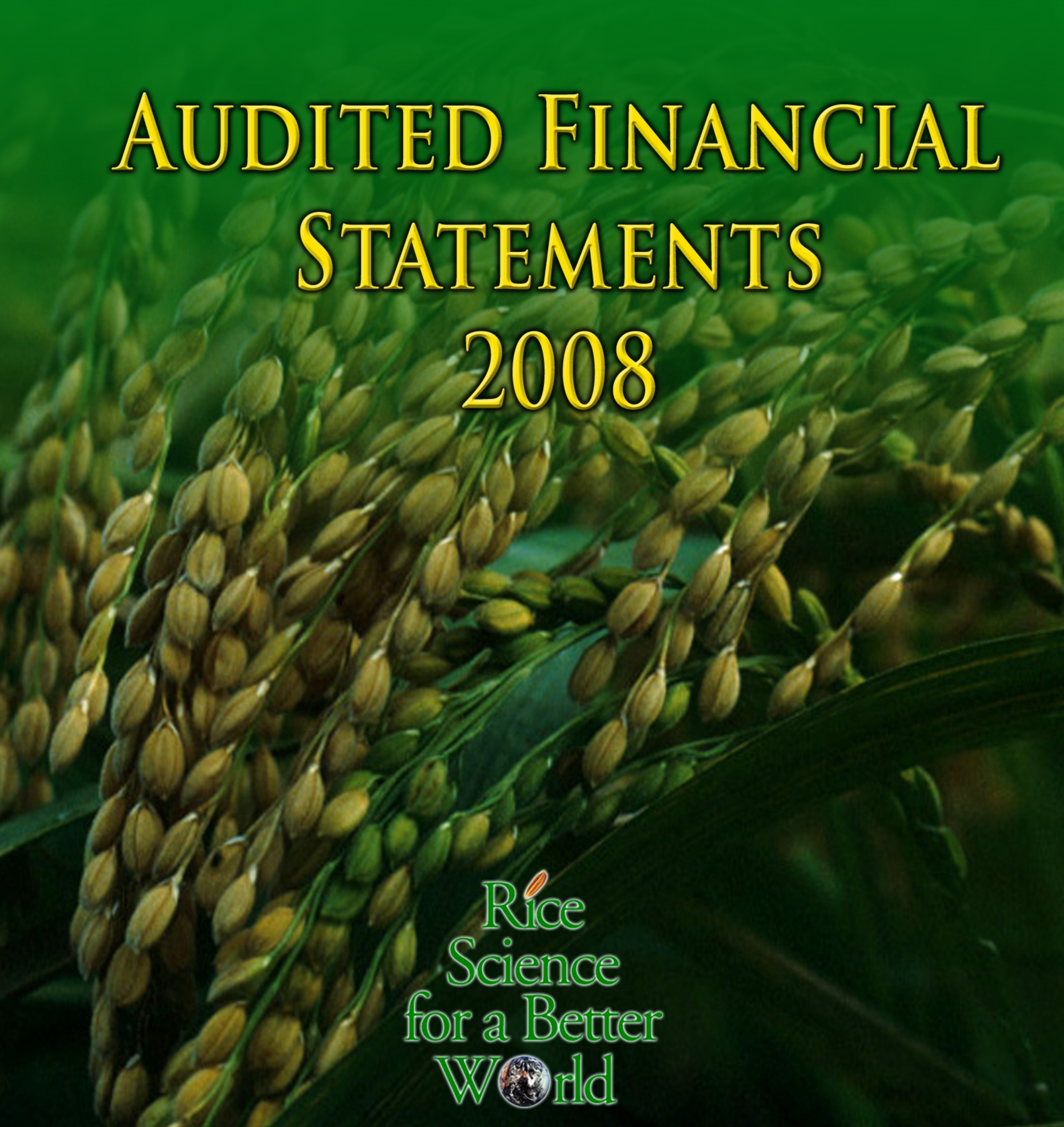
World Bank

- CGIAR Systemwide Ecoregional Program: funding to the Rice and Wheat Consortium (DPPC2008-39), 1/1/2008–12/31/2008

IRRI

INTERNATIONAL RICE RESEARCH INSTITUTE

AUDITED FINANCIAL STATEMENTS 2008



Rice Science for a Better World

IRRI

Corporate information

Los Baños Headquarters Location/Address

College, Los Baños
4031 Laguna
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Fax: (63-2) 580-5699; 845-0606
(63-49) 536-7995
+1 (650) 833-6621 (USA direct)

Email: irri@cgiar.org
Web: www.irri.org

IRRI Makati Office Location/Address

10th Floor, Suite 1009
Security Bank Center
6776 Ayala Avenue, Makati City 1226
Philippines
Tel: (63-2) 856-6133; 856-6129
Fax: (63-2) 891-1236

External Auditors

Isla Lipana & Co.
A member firm of PricewaterhouseCoopers

IRRI

Audit Committee

Membership

The members of the Audit Committee are appointed by the Board. It assists the Board in fulfilling its oversight responsibilities by reviewing and auditing, from time to time, the accounts and financial condition as well as the management and operating systems and procedures of the Institute. The Committee may undertake other duties delegated to it by the Board.

For the Institute's audit and accounts, the Committee discharges its functions in consultation and coordination with the external auditors, the internal auditors, and appropriate consultants of the Institute.

The Chairperson of the Audit Committee, who is customarily appointed by the Board at the time when the Board appoints members of the Committee, presides over all meetings of the Committee. In his/her absence or disability, the Vice Chairperson shall acts as the Chairperson for that meeting.

A vacancy in the Audit Committee is filled from among other members of the Board through election by the Board or election by the remaining members of the Audit Committee. Any person so elected by the Committee serves only until the next meeting of the Board.

The Audit Committee shall meet at least once a year. Special meetings may be held upon call by its Chairman or upon request of at least one member. The committee shall report to the Board, at least at the conclusion of each committee meeting about Committee activities, issues, and related recommendations, confirming that all responsibilities outlined in the charter have been carried out.

Authority

The Audit Committee is authorized to commission investigations into matters within its scope of responsibility. It is empowered to seek any information it requires from Institute management and staff or external parties, meet with Institute management and staff, external auditors, or legal counsel, as necessary, and, retain independent counsel, accountants, or others to advise the committee or assist in the conduct of an investigation.

The Composition in 2008 and Designation of Audit Committee

Dr. Emerlinda Roman - Chairperson
Mr. M. Syeduzzaman -Vice Chairperson
Dr. Ronald Phillips - Member
Prof. Elizabeth Woods - Member
Prof. Baowen Zhang - Member
Prof. Ruth Oniang'o - Member

IRRI

Statement by the Board Chair

For the year ended 31 December 2008

As IRRI nears the half-century mark, we are pleased to report that the Institute continues to meet the high standards expected by our stakeholders.

Resource Mobilization

The global food crisis has rekindled awareness of the importance of research to increase food production to assure future food security, especially in Asia and Africa, where most of the world's poor are located. IRRI clearly has an important role to play.

In 2008, IRRI's revenue increased by 11% to US$37.5 million. IRRI has been successful in attracting significant new investments to further its mission and to continue in its leading role in the important task of reducing poverty through rice science. This included new restricted grants from the Asian Development Bank, ACIAR, the Bill & Melinda Gates Foundation, the Chinese Academy of Agricultural Sciences, and Germany.

Financial Status

IRRI's financial position remains stable, with total assets of $71.5 million. The liquidity and long-term stability indicators remain above the CGIAR benchmarks.

IRRI incurred a deficit of $3.6 million in 2008. The deficit on normal operations was $2.4 million. The remaining portion of the deficit ($1.2 million) was due to use of the reserves for identified research and management initiatives within the new Strategic Plan, such as the Knowledge Pathways Initiative, Climate Change, and Drought Frontier projects.

The deficit was consistent with the Board-approved plan to reduce the reserves and was described in the Medium-Term Plan.

Risk Management

The Board continuously monitors the risk management system and risk mitigation measures and is satisfied with the progress made on implementing the risk management framework, which included the appointment of a full-time risk management/quality assurance coordinator.

External Program and Management Review

The EPMR began in 2008 and a report was issued in early 2009. IRRI welcomes the recommendations and is pleased to note that the Institute's finances are well managed and the internal control systems are functioning well.

CGIAR Award

The Board would like to congratulate Dr. Edilberto Redoña, global coordinator of the International Network for Genetic Evaluation of Rice (INGER), and his team for being named

IRRI

the "**2008 CGIAR Outstanding Scientific Support Team"** at the CGIAR Annual General Meeting held in Mozambique, for their systematic efforts to collect rice varieties from all over the world and use them to create "elite breeding lines" that have improved rice production in more than 50 countries.

Appreciation
On behalf of the Board of Trustees, I would like to thank our partners and donors for their continued support and cooperation to fulfill IRRI's mission. I would also like to recognize the dedication and perseverance of IRRI's staff.

Elizabeth Woods

Prof. Elizabeth Woods
Chair
Board of Trustees

IRRI

International Rice Research Institute
Financial statements
December 31, 2008 and 2007

Management Statement of Responsibility for Financial Reporting

The accompanying financial statements of the International Rice Research Institute (IRRI), for the years ended December 31, 2008 and 2007 are the responsibility of management. IRRI management also claims responsibility for the substance and objectivity of the information contained therein.

Our financial reporting practices follows the "Accounting Policies and Reporting Practices Manual – Financial Guidelines Series No. 2" of the CGIAR. IRRI maintains a system of internal control designed to provide reasonable assurance that assets are safeguarded and transactions are properly recorded and executed in accordance with management's authorization.

A system of reporting within the Institute present the management with an accurate view of the operations, enabling us to discern risks to our assets or fluctuations in the economic environment of the Institute at an early stage and at the same time providing a reliable basis for the financial statements and management reports.

The Board of Trustees exercises its responsibility for these financial statements through its Finance and Audit Committee. The Committee meets regularly with management and representatives of the external auditors to review matters relating to financial reporting, internal controls, and auditing.

Dr. Robert S. Zeigler
Director General

Norman A. Macdonald
Treasurer and Director for
Management Services

INTERNATIONAL RICE RESEARCH INSTITUTE
(A Nonstock, Not-for-Profit Organization)

**FINANCIAL STATEMENTS
AND SUPPLEMENTARY INFORMATION
AS OF AND FOR THE YEARS ENDED
DECEMBER 31, 2008 AND 2007**

INTERNATIONAL RICE RESEARCH INSTITUTE
(A Nonstock, Not-for-Profit Organization)

FINANCIAL STATEMENTS AND SUPPLEMENTARY INFORMATION
AS OF AND FOR THE YEARS ENDED DECEMBER 31, 2008 AND 2007

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Independent Auditor's Report

To the Board of Trustees of
International Rice Research Institute
Los Baños, Laguna

We have audited the accompanying financial statements of the International Rice Research Institute (a nonstock, not-for-profit organization), which comprise the statements of financial position as of December 31, 2008 and 2007 and the related statements of activities, changes in net assets and cash flows for the years then ended, and a summary of significant accounting policies and other explanatory notes.

Management's Responsibility for the Financial Statements

Management is responsible for the preparation and fair presentation of these financial statements and the supplementary schedules in accordance with the basis of Accounting Policies and Reporting Practices Manual - Financial Guidelines Series No. 2 prescribed for international agricultural research centers under the auspices of the Consultative Group on International Agricultural Research (CGIAR). This responsibility includes: designing, implementing and maintaining internal control relevant to the preparation and fair presentation of financial statements that are free from material misstatement, whether due to fraud or errors; selecting and applying accounting policies; and making accounting estimates that are reasonable in the circumstances.

Auditor's Responsibility

Our responsibility is to express an opinion on these financial statements based on our audits. We conducted our audits in accordance with International Standards on Auditing. Those standards require that we comply with ethical requirements and plan and perform the audit to obtain reasonable assurance whether the financial statements are free from material misstatement.

An audit involves performing procedures to obtain audit evidence about the amounts and disclosures in the financial statements. The procedures selected depend on the auditor's judgment, including the assessment of the risks of material misstatement of the financial statements, whether due to fraud or error. In making those risk assessments, the auditor considers internal control relevant to the entity's preparation and fair presentation of the financial statements in order to design audit procedures that are appropriate in the circumstances, but not for the purpose of expressing an opinion on the effectiveness of the entity's internal control. An audit also includes evaluating the appropriateness of accounting policies used and the reasonableness of accounting estimates made by management, as well as evaluating the overall presentation of the financial statements.

(1)

PRICEWATERHOUSECOOPERS

Independent Auditor's Report
To the Board of Trustees of
International Rice Research Institute

We believe that the audit evidence we have obtained is sufficient and appropriate to provide a basis for our audit opinion.

Opinion

In our opinion, the accompanying financial statements present fairly, in all material respects, the financial position of the International Rice Research Institute (a nonstock, not-for-profit organization) as of December 31, 2008 and 2007, and the results of its activities and its cash flows for the years then ended in accordance with the CGIAR's Accounting Policies and Reporting Practices Manual - Financial Guidelines Series No. 2.

Our audits were made for the purpose of forming an opinion on the basic financial statements taken as a whole. The supplementary schedules of grants revenues, restricted funding and operating expenses and the indirect cost rate calculation for the years ended December 31, 2008 and 2007 are presented for purposes of additional analysis and are not a required part of the basic financial statements. The information in such supplementary schedules has been subjected to the auditing procedures applied in the audit of the basic financial statements and, in our opinion, is fairly stated in all material respects in relation to the basic financial statements taken as a whole.

Other Matter

This report, including the opinion, has been prepared for and only for the members of the Board of Trustees as a body. We do not, in giving this opinion, accept or assume responsibility for any other purpose or to any other person to whose knowledge this report may come to.

PricewaterhouseCoopers

Makati City, Philippines
April 17, 2009

(2)

INTERNATIONAL RICE RESEARCH INSTITUTE
(A Nonstock, Not-for-Profit Organization)

STATEMENTS OF FINANCIAL POSITION
DECEMBER 31, 2008 AND 2007
(All amounts in thousand US Dollars)

	Notes	2008	2007
ASSETS			
Current assets			
Cash and cash equivalents	3	28,524	21,838
Short term investments	4	2,790	2,064
Accounts receivable			
Donors	5	5,613	7,484
Employees		213	189
Others	6	873	992
Inventories - net	7	543	572
Prepaid expenses		89	319
Total current assets		38,645	33,458
Non-current assets			
Property and equipment - net	8	10,577	11,113
Long term investments	9	22,246	21,612
Total non-current assets		32,823	32,725
Total assets		71,468	66,183
LIABILITIES AND NET ASSETS			
Current liabilities			
Accounts payable			
Donors	10	23,602	16,732
Others	11	1,546	967
Accruals and provisions	12	8,939	7,504
Total current liabilities		34,087	25,203
Net assets			
Designated		37,381	40,980
Total liabilities and net assets		71,468	66,183

The accompanying notes on pages 7 to 17 are an integral part of these financial statements.

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INTERNATIONAL RICE RESEARCH INSTITUTE
(A Nonstock, Not-for-Profit Organization)

STATEMENTS OF ACTIVITIES
FOR THE YEARS ENDED DECEMBER 31, 2008 AND 2007
(All amounts in thousand US Dollars)

		2008				
			Restricted			
	Note	**Unrestricted**	**Temporary**	**Challenge Programs**	**Total**	**2007**
Revenues						
Grants (Exhibit 1)		12,671	21,801	2,796	37,268	32,389
Other revenues, net	16	257	-	-	257	1,298
		12,928	21,801	2,796	37,525	33,687
Operating expenses						
Program related (Exhibit 3)		11,479	21,480	2,796	35,755	31,911
Management and general (Exhibit 3)		6,896	321	-	7,217	7,340
		18,375	21,801	2,796	42,972	39,251
Recovery of indirect costs		(2,782)	-	-	(2,782)	(1,667)
		15,593	21,801	2,796	40,190	37,584
Net deficit from ordinary activities		(2,665)	-	-	(2,665)	(3,897)
Unrealized foreign exchange translation gain (loss)		(971)	-	-	(971)	985
Net deficit		(3,636)	-	-	(3,636)	(2,912)
Memo items						
Operating expenses - by natural classification:						
Personnel costs		9,354	7,350	755	17,459	15,499
Supplies and services		5,835	7,998	1,023	14,856	13,674
Collaborators/Partners		14	4,035	640	4,689	4,863
Operational travel		1,021	2,069	353	3,443	2,924
Depreciation		2,151	349	25	2,525	2,291
Recovery of indirect costs		(2,782)	-	-	(2,782)	(1,667)
		15,593	21,801	2,796	40,190	37,584

The accompanying notes on pages 7 to 17 are an integral part of these financial statements.

INTERNATIONAL RICE RESEARCH INSTITUTE
(A Nonstock, Not-for-Profit Organization)

STATEMENTS OF CHANGES IN NET ASSETS
FOR THE YEARS ENDED DECEMBER 31, 2008 AND 2007
(All amounts in thousands of US Dollars)

			Designated						
		Vested	*Non-Vested*						
	Note	Invested in fixed assets	Fixed assets acquisition	Risk management	Unrealized FOREX translation	GRC reserve	Research initiative fund (Note 14)	Total non-vested	Total Net Assets
Balances, January 1, 2007		9,883	4,553	2,171	5,899	10,000	10,957	33,580	43,463
Board of Trustees re-designation	14	-	-	1,122	(3,364)	-	2,242	-	-
Capital reserve replenishment		(1,838)	1,838	-	-	-	-	1,838	-
Acquisition of fixed assets		3,169	(2,740)	-	-	-	-	(2,740)	429
Net deficit for the year		(101)	-	(1,885)	985	-	(1,911)	(2,811)	(2,912)
Balances, December 31, 2007		11,113	3,651	1,408	3,520	10,000	11,288	29,867	40,980
Board of Trustees re-designation	14	-	-	1,706	(1,706)	-	-	-	-
Capital reserve replenishment		(2,525)	2,525	-	-	-	-	2,525	-
Acquisition of fixed assets		2,039	(2,002)	-	-	-	-	(2,002)	37
Net deficit for the year		(50)	-	(1,344)	(971)	-	(1,271)	(3,586)	(3,636)
Balances, December 31, 2008		10,577	4,174	1,770	843	10,000	10,017	26,804	37,381

The accompanying notes on pages 7 to 17 are an integral part of these financial statements.

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INTERNATIONAL RICE RESEARCH INSTITUTE
(A Nonstock, Not-for-Profit Organization)

STATEMENTS OF CASH FLOWS
FOR THE YEARS ENDED DECEMBER 31, 2008 AND 2007
(All amounts in thousands of US Dollars)

	Notes	2008	2007
Cash flows from operating activities			
Net deficit		(3,636)	(2,912)
Adjustments for:			
Depreciation of property and equipment	8	2,525	2,291
Investment (gains) losses		183	(1,257)
Net book value of disposed property and equipment		50	101
Net deficit before working capital changes		(878)	(1,777)
(Increase) decrease in:			
Short term investments		(726)	588
Accounts receivable		1,966	(3,177)
Inventories		29	(17)
Prepaid expenses		230	(140)
Increase in:			
Accounts payable		7,449	8,857
Accruals and provisions		1,435	277
Cash generated from operations		9,505	4,611
Interest received		747	1,257
Net cash provided by operating activities		10,252	5,868
Cash flows from investing activities			
(Increase) decrease in long term investments		(1,564)	2,126
Net movement of fixed assets/acquisition reserve		37	429
Acquisition of property and equipment	8	(2,039)	(3,622)
Net cash used in investing activities		(3,566)	(1,067)
Net increase in cash and cash equivalents		6,686	4,801
Cash and cash equivalents			
January 1		21,838	17,037
December 31		28,524	21,838

The accompanying notes on pages 7 to 17 are an integral part of these financial statements.

INTERNATIONAL RICE RESEARCH INSTITUTE
(A Nonstock, Not-for-Profit Organization)

NOTES TO FINANCIAL STATEMENTS
AS OF AND FOR THE YEARS ENDED DECEMBER 31, 2008 AND 2007
(All amounts in thousands of US Dollars unless otherwise stated)

Note 1 - General

International Rice Research Institute (the Institute) was established in 1960 to undertake basic research on the rice plant and applied research on all phases of rice production, management, distribution and utilization with the objective of attaining nutritive and economic advantage and benefit for the people of Asia and other major rice-growing areas.

The Institute was first conferred the status of an international organization in the Philippines under Presidential Decree (PD) No. 1620. On May 19, 1995, a multi-lateral agreement recognizing the status of the Institute as an international organization was signed by representatives of 19 countries, including the Philippines (another country subsequently acceded to the Agreement). The 1995 Agreement allows the Institute to have a juridical status to more effectively pursue its international collaborative activities in rice research and training. Pursuant to the 1995 Agreement, the Institute and the Government of the Republic of the Philippines entered into a Headquarters (HQ) Agreement. The HQ Agreement was ratified by the President on May 23, 2006, was concurred by the Senate on April 28, 2008, and came into force on May 14, 2008.

The Institute enjoys, among other privileges and prerogatives, the following tax exemptions:

a. exemption from the payment of gift, franchise, specific, percentage, real property, exchange, import, export, documentary stamp, value-added and all other taxes provided under existing laws or ordinances. This exemption extends to goods imported and owned by the Institute, leased or used by its staff;

b. exemption from payment of gift tax; all gifts, contributions and donations to the Institute are considered allowable deductions for purposes of determining the income tax of the donor; and

c. exemption from payment of Philippine income tax of non-Filipino citizens serving on the Institute's technical and scientific staff on salaries and stipends in United States (US) dollars received solely from, and by reason of, service rendered to the Institute.

The Institute receives support from various donor agencies and entities primarily through the Consultative Group on International Agricultural Research (CGIAR). CGIAR is a group of donors composed of governments of various nations and international organizations and foundations.

The Institute's major facilities are located in Los Baños, Laguna, Philippines. In addition, the Institute owns an administrative office in Makati City, Philippines. As of December 31, 2008, the Institute has 976 employees (2007 - 905).

The accompanying financial statements and supplementary schedules of the Institute were approved and authorized for issue by the Board of Trustees on April 16, 2009.

Note 2 - Significant accounting policies

The principal accounting policies applied in the preparation of these financial statements are set out below. These policies have been consistently applied to all the years presented.

Basis of financial statements

The accompanying financial statements, expressed in US dollars, are prepared on the basis of accounting practices prescribed for international agricultural research centers (Accounting Policies and Reporting Practices Manual - Financial Guidelines No. 2 or APRPM) under the auspices of the CGIAR. These accounting policies are applied consistently in dealing with items that are considered material in relation to the financial statements.

The preparation of financial statements in conformity with CGIAR's APRPM requires the use of accounting estimates and assumptions concerning the future. The resulting accounting estimates will, by definition, seldom equal to related actual results. It also requires management to exercise its judgment in the process of applying the Institute's accounting policies.

Revenue recognition

Grants are recognized as revenue upon the substantial fulfillment of the conditions attached to them, regardless of the period when it is intended to be used, or when the donor has explicitly waived the conditions. Grants are classified according to the type of restrictions attached to them.

Unrestricted grants are grants received which the Institute may freely use for its mandated activities. Unrestricted grants are recognized in full in the period specified by the donor.

Restricted grants are grants received in support of specified projects or activities mutually agreed upon by the Institute and donors. Revenue is recognized to the extent of expenses actually incurred. Excess of grants received over expenses, representing grants applicable to succeeding years, are shown as "Accounts payable - donors" account in the statement of financial position. Claims from donors for project expenses paid in advance are shown as Accounts receivable - donors in the statement of financial position.

Grants in kind are recorded at the fair value of the assets received while cash grants are recorded at its US dollar equivalent.

Expense recognition

Expenses are recognized when a decrease in future economic benefit related to a decrease in an asset or an increase in a liability has arisen that can be measured reliably. Expenses are recognized on the basis of a direct association between the costs incurred and the earning of specific items of revenue.

Cash and cash equivalents

Cash includes cash on hand and in banks. Cash equivalents are short-term, highly liquid investments that are both (a) readily convertible to known amounts of cash and (b) so near maturity date that they present insignificant risk of changes in value. These investments, as distinguished from short term investments, are those that are acquired with original maturities of three months or less.

Short term investments

These consists of investments that are (a) acquired with original maturity of more than three months but not exceeding one year, and (b) those that are originally long term in nature but are currently due to mature within one year of the balance sheet date.

Accounts receivable

Accounts receivable are carried at gross amount less an allowance for any uncollectible amounts. Allowance for doubtful accounts is based on past experience and on a continuous review of receivable aging reports and other relevant factors.

When an accounts receivable is deemed doubtful of collection, the Institute provides an allowance for doubtful debt during the year in which it is deemed doubtful.

Any receivable or a portion thereof adjudged to be uncollectible is written off. The write-off is done after all efforts to collect have been exhausted.

Inventories

Inventories which consist of spare parts and supplies and other inventories are stated at the lower of cost or net realizable value. Cost, which includes the purchase price plus cost of freight, installation and handling charges, is determined using the moving average method.

Property and equipment

Property and equipment acquired prior to 1991 are carried at cost or estimated value; acquisitions starting 1991 are stated at cost. Capital expenditures with a minimum cost of US$500 or its equivalent and with an estimated life beyond one year are capitalized. The cost of an item of property and equipment comprises its purchase price and all other incidental cost in bringing the assets to its working condition for its intended use. Depreciation of all assets which are owned by the Institute is computed using the straight-line method over the estimated useful lives of the related assets, as follows:

Category description	Estimated life in years
Physical facilities	
Building and improvements	60
Infrastructure	
Site improvements	25
Furnishing and equipment	
Farming	
Farm machinery and equipment	7-10
Shop machinery and equipment	7-10
Laboratory	5-10
Office	5-10
Auxiliary units	5-10
Vehicles	4-7
Computers	3-5

Depreciation is charged from the month an asset was placed in operation and is continued until the asset has been fully depreciated or its use is discontinued.

Property and equipment acquired through the use of grants restricted for a specific project are recorded as assets. Such assets are depreciated at a rate of 100% in the year of purchase. The depreciation expense is charged directly to the appropriate restricted project.

Long term investments

Investments are initially recorded at their acquisition cost if they are purchased and at their fair market value if they are received as grants. Investments in equity securities and debt securities are re-measured at their market value as of the reporting date. Investments acquired with the intention of keeping the same for more than a year from the acquisition date and which are not maturing within one year as of the reporting date, are classified as long term investments.

Accruals

Accruals represent liabilities to pay for goods or services that have been received, supplied, invoiced or formally agreed with suppliers.

Provisions

Provisions are recognized when the Institute has: (a) a present legal or constructive obligation as a result of past events, (b) it is more likely than not that an outflow of resources will be required to settle the obligation, and (c) a reliable estimate of the amount can be made. Provisions are measured at the present value of management's best estimate of the expenditure required to settle the present obligation at the statement of financial position date.

When there are a number of similar obligations, the likelihood that an outflow will be required in the settlement is determined by considering the class of obligations taken as a whole. A provision is recognized even if the likelihood of an outflow with respect to any one item included in the same class of obligations may be small.

Leases

Leases of property where a significant portion of the risks and rewards of ownership are retained by the lessor are classified as operating leases. Payments made under operating leases are charged to operations on a straight-line basis over the period of the lease.

Foreign currency transactions and translations

Foreign currency denominated transactions are translated to US dollars for reporting purposes at standard bookkeeping rates which approximate the exchange rates prevailing at the dates of the transactions. Exchange differences arising from (a) the settlement of foreign currency denominated monetary items at rates which are different from which they were originally booked, and (b) the translation of balances of foreign-currency denominated monetary items are credited or charged to operations during the year.

Contribution to provident fund

The contribution to provident fund is charged to personnel costs.

Recovery of indirect costs

The pooling of direct and indirect costs is based on the principle of attribution and assignability. Expenditures are pooled to different resource user units (cost centers) by direct identification. Expenditures that are common to the different cost centers are allocated on the basis of resource drivers. Non-operating and non-recurring expenditures are excluded in the computation.

Direct and indirect costs exclude capital expenditures but include depreciation in the case of unrestricted funded activities. For restricted grants, the indirect cost rates may include capital expenditures depending on the terms and conditions of the relevant agreements.

The method of calculating the indirect cost recovery rate is prescribed in the CGIAR Financial Guidelines No. 5.

Subsequent events

Post-year-end events that provide additional information about the Institute's situation at the statement of financial position date (adjusting events) are reflected in the financial statements, if any. Post-year-end events that are not adjusting events are disclosed in the notes when material.

Note 3 - Cash and cash equivalents

This account consists of:

	2008	2007
Cash on hand and in banks	8,672	12,759
Cash equivalents	19,852	9,079
	28,524	21,838

Note 4 - Short term investments

This account consists of:

	2008	2007
With original maturities of more than 3 months but less than one year	-	28
Long term investments due to mature within one year	2,790	2,036
	2,790	2,064

Note 5 - Accounts receivable - donors

This account consists of outstanding approved unrestricted grants and expenses for restricted and challenge programs projects which are not yet collected from or reimbursed by donors.

	2008	2007
Unrestricted	3,191	4,169
Restricted		
Temporary	2,317	3,105
Challenge programs	105	210
	5,613	7,484

Note 6 - Accounts receivable - others

This account consists of:

	2008	2007
Advances to suppliers	402	625
Others	471	367
	873	992

Note 7 - Inventories

This account consists of:

	2008	2007
Spare parts	506	519
Supplies and other inventories	299	300
	805	819
Allowance for obsolescence	(262)	(247)
	543	572

Note 8 - Property and equipment

The details of property and equipment at December 31, 2008 and their movements during the year consist of:

	Physical facilities	Infrastructure and leasehold	Furnishing and equipment	Total
At January 1, 2008				
Cost	123	2,146	34,859	37,128
Accumulated depreciation	(30)	(514)	(25,471)	(26,015)
Net book value	93	1,632	9,388	11,113
Year ended December 31, 2008				
Opening net book value	93	1,632	9,388	11,113
Cost				
Additions	-	255	1,784	2,039
Disposal	-	-	(616)	(616)
Accumulated Depreciation				
Depreciation expense for the year	(2)	(107)	(2,416)	(2,525)
Disposal	-	-	566	566
Closing net book value	91	1,780	8,706	10,577
At December 31, 2008				
Cost	123	2,401	36,027	38,551
Accumulated depreciation	(32)	(621)	(27,321)	(27,974)
Net book value	91	1,780	8,706	10,577

The details of property and equipment at December 31, 2007 and their movements during the year consist of:

	Physical facilities	Infrastructure and leasehold	Furnishing and equipment	Total
At January 1, 2007				
Cost	123	1,044	33,424	34,591
Accumulated depreciation	(28)	(251)	(24,429)	(24,708)
Net book value	95	793	8,995	9,883
Year ended December 31, 2007				
Opening net book value	95	793	8,995	9,883
Cost				
Additions	-	1,102	2,520	3,622
Disposal	-	-	(1,085)	(1,085)
Accumulated Depreciation				
Depreciation expense for the year	(2)	(263)	(2,026)	(2,291)
Disposal	-	-	984	984
Closing net book value	93	1,632	9,388	11,113
At December 31, 2007				
Cost	123	2,146	34,859	37,128
Accumulated depreciation	(30)	(514)	(25,471)	(26,015)
Net book value	93	1,632	9,388	11,113

Total assets from restricted grants amounted to US$2,657 thousand and US$2,193 thousand as of December 31, 2008 and 2007, respectively.

Depreciation expense amounted to US$2,525 thousand and US$2,291 thousand in 2008 and 2007, respectively.

Note 9 - Long term investments

This account consists of investments with:

	2008	2007
Generali Worldwide Ins. Co. - USD	11,333	8,828
ING Investment Management - USD	750	1,125
ING Investment Management - EURO	2,790	2,925
Citibank New York Long-term Investment Umbrella Portfolio - USD	4,873	5,809
UBS Bank Medium Term Investment - EURO	-	2,925
UBS Bank Medium Term Investment - USD	2,500	-
	22,246	21,612

The average annual interest rate on the above investments is 2% in 2008 (2007 - 4%).

Note 10 - Accounts payable - donors

This account consists of grants received in advance applicable to succeeding years.

	2008	2007
Unrestricted	736	948
Restricted		
Temporary	21,735	14,490
Challenge programs	1,131	1,294
	23,602	16,732

Note 11 - Accounts payable - others

This account consists of:

	2008	2007
Accounts payable - Other CGIAR Centers	97	322
Deferred training charges of scholars and trainees	185	236
Deferred salaries and benefits of post doctoral fellows	172	390
Funds in trust	1,092	19
	1,546	967

Note 12 - Accruals and provisions

This account consists of:

	2008	2007
Accruals		
Trade	2,850	1,769
Others	2,858	2,429
	5,708	4,198
Provisions	3,231	3,306
	8,939	7,504

Provisions consist of accumulated leave credits due to staff as of December 31, 2008 and 2007 based on current personnel policy manual, in addition to repatriation costs of internationally recruited staff.

Note 13 - Nationally Recruited Staff (NRS) Provident Fund

The Institute maintains a non-contributory provident fund for the benefit of its nationally recruited staff. The monthly contribution to the fund is computed at 10.5% of an employee's monthly basic salary which is remitted to the trustee-administered funds. The fund provides for lump sum payment to qualified employees/members upon their separation from the Institute, under certain conditions.

The administration of fund by a Retirement Committee is based on approved investment guidelines as contained in the Trust Agreement.

Based on the latest actuarial report dated February 18, 2008, the fund is considered adequate to cover for the minimum benefits as required by Philippine Laws. The Institute is responsible for any shortfall in the fund to comply with the minimum legal requirements.

Contributions to the fund amounted to about US$425 thousand and US386 thousand in 2008 and 2007, respectively.

Note 14 - Net assets

The movements in Research Initiative Fund are shown below:

	Frontier Projects	Strategic Research Initiative	Africa and Needy Countries	Development Office	Knowledge Pathways Initiative	Total
Balances, December 31, 2007	9,690	413	153	-	701	10,957
Board of Trustees re-designation	-	-	847	1,395	-	2,242
Net deficit for the year	(978)	(192)	(489)	(40)	(212)	(1,911)
Balances, December 31, 2008	8,712	221	511	1,355	489	11,288
Expenses for the year	(725)	(79)	-	(301)	(166)	(1,271)
Balances, December 31, 2008	7,987	142	511	1,054	323	10,017

(15)

Designated

On September 16, 2008, the Board of Trustees approved the re-designation of US$1,706 thousand from Reserve for Unrealized Foreign Exchange to Reserve for Risk Management.

On April 18, 2007, the Board of Trustees approved the re-designation of US$2,242 thousand from the Unrealized Foreign Exchange Translation to Research Initiative Fund and on September 20, 2007, the Board of Trustees also approved the re-designation of US$1,122 thousand from the Reserve for Unrealized Foreign Exchange Translation to Reserve for Risk Management.

Undesignated

The Institute does not have undesignated net assets as of December 31, 2008 and 2007.

Note 15 - Leases

a. On September 7, 2001, the Institute renewed its lease agreement for research facilities with the University of the Philippines System (the University). The new lease agreement, which took effect on July 1, 2000, is for a period of 25 years up to June 30, 2025, and is renewable upon mutual agreement of the parties. Under the terms of the agreement, the following provisions apply:

   i. The Institute will pay a rental of one peso every year for the parcels of land used as sites for its laboratories, office and service buildings and housing. In addition and continuing the past practice of providing the equivalent in cash of the approximate value of agricultural products that otherwise could be grown on this land, the Institute provided a lump sum, and non reimbursable financial assistance to the University in the amount of US$375,000.

   ii. For the duration of the lease, the Institute will also contribute to the cost of development and maintenance of the University road network, utilities, other infrastructure, health services, sanitary landfill management, security, etc. outside the leased land, in the amount of US$12,500 per year. Upon signing of the agreement, the first 10-year payment (US$125,000) was paid as a lump-sum, and the remainder will be paid in annual installments starting from the 11th year of the lease.

   iii. Pursuant to the Second Consolidated Renewal of Lease Contract between the University and the Institute, the latter shall execute documents necessary to facilitate the transfer of ownership of the buildings and permanent improvements to the former upon termination of the lease. Further, in Section 2 of Article XV of the Institute's Charter, all the physical plant, equipment and other assets shall become the property of the University in case the Institute is terminated for any reason. As stated in both documents, the transfer of ownership shall not cover other assets such as the Institute's Gene Bank and Genetic Resources, which have been assigned in trust to the Institute. Other assets donated to the Institute shall be subjected to other conditions in respect of their disposition upon dissolution of the Institute.

   iv. In support of any expansion of the agricultural research program of the Institute and the University, the Philippine Government authorized the University to acquire, by negotiated sale or by expropriation, private agricultural property under PD No. 457.

b. The Institute signed a lease contract with Hewlett Packard (HP) for a seat management agreement involving the lease of computers and other bundled services. The lease covers 4 phases, each phase effective for 3 years. The first phase started in October 2004, the last phase will end in October 2009. The minimum lease payment under this contract is US$25,618 per month.

c. The Institute also leases land and other properties from third parties for project experimental sites with periods ranging from one to five years.

The leases mentioned above are accounted for as operating lease.

Note 16 - Other revenues, net

This account consists of:

	2008	2007
Investment gain (loss)	(183)	1,257
Self-sustaining activities	(91)	39
Miscellaneous, including realized gain (loss) on foreign exchange	531	2
	257	1,298

Note 17 - Indirect cost recovery rate

The indirect cost recovery rate computed as per the CGIAR Financial Guideline No. 5 is 16.63% and 20.38% in 2008 and 2007, respectively. The computation of indirect cost recovery rate is shown on Exhibit 4.

Exhibit 1
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INTERNATIONAL RICE RESEARCH INSTITUTE
SCHEDULE OF GRANTS REVENUES & ACCOUNTS RECEIVABLE/(PAYABLE) - DONOR
FOR THE YEAR ENDED DECEMBER 31, 2008
With comparative figures for the year ended December 31, 2007
(In thousands of US$)

	2008				
Donors	**Total Funds Available**	**Accounts Receivable**	**Advance Payment**	**Grant**	**2007 Grant**
Unrestricted					
Australia	1,387		(726)	661	566
Bangladesh		100		100	100
Canada	313	1,019		1,332	1,026
China		140		140	140
France	102			102	161
Germany	537			537	388
India	150			150	150
Japan		1,152		1,152	844
Korea	150			150	150
Norway	382			382	334
Philippines	101			101	100
Portugal				0	200
Sweden	516			516	555
Switzerland	583			583	531
Thailand	40			40	40
Turkey	10		(10)	0	
United Kingdom	2,070			2,070	2,431
United States of America	2,250	750		3,000	2,700
Vietnam	(15)	30		15	15
Worldbank	1,640			1,640	1,800
Total	**10,216**	**3,191**	**(736)**	**12,671**	**12,231**
Restricted					
5 Prime	484			484	
Aquifer Limited	30			30	166
Asian Development Bank (ADB)	438	556		994	1,081
Australia	1,006		(316)	690	547
Bangladesh	32	3		35	
Belgium				0	
Bill & Melinda Gates Foundation	19,154		(13,449)	5,705	189
Brazil	20		(20)	0	
Canada	97		(32)	65	174
China	92		(62)	30	14
Consultative Group on International Agricultural Research (CGIAR) Centers and Secretariat				0	
Bioversity	80		(44)	36	
CGIAR/System-wide Genetic Resources Programme (SGRP)/Special Program on Impact-Assesstment (SPIA)	248		(93)	155	15
International Center Agricultural Research in the Dry Areas (ICARDA)	81	2		83	
Centro Internacional de Agricultura Tropical (International Center for Tropical Agriculture)/Information and Communication Technology Knowledge Management Initiative (ICT-KM)	33		(4)	29	4
International Fund for Agricultural Research (IFAR)	18		(7)	11	3
International Food Policy Research				0	
Institute (IFPRI)	28		(17)	11	

Exhibit 1
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INTERNATIONAL RICE RESEARCH INSTITUTE
SCHEDULE OF GRANTS REVENUES & ACCOUNTS RECEIVABLE/(PAYABLE) - DONOR
FOR THE YEAR ENDED DECEMBER 31, 2008
With comparative figures for the year ended December 31, 2007
(In thousands of US$)

	2008				
Donors	**Total Funds Available**	**Accounts Receivable**	**Advance Payment**	**Grant**	**2007 Grant**
European Commission	494	1,258		1,752	3,564
Food and Agricultural Organization of				0	
the United Nations (FAO)	38	13		51	20
France	266		(15)	251	240
Foundation for Advanced Studies on				0	
Agricultural Development (FASID)	20	2		22	48
Gatsby Foundation	160		(160)	0	
Germany	865		(316)	549	469
Global Crop Diversity Trust (GCDT)	51	277		328	234
Grand Challenges in Global Health through Albert - Ludwigs University of Freiburg	373	110		483	139
Hybrid Rice Research & Development Consortium (HRDC)	407		(89)	318	
International Atomic Energy Association (IAEA)	34		(17)	17	17
India	500		(56)	444	500
International Fund for Agricultural Development (IFAD)	1,613		(245)	1,368	596
International Fertilizer Association (IFA)/ International Plant Nutrition Institute (IPNI)/International Potash Institute (IPI)	134		(13)	121	61
Iran	246		(81)	165	92
Japan	4,167		(607)	3,560	2,660
Korea	1,202		(527)	675	741
Malaysia	54		(36)	18	44
Mexico	(10)	10			10
Monsanto Fund					47
Nunhems BV	23	6		29	26
Plan International Cambodia	10		(3)	7	42
Philippines		77		77	33
Portugal	150		(92)	58	
Rockefeller Foundation (RF)	4,167		(4,051)	116	616
Switzerland	812		(60)	752	1,214
United Kingdom	55	3		58	-
United States of America (USA)	2,871		(903)	1,968	741
Worldbank	270		(74)	196	321
Others	406		(346)	60	95
Subtotal	**41,219**	**2,317**	**(21,735)**	**21,801**	**14,763**
Challenge Programs					
Water and Food	815	105		920	3,099
Generation	2,618		(1,124)	1,494	1,456
Harvest Plus	389		(7)	382	839
Subtotal	**3,822**	**105**	**(1,131)**	**2,796**	**5,394**
Total Restricted Grants	**45,041**	**2,422**	**(22,866)**	**24,597**	**20,157**
Total Grants	**55,257**	**5,613**	**(23,602)**	**37,268**	**32,388**

EXHIBIT 2
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INTERNATIONAL RICE RESEARCH INSTITUTE
SCHEDULE OF RESTRICTED AGENDA FUNDING
FOR THE YEAR ENDED 31 DECEMBER 2008
(In US$ thousands)

Donor & Program/Project	Grant Period (DD/MM/YY)	Grant Pledged	EXPENDITURES Prior Years	2008	Total
A. Temporary					
5 Prime					
Donation of Molecular Biology Products	01/01/08 - 31/12/08	**484**	**-**	**484**	**484**
Aquifer Limited					
Re-invigorating the Mozambique Rice Industry through a Novel Public-Private Sector Partnership	27/04/07 - 26/04/09	**395**	**166**	**30**	**196**
Asian Development Bank (ADB)					
Development and Dissemination of Water-Saving Rice Technologies in South Asia	01/01/06 - 30/12/09	1,000	390	259	649
Bringing about Sustainable Rice Production in Asia by Reducing Preventable Pre- and Post-harvest Losses	01/10/08 - 30/09/10	2,000	-	58	58
Improving Poor Farmers' Livelihood Through Post-Harvest Technology	11/07/05 - 31/12/08	750	496	234	730
Improving Poor Farmers' Livelihood Through Rice Information Technology	19/11/04 - 19/11/08	1,000	571	249	820
Enhancing Farmers' Income and Livelihoods Through Integrated Crop and Resource Management in the Rice-Wheat System in South Asia	01/01/05 - 31/12/08	849	655	194	849
Total		**5,599**	**2,112**	**994**	**3,106**
Australia					
Finetuning the Happy Seeder Technology for the Adoption in Northwest India	01/10/07 - 30/09/10	149	18	46	64
Impact of Migration and/or Off-farm Employment on Roles of Women and Appropriate Technologies in Asian and Australian Mixed Farming Systems	01/07/04 - 31/03/08	383	353	30	383
Improving Rice Productivity in South and Southeast Sulawesi	01/03/08 - 28/02/11	448	-	133	133
Implementation of Rodent Management in Intensive Irrigated Rice Production Systems in Indonesia and Vietnam	01/04/06 - 30/09/09	90	36	40	76
Further Development of ICIS	01/07/06 - 30/06/08	31	15	16	31
Fertilization-Independent Formation of Embryo, Endosperm and Pericarp for Apomictic Hybrid Rice	01/07/03 - 30/06/08	1,182	1,032	150	1,182
Scoping Study to Identify Research and Implementation Issues Related to Management of the Brown Planthopper/Virus Problem in Rice in Vietnam	01/05/07 - 31/01/08	94	69	25	94
Sustainable Instensification of Rice-Maize Production Systems in Bangladesh	01/07/08 - 30/06/13	1,220	-	71	71
Molecular Marker Technologies for Faster Wheat Breeding in India	26/06/08 - 30/11/09	24	-	14	14
Developing Molecular Markers to Enable Selection Against Chalk in Rice	01/05/07 - 30/04/12	750	35	165	200
Total		**4,371**	**1,558**	**690**	**2,248**
Bangladesh					
Enhancing MAS Capacity for Salt-Stress Rice Breeding in Bangladesh	31/03/08-30/04/09	**40**	**-**	**35**	**35**
Bill & Melinda Gates Foundation					
Stress-tolerant Rice for Poor Farmers in Africa and South Asia	01/11/07 - 31/10/10	19,897	189	5,097	5,286
Cereal System Initiative for South Asia (CSISA)	01/12/08 - 31/11/11	19,954	-	161	161
Creating the Second Green Revolution by Supercharging Photosynthesis: C4-rice	15/10/08 - 31/10/11	11,017	-	447	447
Total		**50,868**	**189**	**5,705**	**5,894**
Canada					
Programmatic Alignment Among IRRI, The Africa Rice Center and CIAT with Focus on Centers' Activities in Africa	21/03/07 - 31/12/08	**253**	**156**	**65**	**221**
China					
Development of Disease-resistant, Cold-tolerant Rice Variety in South China Throughout Genomic Tools	05/02/07 - 04/02/09	26	14	10	24
China IRRI Collaboration	01/01/08 - 31/12/09	80	-	20	20
“Green Super Rice” for the Resource-Poor of Africa and Asia	11/01/08 - 31/10/11	4,633	-	0	0
Total		**4,739**	**14**	**30**	**44**
Consultative Group on International Agricultural Research (CGIAR Centers & Secretariat)					
Bioversity					
System-wide Improvement of Location Data Quality	01/01/07 - 31/12/09	103	13	36	49
System-wide Improvement of Location Data Quality Phase 2	01/10/08 - 31/12/09	34			
Total		**137**	**13**	**36**	**49**
CGIAR/SGRP/SPIA					
Collective Action for the Rehabilitation of Global Public Goods in the CGIAR Genetic System: Phase 2	01/01/07 - 31/12/09	337	252	64	316
GPG2 Compile, Review and Update Standard Operating Procedures	01/03/08-30/11/08	4		4	4
Development and Implementation of Risk Management Procedures for Individual Genebanks and for Collections in Common	31/10/07-31/05/09	84		62	62
Reducing and Managing the Loss of Genetic Integrity of Conserved Germplasm	01/01/07 - 31/12/09	457	20	25	45
Total		**882**	**272**	**155**	**427**

INTERNATIONAL RICE RESEARCH INSTITUTE
SCHEDULE OF RESTRICTED AGENDA FUNDING
FOR THE YEAR ENDED 31 DECEMBER 2008
(In US$ thousands)

Donor & Program/Project	Grant Period (DD/MM/YY)	Grant Pledged	EXPENDITURES Prior Years	2008	Total
ICARDA					
Establishment of the Global Crop Registers for Rice and Wheat	01/01/08-31/12/09	**90**		**83**	**83**
CIAT-ICT/KM					
Centro Internacional de Agricultura Tropical (CIAT) Information and Communications Technology-Knowledge Management Initiative (ICT KM) - Good Practices for Managing Research Data	01/10/07 - 31/12/08	20	1	19	20
ICT KM-Knowledge Management Harmonizing Research Output in the Northern Uplands of Lao PDR	01/08/07-31/01/09	20		10	10
Total		**40**	**1**	**29**	**30**
International Fund for Agricultural Research (IFAR)					
Transferring Sativa Knowledge to Glaberrima to Enable the Evaluation of Quality in Africa Rice	01/06/08-31/07/09	11	-	4	4
Pyramiding Genes for Resistance to Bacterial Blight and Blast in Bangladesh Rice Cultivars Using Marker Assisted Selection	21/05/07 - 20/05/10	11	4	7	11
Total		**22**	**4**	**11**	**15**
International Food Policy Research Institute (IFPRI)					
Scoping the Potential Future for Rice in Asia: Exploring Alternative Strategies and Policies	01/04/07 - 31/12/08	25	-	6	**6**
Supporting Strategic Investment Choices In Agricultural Technology Development	01/06/07 - 31/12/08	25	-	5	**5**
Total		**50**	**-**	**11**	**11**
European Commission					
Eagles Food Forum	01/07/07 - 30/11/08	56		56	56
Raising Productivity in Rainfed Environments	01/01/08 - 31/12/08	698		698	698
Sustaining Productivity in Intensive Rice-Based Systems	01/01/08 - 31/12/08	635		635	635
Coordinating NGO Interventions for Improving Small and Marginal Farmer's Households, Livelihood and Food Security in Bangladesh	01/07/04 - 31/08/09	1,800	902	290	1,192
Assessing Large-Scale Environment Risk with Tested Methods - Extension (ALARM TTC)	01/02/07 - 31/01/09	39	14	15	29
Metabolomic Technology Applications For Plants, Health And Outreach	01/10/06 - 30/09/08	199	36	58	94
Total		**3,427**	**952**	**1,752**	**2,704**
Food and Agriculture Organization of the United Nations (FAO)					
What has been the Role of Crop Management Technologies in Rapid Rice Yield Growth in the Philippines	16/11/07 - 01/12/08	**51**	**0**	**51**	**51**
France					
IRRI/France Collaborative Project	01/01/07 - 31/12/07	240		240	240
Increasing Water Saving in Irrigated Rice in Central Luzon	01/01/08 - 28/02/09	7		5	5
Diversity of Adaptative Traits to Water and Thermal Stress in Rice (Oryza sativa L.): High Throughput Phenotyping for Association Mapping	01/01/08 -31/12/10	59	-	6	6
Total		**306**	**-**	**251**	**251**
Foundation for Advanced Studies on Agricultural Development (FASID)					
IRRI Water Saving Technology Project (A Survey to be Done in China)	01/05/07 - 10/03/08	65	48	17	65
IRRI Loop Survey - Research on Agricultural Transformation in Central Luzon and Laguna	15/05/08 - 15/12/08	5	0	5	5
Total		**70**	**48**	**22**	**70**
Gatsby Foundation					
Collections of Landraces and Wild Species of Oryza in Kenya, Mozambique, Tanzania and Uganda (in collaboration with WARDA)	01/05/07 - 30/04/10	**160**	**-**	**-**	**-**
Germany					
Nutrient Management in Aerobic Rice Systems	01/07/05 - 30/09/08	207	138	40	178
Enhancing and Stabilizing the Productivity of Salt-Affected Areas by Incorporating Genes for Tolerance of Abiotic Stresses in Rice	01/01/08 - 31/12/10	1,184	-	206	206
From Genes to Farmers' Fields: Enhancing and Stabilizing Productivity of Rice in Submergence Prone Environments	01/01/04 - 31/12/08	1,297	999	298	1,297
Rice and Global Climate Change: Candidate Genes for Preventing Heat and Drought-Induced Yield Losses Due to Spikelet Sterility	01/11/08-31/10/10	77		2	2
Transcriptome Profiling of Hybrid Rice	01/12/07 - 30/11/09	87		3	3
Total		**2,852**	**1,137**	**549**	**1,686**
Global Crop Diversity Trust (GCDT)					
Development of a Global Strategy for the Ex Situ Conservation of Rice	01/04/06 - 28/02/08	60	52	8	60
Heat-Tolerant Rice to Combat Global Warming	01/01/08 - 31/12/09	30	-	20	20
Long-term Funding of the Ex Situ Collection of Rice Germplasm Held by IRRI	01/11/06 - 31/10/11	700	400	300	700
Total		**790**	**452**	**328**	**780**

EXHIBIT 2
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INTERNATIONAL RICE RESEARCH INSTITUTE
SCHEDULE OF RESTRICTED AGENDA FUNDING
FOR THE YEAR ENDED 31 DECEMBER 2008
(In US$ thousands)

Donor & Program/Project	Grant Period (DD/MM/YY)	Grant Pledged	EXPENDITURES Prior Years	2008	Total
Grand Challenges in Global Health through Albert - Ludwig's University of Freiburg					
Engineering Rice for High Beta-Carotene, Vitamin E and Enhanced Iron and Zinc Bioavailability	28/09/05 - 27/09/10	**1,213**	**306**	**483**	**789**
Hybrid Rice Research & Development Consortium (HRDC)					
Hybrid Rice Research & Development Consortium	01/02-08 - 31/12/09	**423**		**318**	**318**
International Atomic Energy Association (IAEA)					
Dissecting Drought Tolerance Mechanisms in Rice Through Gain of Function Deletion Mutants	15/06/06 - 14/06/07	21	8	13	21
Selection of Greater Agronomic Water-Use Efficiency in Wheat and Rice Using Carbon Isotope Discrimination	15/11/03 - 14/06/09	40	14	4	18
Total		**61**	**22**	**17**	**39**
India					
IRRI/India Collaborative Project	01/01/08 - 31/12/08	400	-	400	400
IRRI Rice Wheat Consortium	01/04/07 - 31/12/08	100	-	44	44
Total		**500**	**-**	**444**	**444**
International Fund for Agricultural Development (IFAD)					
Managing Rice Landscapes in the Marginal Uplands for Household Food Security and Environmental Sustainability	26/07/05 - 31/03/09	1,190	589	306	895
Accelerating Agricultural Technology Adoption to Enhance Rural Livelihoods in Disadvantaged Districts of India	16/05/07 - 30/06/10	1,000	74	363	437
Reducing Risks from Arsenic Contamination for Poor People	31/10/08 - 31/12/10	200		1	1
Alleviating Poverty Through Improving Rice Production in East and Southern Africa	20/09/07 - 30/09/10	1,500	50	698	748
Total		**3,890**	**713**	**1,368**	**2,081**
International Fertilizer Association (IFA)/International Plant Nutrition Institute (IPNI)/ International Potash Institute (IPI)					
The Irrigated Rice Research Consortium Phase III-Site Specific Nutrient Management	01/01/05 - 31/12/08	**432**	**297**	**121**	**418**
Iran					
IRRI-Iran Collaborative Project	01/01/99 - 31/12/09	**1,331**	**1,085**	**165**	**1,250**
Japan					
Development of Integrated Rice Cultivation System Under Water Saving Conditions	09/08/05 - 08/08/10	1,661	830	303	1,133
Raising Productivity in Rainfed Environments	01/01/08 - 31/12/08	410		410	410
Sustaining Productivity in Intensive Rice-Based Systems	01/01/08 - 31/12/08	270		270	270
East and Southern Africa: Rice for Rural Incomes	01/01/08 - 31/12/08	66		66	66
Rice and Human Health	01/01/08 - 31/12/08	25		25	25
Rice Genetic Diversity and Discovery	01/01/08 - 31/12/08	333		333	333
Information and Communication: Convening a Global Rice Research Community	01/01/08 - 31/12/08	38		38	38
Upland Rice Variety Selection Techniques	07/10/08 - 17/11/08	24	-	24	24
Collaborative Research on Socioeconomic Constraints to Adoption of Technology and Farmer's Response	01/04/05 - 31/03/10	81	61	16	77
Socioeconomic Survey in the Bohol Irrigation System, Philippines	03/11/08 - 30/03/09	14	-	2	2
Transformation of Lowland Rice and Evaluation of Transformed Rice for Environmental Stress Tolerance	21/05/07 - 29/02/08	302	138	164	302
Transformation of Lowland Rice and Evaluation of Transformed Rice for Environmental Stress Tolerance - Year 2	01/05/08 - 27/02/09	333		106	106
Development of Breeding Materials for Rice Blast Resistance-Phenotypic Evaluation and Marker Assisted Selection to Develop Near-Isogenic Lines for Blast Resistance	11/12/07 - 25/02/08	13	3	10	13
Implementation Plans to Disseminate Submergence Tolerant Varieties and Associated New Production Practices to Southeast Asia	19/03/07 - 31/03/09	4,236	1,238	1,793	3,031
Total		**7,806**	**2,270**	**3,560**	**5,830**
Korea					
Korea Support to IRRI's Program	01/01/08 - 31/12/08	50	-	50	50
Wide Hybridization and Gene Introgression for Rice Improvement/Broadening Gene Pool of Rice: Wild Species Introgression and Marker Assisted Selection	01/07/03 - 31/08/09	240	191	25	216
Functional Genomics Approach to Identification of Broad-Spectrum Resistance Genes Against Rice Blast Disease in Korean Germplasm	01/07/03 - 31/08/09	240	177	12	189
Cooperative Funding for Korea-IRRI Collaborative Projects	01/01/99 - 31/12/08	525	342	28	370
Germplasm Utilization and Value-Added Project	01/01/01 - 31/12/08	310	198	27	225
IRRI Korea Office	17/11/01 - 31/12/08	1,786	1,492	273	1,765
Major Characteristics Evaluation of Early Maturing Japonica Rice (MEJR)	01/12/06 - 30/11/08	41	33	8	41

EXHIBIT 2
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INTERNATIONAL RICE RESEARCH INSTITUTE
SCHEDULE OF RESTRICTED AGENDA FUNDING
FOR THE YEAR ENDED 31 DECEMBER 2008
(In US$ thousands)

Donor & Program/Project	Grant Period (DD/MM/YY)	Grant Pledged	EXPENDITURES Prior Years	2008	Total
Development of Submergence Tolerant Japonica Rice Variety	01/04/08-31/03/11	30	-	4	4
Breeding for Micronutrient-Enriched Japonica Rice for Improving Human Health	01/04/05 - 31/03/08	140	124	16	140
Identification of Resistance Genes for Biotic Stresses in Rice Through the Location/Expression Candidate Association Approach	01/01/06 - 31/12/08	90	61	29	90
Korean Seed Multiplication Project	01/07/91 - 31/12/08	404	337	53	390
Temperate Rice Research Consortium	08/02/07 - 31/12/08	402	88	150	238
Total		**4,258**	**3,043**	**675**	**3,718**
Malaysia					
The Impact of Rice Production on Environmental Sustainability	01/09/05 - 30/09/08	90	36	14	50
Genetic Enhancement for High Quality Rice	01/01/06 - 31/12/08	110	40	4	44
Total		**200**	**76**	**18**	**94**
Nunhems BV					
Further Development of International Crop Information Systems (ICIS) in Collaboration with Nunhems - Phase II	01/04/06 - 31/03/10	**80**	**38**	**29**	**67**
Plan International Cambodia					
Poverty Reduction Options Validated in Drought Environments Phase II	01/05/07 - 29/02/08	27	11	0	11
Poverty Reduction Options Validated in Drought Environments Phase III	02/05/08-28/02/09	20	-	7	7
Total		**47**	**11**	**7**	**18**
Philippines					
Implementation of the 2009-2010 Rice Self-Sufficiency Plan (RSSP) of the GMA Rice Program	09/07/08 - 31/12/08	46	0	46	46
Hybrid Nucleus and Breeder Seed Production	16/01/04 - 15/01/08	25	21	4	25
Improving Knowledge Exchange and Decision Making Among Rice Stakeholders Through ICT-based Technology Promotion and Delivery Systems	01/01/06 - 30/06/09	73	27	27	54
Total		**144**	**48**	**77**	**125**
Portugal					
Village-Level Market-Driven Rice Intensification	01/01/08-31/12/08	**150**	**-**	**58**	**58**
Total					
Rockefeller Foundation (RF)					
Developing and Disseminating Resilient and Productive Rice Varieties for Drought-Prone Environments in India	01/03/05 - 28/02/09	610	476	92	568
Introgression of Genes for Drought Tolerance from Oryza Glaberrima into Indica Rice	01/04/05 - 31/03/08	76	67	9	76
Pathway Dissection and Candidate Gene Identification for Drought Tolerance in Rice by a Forward Genetics Approach	01/03/05 - 28/02/08	582	567	15	582
Total		**1,268**	**1,110**	**116**	**1,226**
Switzerland					
The Irrigated Rice Research Consortium - Phase III					
Management Team	01/01/05 - 28/02/09	1,470	1,019	372	1,391
Productivity Workgroup	01/01/05 - 28/02/09	402	296	102	398
Water Saving Workgroup	01/01/05 - 28/02/09	356	226	118	344
Labor Productivity Workgroup	01/01/05 - 28/02/09	356	273	75	348
Post Production Workgroup	01/01/05 - 28/02/09	353	257	85	342
Total		**2,937**	**2,071**	**752**	**2,823**
United Kingdom					
Poverty Alleviation Through Rice Innovation Systems	01/03/08-01/02/11	586	-	57	57
Characterizing Genetic and Soil Induced Variation inArsenic Uptake, Translocation and Metabolism in Rice to Mitigate Arsenic Contamination in Asia	01/01/08-31/12/10	23	-	0	0
Philippine Rice Security Under Climate Change: Building an Evidence Base to Inform Govenmental Policy Options	01/05/08-31/03/09	9	-	1	1
Total		**618**	**0**	**58**	**58**
United States of America					
Development of Rice Biotechnology Products for Asia: Technical and Pre-regulatory Components	01/01/05 - 30/09/09	2,580	982	748	1,730
East and Southern Africa: Rice for Rural Incomes	01/01/08 - 31/12/08	250		250	250
The Development of Adapted Germplasm for India with High Levels of Pro Vitamins Carotenoids	01/01/05 - 31/12/09	385	59	214	273
Modeling the Impacts of BT Transgene Flow on Lepidopteran Food Web Structure and Stability on Wild Rice in Vietnam (Led by CLRRI - Under Program for Biosafety System BBI)	01/01/07 - 30/09/09	128	26	64	90
Ecological Based Participatory IPM for Southeast Asia (Led by Clemson University - IPM-CRSP)	01/10/05 - 30/09/09	49	34	12	46
Advanced Breeding and Deployment of Abiotic Stress Tolerant Rice & Wheat and Expansion of Hybrid Rice	01/10/07 - 30/04/09	150	3	107	110
Famine Fund-Accelerating Adoption of Resource Conserving Technologies in South Asia Under the Umbrella of Cereal System Initiative for South Asia	01/08/08-30/09/11	2,131		133	133
Revitalizing The Rice-Wheat Cropping Systems Of The Indo-Gangetic Plains: Adaptation And Adoption Of Resource-Conserving Technologies In India, Bangladesh And Nepal (Component 1 Of The Global Development Alliance)	01/10/07 - 30/04/09	475	75	364	439
Enabling Open Access to IRRI-Assisted Theses and Dissertations Funding Proposal	30/09/06 - 30/06/08	8	8	0	8
Tilling and Ecotilling Resources of Japonica and Indica Rice	01/04/04 - 30/04/08	90	59	31	90
Georeferencing of Germplasm Resources Information Network - Georeference Project	01/08/07 - 31/12/08	45		45	45
Total		**6,291**	**1,246**	**1,968**	**3,214**

EXHIBIT 2
Page 5 of 6

INTERNATIONAL RICE RESEARCH INSTITUTE
SCHEDULE OF RESTRICTED AGENDA FUNDING
FOR THE YEAR ENDED 31 DECEMBER 2008
(In US$ thousands)

Donor & Program/Project	Grant Period (DD/MM/YY)	Grant Pledged	EXPENDITURES Prior Years	2008	Total
World Bank					
Rice Wheat Consortium - SWEPS		**270**	**-**	**196**	**196**
Others		**1,769**	**81**	**60**	**141**
Bayer - Development of ICIS	01/01/07 - 31/12/09	53	18	21	39
Cornell University -Durable Resistance in Wheat	01/02/08 - 31/01/11	623		27	27
Scientifiic Know-how and Exchange Program between IRRI & Pioneer Hi-Bred International, Inc. (DuPont)	16/07/08 - 15/07/11	744	-	0	0
Rice Wheat Consontium - Reserve Funds	01/01/08 - 31/12/08	266			
JBIC - Mozambique Survey	07/09/07 - 15/04/08	19	19	0	19
GRIPS - Mozambique Survey	01/08/07 - 15/02/08	22	22	0	22
National Graduate Institute for Policy Studies (GRIPS) - Mozambique Survey	01/08/07 - 15/02/08	22	22	0	22
FOSS - Improving the Capacity of Indica Rice-Breeding Programs to Measure the Traits of Physical Quality of Grain	01/01/08 - 31/12/10	20	0	12	12
Subtotal		109,154	19,491	21,801	41,292

Donor & Program/Project	Grant Period (DD/MM/YY)	Grant Pledged	Prior Years	2008	Total
B. Challenge Program					
Water and Food					
Theme I Leadership	01/11/02 - 31/12/08	299	-	243	243
Managing Water and Land Resources for Sustainable Livelihoods at the Interface Between Fresh and Saline Water Environments in Vietnam and Bangladesh	01/06/04 - 30/06/08	803	721	82	803
Development of Technologies to Harness the Productivity of Salt-Affected Areas of the Indo-Gangetic & Nile River Basins (PN#7)	15/06/04 - 31/12/08	1,353	1,051	302	1,353
Exploring the Relevance and Feasibility Approaches for Producing Environmental Services through Changes in Agricultural Practices	01/04/07 - 31/12/08	24	1	16	17
Developing a System of Temperate and Tropical Aerobic Rice (STAR) in Asia	01/10/04 - 31/03/08	848	755	91	846
Rice Landscape Management for Raising Water Productivity, Conserving Resources, and Improving Livelihoods in Upper Catchments of the Mekong and Red River Basins (PN#11)	01/11/05 - 31/10/09	910	343	186	529
Total		**4,237**	**2,871**	**920**	**3,791**
Generation					
GCP Support to SP Leader 2	01/01/07 - 31/12/08	94	71	23	94
Drought Tolerant Rice Cultivars for North China and South/Southeast Asia by Highly Efficient Pyramiding of QTLs from Diverse Origins	01/01/05 - 31/12/08	317	187	130	317
Implementation of Web Services Technology in the Generation Challenge Programme Consortium	01/01/08 - 31/12/08	5		5	5
Genotyping Services Asante Ghana	07/03/08 - 06/03/09	12		3	3
Development of CP Domain Models and Ontology	01/01/08- 31/12/08	28		28	28
Provision of Genotyping Support Services	07/03/08 - 06/03/09	12		9	9
Determination of a Common Genetic Basis for Tissue Growth Rate Under Water-Limited Conditions Across Plant Organs and Genomes	01/01/05 - 15/10/08	182	116	66	182
Validation of Drought-Response/Resistance Pathway Genes by Phenotypic Analysis of Mutants - Year 1	01/08/08 - 31/07/09	65	46	19	65
Validation of Drought-Response/Resistance Pathway Genes by Phenotypic Analysis of Mutants - Year 2	01/08/07 - 31/07/08	66		58	58
Speeding the Development of Salt Tolerant Rice Varieties Through Marker Assisted Selection and Their Dissemination in Salt Affected Areas of Bangladesh	01/01/08- 31/12/08	129		129	129
Connecting Performance Under Drought With Genotypes Through Phenotype Associations	01/01/08- 31/12/08	114		101	101
Transcriptome Analysis of Near-Isogenic Rice Lines to Identify Expression Signatures and Gene Combinations Conferring Stress Tolerance	01/01/08- 31/12/08	73		73	73
Population Development to Underpin Gene Discovery and Allele Validation in Rice: The Multiparent Advanced Generation Inter-Crosses (MAGIC)	01/01/08- 31/12/08	56		56	56
Application and Validation of the Major QTL Phosphate Uptake 1 (Pup1)	01/01/08 - 31/12/08	81		52	52
Targeted Discovery of Superior Disease QTL Alleles in the Maize and Rice Genomes	01/01/05 - 31/12/08	145	114	16	130
Quality Management and Data Quality Improvement	01/01/08 - 30/06/09	46		27	27
Development of Tools and Technology to Increase the Functionality of the GCP Information Platform	01/01/08 - 31/12/08	81		81	81
Revitalizing Marginal Lands: Discovery Of Genes For Tolerance Of Saline And Phosphorus-Deficient Soils To Enhance And Sustain Productivity	01/01/05 - 30/06/08	900	790	110	900
Identifying Genes Responsible for Failure of Grain Formation in Rice and Wheat Under Drought	01/01/05 - 30/06/09	900	735	79	814
Large Scale Phylogenomic Analyses to Gene Function Prediction for GCP Crops	01/01/08 - 31/12/08	97	0	78	78
High Performance Computing Facilities for the GCP Platform	01/01/08 - 31/12/08	5	0	5	5
Drought from Different Perspective: Improved Tolerance through Phosphorous Acquisition	01/11/08 - 31/10/11	900	0	13	13
Detecting and Fine-Mapping QTLs with Major Effects on Rice Yield under Drought Stress for Deployment via Marker Aided Breeding	01/08/07-31/07/09	599	43	173	216
Developing and Disseminating Resilient and Productive Rice Varieties for Drought-Prone Environments in India	01/03/05 - 28/02/09	120	84	14	98
Pathway Dissection and Candidate Gene Identification for Drought Tolerance in Rice by a Forward Genetics Approach	01/03/05 - 28/02/08	120	101	19	120
Targeting Drought-Avoidance Root Traits to Enhance Rice Productivity Under Water-Limited Environments	01/11/08 - 31/10/11	900	0	2	2

INTERNATIONAL RICE RESEARCH INSTITUTE
SCHEDULE OF RESTRICTED AGENDA FUNDING
FOR THE YEAR ENDED 31 DECEMBER 2008
(In US$ thousands)

Donor & Program/Project	Grant Period (DD/MM/YY)	Grant Pledged	EXPENDITURES Prior Years	2008	Total
Data Analysis Support for Existing Projects in SP2 with Emphasis on Integrating Results from Microarray and Mapping Experiments	01/01/07 - 31/12/08	20	18	2	20
Data Analysis Support for Existing Projects in SP2 with Emphasis on Integrating Results from Microarray and Mapping Experiments	01/01/08 - 31/12/08	48		48	48
High Performance Computing Facilities for the GenerationCP	01/01/07 - 31/10/08	15	9	6	15
Creation and Maintenance of Templates for GenerationCP Data Storage in Repositories	01/01/07 - 31/10/08	29	18	11	29
Application and Development of Web Services Technology	01/01/07 - 31/10/08	8	6	2	8
Application and Development of Web Services Technology	01/01/07 - 31/12/08	49	44	5	49
Development of an Integrated GCP Platform	01/01/08 - 31/12/08	51		51	51
Total		**6,509**	**2,382**	**1,494**	**3,876**
Harvest Plus					
Biofortified Crops for Improved Human Nutrition	01/01/03-31/12/08	2,203	1,664	296	1,960
Assessing the Potential of Bio-fortification to Address Micronutrient Malnutrition in Rice-Based Cropping Systems of South & Southeast Asia	26/04/04-31/12/08	280	232	48	280
Developing Biofortified Iron-Dense for India	01/07/05-31/12/08	96	58	38	96
Total		**2,579**	**1,954**	**382**	**2,336**
Subtotal		**13,325**	**7,207**	**2,796**	**10,003**
Grand Total		**122,479**	**26,698**	**24,597**	**51,295**

EXHIBIT 3

INTERNATIONAL RICE RESEARCH INSTITUTE
DETAILS OF OPERATING EXPENSES
FOR THE YEARS ENDED DECEMBER 31, 2008 AND 2007
(In thousands of US$)

	Program Related				Management and General				
	Research Programs	Research Support	Operations	Sub-total	Management	General Administration	Sub-total	Total	2007
Unrestricted									
Personnel costs	4,313	706	1,968	6,987	2,367		2,367	9,354	8,649
Supplies & services	1,888	374	46	2,308	1,142	2,385	3,527	5,835	7,271
Collaborator/Partners	14			14				14	269
Operational travel	358	78	84	520	333	168	501	1,021	1,066
Depreciation	921	237	492	1,650	85	416	501	2,151	1,838
Total operating expenses	7,494	1,395	2,590	11,479	3,927	2,969	6,896	18,375	19,093
Recovery of indirect cost						(2,782)	(2,782)	(2,782)	(1,667)
Subtotal	7,494	1,395	2,590	11,479	3,927	187	4,114	15,593	17,426
Restricted									
Temporary									
Personnel costs	7,245	90		7,335	15		15	7,350	6,092
Supplies & services	7,527	107	81	7,715	17	266	283	7,998	5,100
Collaborator/Partners	4,035			4,035				4,035	1,771
Operational travel	1,963	36	47	2,046	23		23	2,069	1,392
Depreciation	349			349				349	410
Subtotal	21,119	233	128	21,480	55	266	321	21,801	14,765
Challenge Programs									
Personnel costs	755			755			-	755	758
Supplies & services	1,023			1,023			-	1,023	1,303
Collaborator/Partners	640			640			-	640	2,823
Operational travel	353			353			-	353	466
Depreciation	25			25			-	25	43
Subtotal	2,796			2,796	-	-	-	2,796	5,393
Total Restricted	23,915	233	128	24,276	55	266	321	24,597	20,158
Grand total	**31,409**	**1,628**	**2,718**	**35,755**	**3,982**	**453**	**4,435**	**40,190**	**37,584**
Personnel costs	12,313	796	1,968	15,077	2,382	0	2,382	17,459	15,499
Supplies & services	10,438	481	127	11,046	1,159	2,651	3,810	14,856	13,674
Collaborator/Partners	4,689	0	0	4,689	0	0	0	4,689	4,863
Operational travel	2,674	114	131	2,919	356	168	524	3,443	2,924
Depreciation	1,295	237	492	2,024	85	416	501	2,525	2,291
Sub-total	31,409	1,628	2,718	35,755	3,982	3,235	7,217	42,972	39,251
Recovery of indirect cost						(2,782)	(2,782)	(2,782)	(1,667)
Grand total	**31,409**	**1,628**	**2,718**	**35,755**	**3,982**	**453**	**4,435**	**40,190**	**37,584**

Exhibit 4

INTERNATIONAL RICE RESEARCH INSTITUTE
INDIRECT COST CALCULATION
FOR THE YEARS ENDED DECEMBER 31

	2008	2007
Direct Operating Expenses		
Research	32,340	27,708
Research support	3,168	3,721
Operations	1,733	1,460
Subtotal	37,241	32,889
Less: Overhead recovery	2,782	1,667
Total	**34,459**	**31,222**
Indirect Operating Expenses		
Management	3,218	3,263
Common sustenance services	2,513	3,099
Total	**5,731**	**6,362**
Total Operating Expenses	**40,190**	**37,584**
Cost Ratios		
Direct/Total	85.74%	83.07%
Indirect/Total	14.26%	16.93%
Indirect/Direct	16.63%	20.38%

Exhibit 5

INTERNATIONAL RICE RESEARCH INSTITUTE
EUROPEAN COMMUNITY FUNDING
STATEMENT OF EXPENDITURES
FOR THE YEAR ENDED 31 DECEMBER 2008
(In thousands)

Programme	Grant period	Grant pledged		Expenditures (2008)		Budget balance	
		In EUR	In USD	In EUR	In USD	In EUR	In USD
Raising Productivity in Rainfed Environments	01/01/08 - 31/12/08	501	698	501	698	-	-
Sustaining Productivity in Intensive Rice-Based Systems	01/01/08 - 31/12/08	455	635	455	635	-	-
Total		**956**	**1,333**	**956**	**1,333**	**-**	**-**

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SCIENCE COUNCIL

CGIAR

Report of the Seventh External Program and Management Review (EPMR) of the International Rice Research Institute (IRRI)

FEBRUARY 2009

THIS DOCUMENT CONTAINS:

- IRRI Letter and Response to the Seventh EPMR
- Transmittal letter and Report of the Panel on the Seventh IRRI EPMR
- Science Council commentary on the Seventh IRRI EPMR

IRRI
INTERNATIONAL RICE RESEARCH INSTITUTE

IRRI 1960-2010

12 March 2009

Dr. Rudy Rabbinge
Chair
Science Council

Dr. Ren Wang
Director
CGIAR

Dear Drs. Rabbinge and Ren Wang:

On receipt of the Report of the 7th External Program and Management Review (EPMR7) of IRRI, the Board of Trustees, Management and staff have carefully considered the 11 recommendations made by the Panel. We are pleased to forward to the Science Council and the CGIAR Secretariat the Institute's formal response to those recommendations.

At the same time, we should like to express our appreciation to Dr. Greg Edmeades, Chair of the EPMR7 Panel, and his colleagues on the Panel for the way in which the review was conducted, and the collegial spirit of all interactions with Board, staff, and stakeholders. We would also like to recognize the important role that Dr. Peter Gardiner played in steering the whole review process forward and keeping it on an even keel.

We find this a very positive and optimistic report, and IRRI is pleased to accept all 11 recommendations. Indeed, we can report that progress in responding to some of them is already in train. The review has recognized the strengths of the Institute, particularly in the formulation of a strategic vision, an ambitious research agenda, its scientific excellence and reputation, as well as management and excellent governance of the institute, and its financial stability. The Panel has recognized strengths in five areas that will permit IRRI to remain resilient and creative in the uncertain funding and change process environment. We take particular note of the need to retain our scientific excellence, in the service of programmatic relevance and opportunities for impact.

In addition to the 11 recommendations, we take note of the several suggestions and encouragements that the Panel has highlighted in the report, such as: the need to constantly review our commitment to Frontier Projects such as apomixis; rules of engagement with the private sector; the scope and impact or our research in the uplands; efficiency of partnerships through CURE and IRRC; research on micronutrients; and other aspects of research management not specifically addressed in Recommendation 10, as well as the role of the Board of Trustees in terms of oversight of HR policies and appraisal of the Director General.

The recommendations will help the Institute move forward confidently and address areas where improvements are indeed warranted, and we will develop a timetable and milestones to monitor our progress in this respect. We are pleased that the EPMR panel concluded that IRRI continues to be a strong organization, with an important mission and mandate. The report of the 7th EPMR helps IRRI position itself to continue to contribute its science that will underpin efforts to provide food for half the world's population.

Yours sincerely,

Elizabeth J. Woods
Chair, IRRI Board of Trustees

Robert S. Zeigler
Director General

Rice Science for a Better World

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RESPONSE OF THE INTERNATIONAL RICE RESEARCH INSTITUTE (IRRI) TO THE 11 RECOMMENDATIONS OF THE 7TH EXTERNAL PROGRAM AND MANAGEMENT REVIEW

R1: BREEDING

The Panel recommends that IRRI re-evaluate the scope and extent of its methodologies for yield testing, and that it expand multi-location yield testing for major classes of irrigated and rainfed germplasm. This will enable IRRI to accurately phenotype and quantify the yield advantages of new advanced germplasm, and assess whether genotype x environment interaction is significant over and within its target environments.

IRRI is conscious of the need for reviewing the extent and scope of the process of yield testing; thus we **agree** with this recommendation. Multi-location testing indeed is an important component to provide valuable information in selecting germplasm, allowing identification of genotypes with wider adaptation, ensuring production stability, and more durable resistance to biotic and abiotic stresses. Also, such testing will enable us to determine genotype x environment interactions (G X E) both for irrigated and rainfed production systems.

In our experience rice is relatively more resilient than other crops e.g. IR64 was released in 12 countries and at one time occupied more than 15 m ha of ricelands. Similarly, Swarna is another mega variety widely grown in eastern India and Bangladesh. Therefore, testing in a few key sites representing target environments particularly for the irrigated ecology would suffice, we believe, to understand and exploit G x E.

During a two-day brainstorming session at IRRI in January 2009, we already discussed at length the process of implementing multi-location testing of breeding lines. Expanding multi-location trials and evaluation of elite germplasm in target environment in collaboration with NARES and private sector partners has already begun. In 2008, the Hybrid Rice Research and Development Consortium (HRDC) established a regional multi-location yield trial for hybrids, including promising IRRI entries. Starting in 2009, we will have multi-location testing of breeding lines at 3-4 sites in collaboration with PhilRice in the Philippines and later expand testing in different countries. For rainfed rice, we are already testing breeding materials under two networks in multi-location trials for drought and submergence in target environments in South and Southeast Asia. We also note the Panel's suggestion to utilize drought hot spots as phenotyping sites, and will look how best we can pursue this further in collaboration with our NARS partners.

Realistically, however, the costs involved in fully responding to this recommendation are prohibitive in the current climate of reduced unrestricted funding. Some of the work may be built into longer restricted grants (e.g. 5 years).

R2: HYBRIDS

The Panel recommends that IRRI develops a greater capacity to produce superior F_1 hybrids by improving the agronomic and grain quality characteristics, and broadening the genetic variability, of parental inbred lines. Research on the genetics and physiology of rice floral biology will be an important component of achieving crossability characteristics leading to more efficient seed production.

We **fully agree** with this recommendation since the development of hybrid rice is a mainstream IRRI activity. IRRI's current annual investment in hybrid rice is only about USD 0.6 million. We will seek at least to double our investments in hybrids within the next 1-2 years, and expect to increase this further within 5 years. This will primarily be done through various public-private partnerships that will address some of the fundamental issues confronting hybrid production and performance as well as provide more manpower for producing more and better parental lines and hybrids.

A team for studying yield potential has already been formed and is active in studying the traits contributing to yield, including both agronomic and physiological selection criteria. A study of exploring the genetic diversity of IRRI hybrid rice germplasm (through the IRRI-Pioneer Scientific Knowhow Exchange Program, or SKEP) is on-going. More activities will follow to study heterotic pools within indica germplasm, with the goal to enable more targeted breeding of parental lines for increased heterosis and seed yield.

Efforts are also ongoing to search for new germplasm, including from wild rice, with higher outcrossing. Some of this germplasm has been applied in CMS-line breeding to improve the yield of seed production, and preliminary results look very promising. We have initiated discussions on needs for basic research on floral biology and genomics. However, the flowering physiology of hybrid rice, as well as desirable agronomic and grain quality characteristics, can be site-specific. Strengthened collaboration with NARS will be necessary for expanded hybrid rice development.

R3: AFRICA

The Panel recommends that without delay IRRI, with WARDA, establish an East and Southern Africa regional office and a fully-supported multidisciplinary research team in Tanzania; that it engages with Madagascar's NARS, and develops partnerships with key institutions in ESA, especially in the seed sector.

We **agree fully** with this recommendation. IRRI and WARDA have developed a first draft of a joint work plan for Eastern and southern Africa (ESA) and have already established a joint office in Tanzania. IRRI and WARDA have obtained, and continue to seek joint funding for this program. IRRI is placing an internationally-recruited plant breeder and a postdoctoral fellow (PDF) agronomist in Tanzania in mid-2009. WARDA is adding a weed scientist/agronomist and a PDF social scientist to the joint team.

IRRI is already working closely with the Coalition for African Rice Development (CARD), the Millennium Village Project, and several ministries of agriculture to help purify existing seed supplies and develop a rice seed industry across the region. There are several successful NGO-led seed initiatives with maize, pulses, groundnut, etc. that IRRI will look at for developing partnerships for rice seed production.

We have begun a dialogue with Madagascar, building on IRRI's earlier relationship with the national rice program and experiences during the 1990s, and plan to visit as soon as the present political unrest subsides.

R4: IPM

The Panel recommends that IRRI commission a CCER on Integrated Pest Management to assess the current capabilities and future needs of IRRI and to enhance the Center's position in developing IPM for rice production systems.

The first plant hopper international conference convened by IRRI in 1977 can be said to have "triggered" activities including the IPM concept. This has now become more important because of climate change and need for ecological management in sustaining growth in production of rice. The recent International Planthopper Conference held at IRRI in June 2008 identified the importance of revitalizing IPM research to create awareness for policy makers.

A CCER on this topic is indeed necessary and welcomed; thus we **agree fully** with this recommendation. Indeed, a CCER on insect pests and virus diseases had been planned for 2008, but placed on hold until new internationally recruited scientists had been hired. As an immediate next step, we will define the scope and terms of reference for such a CCER to be held in the second half of 2009.

The CCER will have to confront a major challenge in this area of science and its application, which is the selection and integration of control tactics using ecological principles to develop strategies that are both environmentally and economically sound, but also socially acceptable. The assessment should also include scope for genetically-engineered pest resistance within an IPM package.

We recognize that declining staff numbers and resources, and the absence of a common divisional home for research and applications in the whole IPM domain, have contributed to weaknesses in this research area at IRRI. Consequently the rebuilding of plant pathology and entomology research began in early 2008, including the hiring of several new staff.

R5: WATER

The Panel recommends that IRRI encourage a unified and coherent approach to the efforts of scientists from all Divisions to develop suitable lowland cropping systems and germplasm to meet the challenge of the changing water environment; and that water is used as a strong organizing principle across the whole center to develop new products for the future.

We **agree**. IRRI does a large amount of work on 'water', but this recommendation suggests that the work may be too scattered. For example, four projects funded by the Challenge Program on Water and Food (CPWF) are distributed over different MTP programs. At the very least, this research could benefit from better visibility. We also agree that water is one of the most important organizing principles for structuring our research and development (R&D) agenda. In fact, most of our work is explicitly geared towards well-defined 'water environments'.

We develop products (germplasm and integrated management options) for drought-prone rainfed lowlands and uplands, salt-affected areas, submergence-prone areas, and irrigated areas. In irrigated lowlands, we specifically address water shortages in our water-management group that develops water-saving technologies such as 'alternate wetting and drying' and aerobic rice. In the Cereal System Initiative for South Asia (CSISA – funded by the Bill & Melinda Gates Foundation and USAID) we will implement a complementary breeding program for water-short irrigated areas, focusing on direct seeding, aerobic rice, and resource-conserving technologies. However, having said this, 'water' does not feature as prominently in our strategic plan and current MTP as it could, given the global importance of declining water resources (quantity and quality) and predicted increases in flooding in certain delta areas. Until 2006, IRRI's MTP included a project dedicated to increasing water productivity (one of the 11 projects). During development of the new MTP (2007 onwards), however, it was decided to de-emphasize water and treat it like other input factors, while emphasizing the development of integrated crop-soil-water technologies.

We will address this issue specifically as we refine IRRI's research agenda and report it in our next MTPs in the coming 12 months.

R6: SOCIAL SCIENCES

The Panel recommends that IRRI strengthen the delivery of its research products by refocusing the strategies of the Social Sciences Division. This includes the identification of high priority issues for policy research and impact studies; and greater emphasis on research on technology generation to ensure that IRRI's innovations are actually reaching farmers.

We **mostly agree** with the recommendation. We are carefully looking into all aspects of our work, i.e., participatory varietal selection (PVS), socioeconomic surveys, impact assessment, technology targeting, and data management. Efforts are already underway to strengthen our capacity in policy research and impact analysis. We have already recruited an impact assessment and strategic planning specialist, and in the process of hiring another quantitative impact assessment economist. We hope to have both on board by the middle of 2009.

We are also moving ahead in strengthening our capacity in policy research by developing a comprehensive analytical framework capable of analyzing a variety of issues related to domestic and trade policies, marketing and food security.

We are not comfortable with the statement that IRRI should place *'…greater emphasis on research on technology generation…'* IRRI is more likely to enhance the delivery of its research products to ensure that they reach farmers through engaging more effectively with development partners than through more research on technology generation.

R7: MANAGING COUNTRY PARTNERSHIPS

The Panel recommends that IRRI better define its strategy and objectives for country and regional programs, and that the mandate and functions of the International Programs Management Office (IPMO) be clarified to support these objectives.

We **agree** with this recommendation. Our current strategy focuses on building and sustaining strong country programs and offices in three key countries/regions where we have many new, large projects ongoing: India, Bangladesh, and East and southern Africa. In all three cases, we have already substantially increased staff placement and we expect those to grow further. Similar opportunities will be sought for other key countries as restricted grants can be raised. The roles and responsibilities of IPMO will be re-assessed during the ongoing process of evaluating and modifying our research management structure.

IPMO will continue to support the regional and country offices when needed and until they have settled and established their local/regional operations. It will also continue to provide support and supervision in countries without an IRRI representative (IR) or Liaison scientist (LS) like Cambodia, Myanmar, Nepal, Sri Lanka, Thailand, and Vietnam, until such time that a more sustainable set up is in place.

The Panel mentions in the text that IRRI can strengthen its partnerships with the national programs particularly in countries where there is no IR or LS by officially designating "resource scientists" for these countries. In fact, IRRI already has informal resource scientists for almost all important Asian rice growing countries. These resource scientists, by virtue of their being nationals of these countries or being familiar with the country, serve as advisers or champions for these countries whenever needed. In this way, the broader rice R&D interests of these countries, including their needs and opportunities, will be represented in IRRI for the time being. This arrangement is naturally an additional load for these scientists and may have its own disadvantages and weaknesses and may not be the most appropriate arrangement over the longer term. We will continue to review this situation, but immediately we can make this arrangement more widely known.

R8: BoT PROGRAM COMMITTEE

The Panel recommends that the Program Committee of the Board refocus its attention to strategic issues facing IRRI, and use CCER and other review processes for monitoring of IRRI research programs. It should refine its agenda-setting and ensure that program presentations are clearly linked to strategic questions which require Board deliberation.

We **agree** with this recommendation and will focus Program Committee (PC) meetings primarily on strategic issues. The April 2009 BoT PC meeting will be a starting point for that because it coincides with the last day of our Annual Program Review (APR). Topics of strategic importance will all be on the agenda for the joint APR/BoT-PC session.

R9: CAREER PATHS

The Panel recommends that IRRI establish and publicize a career framework for IRRI staff with clearly articulated professional levels, transparent salary scales, and performance incentives.

We **agree**. Indeed, the Panel's recommendations in this area are welcomed, and reflect the work currently underway to transition HRS at IRRI from an administrative, reactive, compliance-driven model to a service-oriented, proactive, valued-added approach. The issues raised by the Panel are critical elements of the 2009-10 HRS work plan.

The current rapid growth phase and the subsequent requirement for engaging the necessary personnel in an efficient and effective manner require the immediate modernization of IRRI's recruitment and selection policy and practices. This is currently underway, and significant progress has already been made, resulting in streamlined competency-based processes, more efficient Search Committees which feature HR members, the use of modern tools and services to identify and attract suitable candidates and widen the applicant pool, and a continued focus on gender and diversity. Clearly articulated staff classification models and transparent reward systems throughout the organization will further strengthen this methodology and work has already been initiated on moving towards a one-staff approach and away from unnecessary internationally-recruited and nationally-recruited staff workplace divisions.

Other on-going work in this area includes refinements of search approaches focusing on those which give the highest yield ratios, exploring internal recruitment as a vehicle for career progression, ensuring that recruitment and selection remain gender and diversity aware, and the movement from the traditional one-job one-career perception, to that of a dynamic staffing model which supports staff mobility and better reflects the increased nature of project work. Underpinning such an approach is the need to strengthen the current performance management process by linking it to IRRI's strategic purpose, and aligning it with a flexible career management model which encourages retention. The recent piloting of the new competency-based Individual Performance and Development (IPaD) approach will form the foundations for future work in this area.

The issue of retention, both at HQ and in Country Offices, will remain important. Current work underway is centered on the need to create and sustain job satisfaction through: offering complex and meaningful jobs; establishing clear, appropriate roles; reinforcing shared values which include the provision of social support and the pursuit of organizational goals; and an appropriate and transparent compensation and benefits philosophy.

The Panel's recommendations are therefore considered to be timely, confirming the appropriateness of the changes currently underway and the contributions of HR to supporting and sustaining high performance at IRRI.

R10: RESEARCH MANAGEMENT

The Panel recommends that IRRI review and, if necessary, modify its research management structure in order to promote effective and efficient project development, quality and relevance of science, resource allocation, communication, staff mentoring and staff evaluation.

We **agree** with the Panel's assessment that a review of IRRI's research management structure is needed. In November 2008 we formed a task force for reviewing IRRI's research management structure, and we are in the process of evaluating various models. A consultant joined IRRI in early February to undertake the last day of our Annual Program Review (APR). Topics of strategic importance will all be on the agenda for the joint APR/BoT-PC session.

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26th February, 2009

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Dear Drs Rabbinge and Wang,

On behalf of the Panel, I am pleased to transmit the Report of the Seventh External Programme and Management Review (EPMR) of the International Rice Research Institute (IRRI). The Panel has reviewed IRRI's performance in the four broad areas of: i) mission, strategy and priorities; ii) quality and relevance of the science; iii) effectiveness and efficiency of management (including governance and finance); and, iv) accomplishments and impacts. We have also addressed the list of strategic issues received from the Science Council and provide an annex to the Report for ease of reference.

The Panel finds IRRI to be in a healthy position with respect to most significant indicators and on the threshold of a period of growth. It has developed a clear long term strategy to which it adheres, has good management at Board and Center level and has a committed cadre of scientists and support staff. In general, it conducts a well thought out set of activities balanced between programs and divisions linked to NARS through several networks. It has established or re-established strong working relations with two important sister CGIAR institutes: with WARDA, allowing the development of a consultative approach and appropriate entry point for IRRI research on rice into East and southern Africa; and with CIMMYT, working specifically on rice-wheat cropping systems and perhaps providing the nucleus for future CGIAR work on cereals more generally. IRRI has a strong science culture, especially at its headquarters site in Los Baños in the Philippines. It has recently achieved a milestone in the ratification of the Headquarters agreement with the Government of the Philippines, and overall interactions with the host country are cordial and well managed.

IRRI has maintained its traditional strengths in the development of new varieties and in technologies which address environmental challenges faced in rice systems: water, and pest and disease management (on which the Panel places emphases); and climate change. The Panel applauds the steps taken by the Center to speak to the issue of the recent dramatic price spikes in rice. The Panel makes eleven recommendations to assist IRRI build for the future. Particularly, the Panel makes recommendations as to how IRRI may seek to increase gains in yield potential through rice hybrid technologies, and how some of its traditional networks may be reviewed or modified for purposes such as more extensive multilocation yield testing, without losing the important linkages with NARS partners. The Frontier project on C_4 rice is an example of IRRI's capacity to lead global initiatives in rice research on high benefit but high risk areas. The Panel endorses and encourages the new hybrid rice development consortium, noting that the context for rice research needs to be constantly held under review

IRRI has made a substantial commitment to improving its governance and management, particularly in efforts to evaluate quality and risk management. It has also made prudent use of its reserves and is continuously working to improve its financial and human resource management frameworks, following some very valuable CCERs, whose advice is endorsed by the Panel. The Center has strong leadership and has managed well transitions among senior staff during the review period. The Panel perceives that the Center has an air of confidence, and staff morale is high.

For the future, the Panel recommends that IRRI give equal emphasis to its partnership strategies and the organisation of social science to monitor impacts and guide technology generation. IRRI recognises and is taking steps to address ageing facilities and simultaneously to implement a period of growth brought about by its own good choices in science and new major funding support. A growth in funding in 2009 of approximately 60% will put pressure even on well managed systems. The Panel calls for attention to some of these, including the present research management matrix, even if it has served IRRI well to this point.

Our review was greatly helped by IRRI's open and constructive attitude and the information, support and facilities put at our disposal. We are grateful to IRRI's Board of Trustees, the management and staff at HQ and in country programs who hosted us, and presented their work and responded to questions. We also thanks the Center's stakeholders in many countries for sharing their time and in making contributions to the Panel's work.

Finally, the Panel members join me in expressing our appreciation for the opportunity to participate in this review and learn more about the extremely important issues confronting rice production and research. We are appreciative of the technical support given by Dr. Peter Gardiner of the Science Council Secretariat in the completion of the Report.

We trust that our Report, as IRRI nears its 50th Anniversary, will help make a good Center stronger, and assist IRRI and its partners to meet the pressing requirements of raising rice productivity globally and in a sustainable manner. The Panel was always acutely aware that for many of the poor, rice is life.

Yours sincerely,

Greg Edmeades

Greg Edmeades

Panel Chair
Seventh External Program and Management Review of IRRI

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CONSULTATIVE GROUP ON INTERNATIONAL AGRICULTURAL RESEARCH

CGIAR SCIENCE COUNCIL SECRETARIAT

Report of the

Seventh External Program and Management Review (EPMR) of the International Rice Research Institute (IRRI)

Review Panel: Greg Edmeades (Chair)
Shu Fukai
John Snape
Martha ter Kuile
Robert Tripp
Nicolas Drossos (Consultant)

SCIENCE COUNCIL SECRETARIAT

FEBRUARY 2009

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SUMMARY

Nearly fifty years ago, the Government of the Philippines offered to host a small research center at Los Baños "*to reduce poverty and hunger, improve the health of rice farmers and consumers, and ensure environmental sustainability through collaborative research, partnerships, and strengthening of national agricultural research systems and extensions systems*". As IRRI reaches the half-century mark, the EPMR Panel is pleased to report that on all significant measures, IRRI meets the high standards it has set for itself. The Institute is well managed, financially sound, strong in science and appropriately engaged with partners worldwide to bring the best efforts of rice science to bear on the immense challenges of food and the environment faced by developing countries.

The Seventh External Program and Management Review of IRRI took place between September 2008 and February 2009. The team met with IRRI scientists and partner organizations in China, India, Bangladesh, Thailand, Laos, Cambodia, the Philippines, Nigeria, Tanzania and Mozambique as well as at IRRI Headquarters in Los Baños**.** Through telephone calls, email exchanges and surveys, contacts were made with staff members, donors and other stakeholders. The Panel chair and another member observed a meeting of the Board of Trustees September 2008. In all aspects of its work, the Panel was impressed with the professionalism and engagement of IRRI management and staff.

The continuing challenge for rice production in an increasingly variable context: Demand for additional global rice production is estimated at 10 m tons per year. Approximately 90% of rice is produced and consumed in Asia, where land area devoted to rice is essentially fixed. Demand for rice from urban populations significantly outstrips supply in sub-Saharan Africa (SSA). While area devoted to rice may increase in SSA and the Americas, these regions are relatively minor contributors to global rice production. Production increases, therefore, must come largely from increased yields. Gains in yield potential, yield stability and input use efficiency are essential if these production goals are to be met.

IRRI operates in changing scientific and physical environments in which there are an increasing number of players. Molecular tools with potential for significantly increasing genetic gain in rice are available now, or are under development in ARIs (e.g. in China and industrialized countries). Three transgenic crop species have been released commercially in some Asian countries, and many more are under development. With these changes comes a complex web of Intellectual Property regulations that IRRI needs to unravel on a case-by-case basis to gain access to these technologies. At the same time, soil and water resources for cropping in Asia are under threat from erosion, pollution and a growing population. Water shortages for rice in the future appear likely. Climate change will further threaten rice yields through more extreme weather events, water constraints, high temperatures and new challenges from pests and diseases. IRRI cannot tackle these formidable challenges alone, but establishes and often leads research with partners addressing rice production against the backdrop of these changing circumstances. The remarkable increases in information technologies offer new opportunities for IRRI to communicate rapidly and effectively with research partners, and to extend rice-related knowledge from the lab to the paddy. Research partnerships based on shared goals, integrity and equitable attribution, however, remain the foundation of IRRI's present and future success.

IRRI conducts its *program of work* through a research management structure that is a matrix consisting of seven Programs, and eight operational units, the latter comprising the three Divisions of Plant Breeding, Genetics and Biotechnology (PBGBD), Crop and Environment Sciences (CESD), and Social Sciences (SSD), three research and support units, namely the

Genetic Resources Center (GRC), the Crop Research Informatics Laboratory (CRIL), and the Grain Quality, Nutrition and Post-Harvest Center (GQNPC) and two smaller units. The Programs are responsible for conducting relevant thematic research for development under a team structure that draws from the appropriate divisions and Units that in turn are responsible for ensuring high quality science.

IRRI tackles the two major agro-ecosystems for rice, namely irrigated and rain fed systems, principally through two large ecosystem-based programs. The first of these, the program for *Rainfed Rice System*s, covers regions where rice yield is generally low and variable, and poverty is prevalent. Most of the work is for rainfed lowland rice ecosystems, reflecting the importance of this ecosystem in South and Southeast Asia. Here, the major physical constraints for rice production are lack of water availability and adverse soil conditions. The main emphasis is on selection of adapted genotypes, particularly using Marker Assisted Selection (MAS), complemented by land and crop management research to minimize the adverse effects of drought, submergence, salinity and other adverse soil conditions, and an emphasis on development of crop and natural resource management and management options.

The program has achieved significant outputs including lines that could have 1-2 t/ha yield advantage over existing cultivars under drought stress; the use of the *PUP1* gene in P-deficient areas; the identification *SUB1* gene for tolerance to submergence and its transfer to several mega-varieties; establishment of conditions for successful aerobic rice production systems; and salinity tolerant varieties developed through participatory variety selection (PVS) in Bangladesh.

IRRI HQ is not located in a drought-prone area and this makes it difficult to work there on drought problems under natural conditions. Thus the Panel strongly suggests that efforts should be made to utilize other drought hot spots as phenotyping sites in collaboration with NARES. To continue providing research products that will have impact on *upland* rainfed systems IRRI needs to make a careful selection of priority upland systems so as to ensure a critical mass of scientists and adequate infrastructure. In the same vein, it needs to strengthen the Consortium for Unfavorable Rice Environments (CURE) to contribute to this effort, particularly in areas where NARES involvement appears strong.

The second major program addresses intensive rice production systems, many of them irrigated, that account for over 70% of the world's production. IRRI's Program on *Sustaining Productivity in Intensive Rice Systems* develops new germplasm using conventional and MAS approaches to address emerging sustainability issues in rice production such as reduced water availability for irrigation, the need to reduce the environmental footprint of agriculture, and uncertainties concerning the effects of climate change. IRRI is leading in efforts to use MAS in rice breeding, as witnessed by the number of genes for abiotic and biotic stress undergoing MAS. The Panel strongly endorses continued efforts in gene discovery and gene tagging at IRRI and with collaborating ARIs.

There has been rapid development of technologies for sustainable intensive rice production systems. Technologies for reduced water use via alternate wetting and drying of the root zone have been developed and delivered, as has site specific nutrient management, which is utilized to identify optimum nutrient inputs for intensive lowland rice. This technology is being used to rectify the problem of N overuse, which is a major problem in countries such as China and Vietnam.

The involvement in the 'Green Super Rice' project with China is also an important mechanism for germplasm enhancement through the use of IRRI's extensive networks in SE Asia, and the developing networks (with WARDA) in Africa. The Program has also initiated research towards mitigating the possible effects of climate change through participation in the Rice Climate Change Consortium (RCCC).

The Program thus continues the long history of IRRI in delivering higher yielding germplasm with good pest and disease resistance to NARS through a number of formal network partnerships. At present, however, some of these partnerships appear less efficient than they could be, especially as collaborators in multilocation testing of segregants and new germplasm products. The rate of yield potential increase seems to be slower than expected and less than is needed, and this may be a product of the current yield testing systems. The Panel supports a more pragmatic approach to increasing yield potential built on yield results and physiological and genetics studies, rather than ideotype design (i.e. of new plant types or NPTs). IRRI's investment in hybrid rice, with its 10-15% yield advantage, is currently insufficient to bring the germplasm to levels of yield, biotic stress resistance, and grain quality that can effectively complement efforts of other hybrid rice breeding programs and meet the expectations of private seed companies.

The Panel recommends that IRRI re-evaluate the scope and extent of its methodologies for yield testing, and that it expand multi-location yield testing for major classes of irrigated and rainfed germplasm. This will enable IRRI to accurately phenotype and quantify the yield advantages of new advanced germplasm, and assess whether genotype x environment interaction is significant over and within its target environments. The system should also include strategies for phenotyping within target environments through a shuttle breeding approach, particularly aimed at systematically exposing segregating lines to the production systems of the future where less water will be available.

The Panel recommends that IRRI develops a greater capacity to produce superior F1 hybrids by improving the agronomic and grain quality characteristics, and broadening the genetic variability, of parental inbred lines. Research on the genetics and physiology of rice floral biology will be an important component of achieving crossability characteristics leading to more efficient seed production. IRRI should also determine the underlying patterns of combining ability and heterosis in germplasm, building on current work, and assess whether the stability of hybrids is superior to inbreds through multi-location testing.

IRRI is undertaking *new initiatives in East and southern Africa* (ESA) which respond to a growing need for increased rice production in the African continent. A close working relationship has been forged between WARDA (African Rice Center) and IRRI, and donors have stepped forward to help crystallize this ambition. The program is initially focused on formulation of research priorities and policy options, predicated by a good understanding of rice production environments and farmer circumstances. At the same time a large number of IRRI's elite indica lowland breeding lines are being evaluated in West Africa and in ESA to identify stress tolerant genes. Mean yields in ESA are low, so a third priority is to validate sustainable production and post-harvest technologies. This region has relatively few rice researchers, and the program is in the process of training a large number of rice scientists, technicians and extension staff. A joint IRRI-WARDA regional office and research team are planned for Tanzania.

The joint IRRI-WARDA program is focusing mainly on four countries in ESA, but the leading rice producer in the region, Madagascar, is not among them. Research to improve rice production in this region will move IRRI downstream in the research continuum, and expose its staff to new challenges in rice production in countries characterized by low average rice yields and weak seed distribution systems. IRRI will be required to establish new partnerships in a region where several other CGIAR centers have worked for many years. The Panel commends IRRI for its partnership with WARDA and the successful establishment of a rice research program in ESA.

The Panel recommends that without delay IRRI, with WARDA, establish an East and Southern Africa regional office and a fully-supported multidisciplinary research team in Tanzania; that it engages with Madagascar's NARS, and develops partnerships with key institutions in ESA, especially in the seed sector.

IRRI's Program on *Rice and Human Health* responds to several human health problems related to rice consumption. However, the great majority of current Program work is devoted to increasing the content of three micronutrients (Vitamin A, iron, zinc) in rice in cooperation with the Harvest Plus Challenge Program. Of these, the most prominent activity is the effort to enhance provitamin A content through transgenic 'Golden Rice' (GR). Promising lines with high levels of provitamin A are being backcrossed with popular rice varieties cultivated in the Philippines, India and Bangladesh. It is hoped that some of these varieties would be available for release by 2011-12 in the Philippines. The Program is taking a cautious approach to the release of the materials, following biosafety studies and intensive investigations of the storage/cooking stability and bioavailability of provitamin A. Most of the activities are being conducted by other institutions, but several grants to IRRI will help promote the deployment of GR, including meeting some of the costs of biosafety regulation.

IRRI is able to take advantage of the huge national and international investments in rice genetics and genomics over the last two decades in its *Rice Genetic Diversity and Discovery program*. This approach is augmented by the IRRI Gene Bank, which remains the best collection of rice germplasm in the world, and is a global asset. In collaboration with its many partners in ARIs and NARS, IRRI continues to be a leading Institute in the conservation, genetic characterization and exploitation of rice genetic resources for rice improvement, using forward and reverse genetic approaches for genetic dissection of key traits by direct genetic analysis and comparative genomics approaches. A significant development is the Oryza SNP project designed to develop a cross-genome SNP chip. A large proportion of funding for gene discovery comes from restricted funds, including funds from the Generation Challenge Program, to enhance germplasm characterization and use.

IRRI has set itself ambitious targets in terms of the genetic analysis of key traits, including drought tolerance. IRRI continues to develop specialized genetic stocks and has restored key capabilities in the development and application of rice transformation (including transformation of indica varieties). However, it also requires excellent phenotyping facilities and many of IRRI's facilities are no longer state-of-the art. IRRI must decide whether to spend more funds on greenhouses or spend them instead on high quality field facilities where the target stress occurs naturally and where stress intensity and timing could be managed effectively.

IRRI has the breadth of experience and resources to undertake speculative projects with potentially high pay off. The possibility of developing 'C4 rice' is a grand challenge that IRRI is well positioned to pursue and coordinate. Work on previous Frontier projects, particularly apomictic rice, has greatly decreased, and the Panel suggests dropping this aspiration.

IRRI's *Information and communication program* has made considerable progress toward the development of the International Crop Information System (ICIS) as the common crop information system for rice, maize and wheat in IRRI and CIMMYT. Version 5.5 of ICIS was released recently. A large amount of information on rice is now available on the web and the Rice Knowledge Bank contains basic and applied rice information that is useful for technology transfer targeted for extension workers and farmers. The appearance of individual Country Knowledge Banks in the relevant languages indicates the importance of this resource to partners.

Policy Support and Impact Assessment at IRRI focuses on analyzing policies relevant to rice technology development, improving technology dissemination strategies and assessing the impacts of rice technology utilization. Development of farm-level databases in several countries can be used for policy analysis. Results of work done in several countries on the livelihood, gender, and poverty correlates of rice production has the potential to be used in research decision-making and priority setting, both by national partners and IRRI. The Program also organizes the analysis of data on rice production and markets. During the recent rice price crisis IRRI was able to provide a timely and coherent summary and analysis of the situation and to use this as a way of promoting its vision for greater support to rice research. The Program also addresses issues in technology dissemination and hence has significant responsibilities for ensuring that IRRI's innovations are delivered to farmers. The Panel stresses the need for IRRI to continue to demonstrate widespread impact of IRRI technologies, and to focus on the identification of delivery pathways for policy analysis.

The role of divisions in IRRI: The Plant Breeding, Genetics and Biotechnology Division (PBGBD) is at the heart of IRRI's research programs and mission, and it has a cohort of internationally known scientists covering a range of disciplines from conventional breeding, genetics, cytogenetics, genomics, molecular biology, tissue culture and transformation technologies. PBGBD has numerous collaborative links with institutions in industrialized and developing countries, with particular emphasis on its close interactions with NARS in collaborative breeding, varietal release and new technologies. It has supported technology transfer and training to build core competencies in its partner institutions. Overall, the PBGB Division has maintained and enhanced its inherited strengths and the Division's strategy was endorsed by the 2008 CCER on Biotechnology which recognized the significant contribution made to the global efforts in applying modern genomic tools towards rice genetics and breeding. The CCER recommended that there needs to be a narrowed focus, with priority being given to water-related traits, and an upgrading of facilities for field phenotyping. The Panel strongly endorses the conclusions and recommendations of the CCER.

However, judged across the disciplinary strengths, the Panel feels that IRRI's overall expertise in pest and disease research has declined in recent years, and its capacity for IPM deserves attention by management:

The Panel recommends that IRRI commission a CCER on Integrated Pest Management to assess the current capabilities and future needs of IRRI and to enhance the Institute's position in developing IPM for rice production systems. IRRI has increased its capabilities in plant pathology, but the Panel has concerns that IRRI's capabilities in IPM have declined to a level that is inhibiting a systems approach to sustainable pest and disease management.

Conventional breeding is a long-term activity which requires sustained efforts and is resource-demanding in terms of land and manpower. The Panel endorses the strong support for breeding research from management and urges a continued stable funding basis, which may be augmented through the new CGIAR structure.

As mentioned, *the Genetic Resources Center* (GRC) at IRRI manages and curates the world's largest collection of cultivated and wild rice germplasm, along side a very active research program for the phenotypic, genetic and genomic characterization of the germplasm allowing for its wider use. The development of genetic and genomics resources at IRRI (and in other labs worldwide) will require the curation of new materials such as precise genetic stocks (e.g. mapping populations) and DNA resources (e.g. BAC libraries). Decisions will need to be made whether this is the province of the GRC in the longer term and the level of commitment required if the GRC is to establish itself as a major center of genomic as well as genetic resources for the international community. The need is also recognized to develop an integrated network of rice genebanks globally. It is important that IRRI continues the process of system-wide integration of the IRRI GRC with WARDA and CIAT, and helps to establish an inventory of world rice germplasm. The GRC also needs to maintain its role in training others so that its best practices (for collection, curation and dissemination of plant genetic resources) are communicated to IRRI's stakeholders and collaborators.

The *Crop and Environmental Science Division* (CESD) includes expertise in plant and crop physiology, agronomy, soil science, water science, environmental science, weed science, entomology, nematology and rodent ecology. Achievements include the demonstration of the sustainability of lowland rice cropping and the elucidation of mechanisms for such sustainability; development and promotion of site-specific nutrient management (SSNM) technology for rice-based cropping systems; and the development of water saving technologies such as alternate wetting and drying, and the transfer of this technology to farmers in some regions. Further, dry direct seeding before commencement of the wet season, has allowed double cropping of rice or rotation with non-rice crops, as practiced by thousands of farmers in Bangladesh and India. Strong linkages with social scientists to understand adoption pathways are required to enhance the rate of adoption of technologies promoted by the Division.

The challenge of effective resource use, particularly water, is likely to remain a key area in rice crop and environmental science. Increased climate variability and climate change require the development of new cropping systems that meet the challenge of variation in rainfall patterns. Additional scientific research would include identification of soil and weather conditions which define suitability for different cropping systems, and quantification of water balance components in different systems to aid future water saving. Any new cropping systems developed to increase water productivity need to have varieties that are well adapted to water constraints and other growing conditions typical of the target environment, and hence need an interdisciplinary team and an appropriate field phenotyping platform to develop the products that are appropriate to the physical, biological and social environments.

The Panel recommends that IRRI encourage a unified and coherent approach to the efforts of scientists from all Divisions to develop suitable lowland cropping systems and germplasm to meet the challenge of the changing water environment; and that water is used as a strong organizing principle across the whole Institute to develop new products for the future. Research for the development of sustainable cropping systems and germplasm to address water shortage may include (but not be limited to): plant and soil factors that determine water uptake and underpin new cropping systems; genotypic adaptation and physiological mechanisms for genotypic variation; interactions with nutrient availability and weeds; socioeconomic factors related to farmers' adoption of new practices and varieties; and development of new strategies for technology transfer.

IRRI's *Social Sciences Division* (SSD) has made significant contributions in recent years to understanding the socioeconomic context of technology generation and adoption. It has provided insights into the relationship between livelihood diversity and rice production strategies, carrying forward SSD's commitment to practical gender analysis and broadening IRRI's knowledge of the impact of changing economic conditions on rice management. A large study documented the costs of drought (and drought-avoidance) to rice productivity. Significant involvement in projects in Bangladesh led to an important contribution to local policy discussions. Analysis of rice markets in the Philippines and Thailand helped clarify differences in efficiency between those markets. SSD staff involvement in IRRI projects for technology testing and development includes the conduct of baseline studies and follow-up analyses (often involving training of local collaborators). The site-specific work was also an opportunity for SSD to make significant contributions to methodologies for participatory variety selection (PVS). SSD has also continued to place considerable emphasis on training and capacity building. The Division is currently under-resourced, and a large proportion of its activity is funded by special projects. The Panel underlines the importance of identifying clear priorities for SSD to help ensure IRRI's capacity to deliver its products.

The Panel recommends that IRRI strengthen the delivery of its research products by refocusing the strategies of the Social Sciences Division. This includes the identification of high priority issues for policy research and impact studies; and greater emphasis on research on technology generation to ensure that IRRI's innovations are actually reaching farmers. Policy research opportunities should be identified that have the highest probability of actionable follow-up, and impact studies should focus on broad-based gains. Research on technology generation would include attention to monitoring and adoption studies, greater recognition of the iterative nature of technology development, and the analysis of national-level policy constraints. As SSD activities are re-prioritized and focused, IRRI should actively pursue mechanisms for providing more unrestricted funding for the Division.

IRRI's Partnerships: IRRI's partnerships are broader and more complex than in the past. Many traditional NARS partners are growing stronger and some, such as China and India, have capacities that require IRRI to re-examine its own comparative advantage in rice research. In addition, IRRI increasingly interacts with other CGIAR Centers, advanced research institutes (ARIs), and the private sector.

One important strategy has been IRRI's use of consortia to focus interaction on specific areas of research, to build NARS capacities, and to increasingly assign responsibilities to local partners. Several of these consortia have a long history and have led to significant technological innovation; several new consortia offer considerable promise for extending these gains. Nevertheless, a more comprehensive approach to NARS partners is required. The heterogeneity of Asian NARS makes it impossible to define a common strategy, but IRRI's interactions with NARS deserve particular attention.

The Panel recommends that IRRI better define its strategy and objectives for country and regional programs, and that the mandate and functions of the International Programs Management Office (IPMO) be clarified to support these objectives. IRRI should have a well-defined strategy for each of its partner countries. IRRI should designate a staff member to serve as a focal point for each significant rice-producing country in Asia to coordinate information and contacts; for many countries, a meeting (approximately every five years) to discuss national rice research priorities will be useful. The examination of IRRI's interactions with NARS should also include the possibility of placing a larger proportion of staff outside of headquarters.

As funding pressures and the challenges of increasing agricultural productivity have mounted, it has become increasingly important for CGIAR Centers to collaborate effectively. One of the most noteworthy accomplishments has been the commitment of IRRI and WARDA in developing a coherent program for rice research in Africa. There are also several important programs that have emerged from cooperative agreements within the Alliance between IRRI and CIMMYT. In addition, IRRI is an active participant in three Challenge Programs (in genetic resources, nutritional enhancement of cereals, and water).

IRRI's interactions with the private sector cover a range of activities, including joint research projects and the acquisition of proprietary technology for IRRI's own research and technology development. In addition, IRRI has recently established a Hybrid Rice Research and Development Consortium in order to facilitate the transfer of IRRI germplasm to the private seed companies that are best placed to deliver hybrid rice to farmers. IRRI is cognizant of its responsibilities for ensuring that both its acquisition of IP and its delivery of products to the private sector must be done in a way that facilitates and protects IRRI's role as a provider of international public goods (IPG). IRRI needs to further develop and standardize its 'rules of engagement' with the private sector.

IRRI's institutional success rests on its relationships with its partners. IRRI remains a highly respected collaborator that relates well to its partners, though these relationships need to be continually monitored in an evolving institutional environment.

IRRI's facilities: IRRI was established in 1960 on a 252 ha property that is still leased from the University of the Philippines. The Institute was built as a self-sufficient research community to a standard that would attract the world's best rice researchers. This has served IRRI's goals well, although today's legacy of that policy is a large and ageing research infrastructure which requires selective decommissioning or capital-intensive updating if it is to meet the needs of research over the next decades. Estimates of this step put the cost at around $US150 million. It is a tribute to IRRI's management that through the newly-formed IRRI Fund it is already making provisions to raise funds for such a step. Housing and accommodation facilities are also variable in quality. Since IRRI is on the verge of significant growth, the Institute will also have to provide and expand appropriate accommodation facilities for its additional staff.

Assessment of the quality of science: IRRI's Strategic Plan was established after appropriate consultation with a range of stake-holders, and the Plan determines the goals that are appropriate to the Institute in the current environment. The Panel applauds the annual planning week where goals are set across the institute in a thorough and open manner. The MTP is a clear and comprehensive document and guide to current activities. It is updated annually and individual IRS have clear tasks that meet the overall objectives of Programs where they work. In general, IRRI staff are of high caliber and this is confirmed by a good publication record in internationally well recognized journals. However there is concern over the current limits to career paths and problems in meeting personal staff ambitions, and these need to be addressed. There has been excellent work conducted in the different programs in Asia over the 5 year period. There is an institution-wide sense of achievement, and these achievements are widely recognized by the IRRI stakeholders. The expert knowledge available in the Institute should be utilized effectively in the new challenge to enhance rice productivity in Africa.

Several new technologies have been developed based on sound scientific principles. Development of consortia such as CURE and IRRC, and the expansion of activities within consortia to verify the new technologies, are applauded. IRRI has gradually moved from emphasis on intensive production system to more marginal rainfed environments. The rainfed environments require well coordinated research within the research teams at IRRI and also with other groups such as NARES. It is important to recognize that IRRI has a diverse group of scientists, and the research projects need to be formulated to take advantage of this diversified skill base. One of the challenges facing IRRI is to find ways to ensure that technologies developed are adopted by resource-poor farmers in the target regions. IRRI should pursue opportunities for more effective scaling up of its technologies.

IRRI's Governance and Management: The Board of Trustees of IRRI provides outstanding leadership in its oversight of IRRI's operations. The current board of IRRI maintains a clear focus on the well-being of the institute, while simultaneously responding appropriately to the concerns of donors, host country, national program partners, civil society interest groups, scientific collaborators, and the CGIAR.

As IRRI enters a period of rapid expansion, concurrent with a major change in the organization of the CGIAR system, it will be essential that IRRI's research program is designed and implemented in a way that maximizes its effectiveness and sustains momentum through institutional changes. The Program Committee of the Board needs to play a critical role as IRRI seeks to identify and anticipate priorities, opportunities and opportunity costs in a challenging environment. **The Panel recommends that the Program Committee of the Board refocus its attention to strategic issues facing IRRI, and use CCER and other review processes for monitoring of IRRI research programs. It should refine its agenda-setting and ensure that program presentations are clearly linked to strategic questions which require Board deliberation.**

IRRI's financial management is very strong, and the financial health of the institute is excellent. IRRI complies fully with CGIAR Financial Guidelines and meets the requirements of its investors. Its framework of accountability systems is comprehensive.

IRRI has now moved decisively away from the original core-financed institutional model. Instead, IRRI's core mission is delivered through a complex mix of projects and collaborative arrangements financed by restricted grants, which will account for 79% of IRRI's budget in 2009. The corollary of this change, which has occurred gradually over the past decade, implies that significant changes should be made in research management, research oversight, financial and human resources management, and capital investment practices. In particular, it has been necessary during the review period to move toward full cost recovery in the management of donor grants. IRRI has responded well to the new funding reality, and has pragmatically adapted many of its systems to accommodate the requirements of a grants-based institution. The challenge now is to complete the transition so that all management systems support the grants-based model in a time of very rapid growth.

In Human Resources management, **the Panel recommends that IRRI establish and publicize a career framework for IRRI staff with clearly articulated professional levels, transparent salary scales, and performance incentives.** This career structure should identify pathways from Post-Doctoral Fellow through Principal Scientist, and for NRS Grades 1 through 8. The implementation of this framework should be supported by staff development measures in performance appraisal, training and career planning, and it should recognize the special circumstances of out-posted staff members.

In research management, the Panel notes that project grants have added another dimension to the program-by-division research management matrix at IRRI. **The Panel recommends that IRRI review and, if necessary, modify its research management structure in order to promote**

effective and efficient project development, quality and relevance of science, resource allocation, communication, staff mentoring and staff evaluation. The strength of IRRI's research management matrix has been in its ability to capture both the coherence of programs and the fostering of communities of practice in disciplinary divisions and operational units. If the matrix is to be modified substantially, IRRI will want to ensure that a new structure does not dilute the disciplinary critical mass which contributes to the quality of science.

IRRI has succeeded admirably in attracting donor support for its mission objectives. IRRI is on a significant growth trajectory. The budget for 2009 is 61% higher than 2008. In order to meet the needs of IRRI researchers and collaborators over the coming decade, a substantial investment in capital improvements is necessary. **The Panel recommends that IRRI prepare a comprehensive plan for the refurbishment and redevelopment of its Los Baños and other sites, and embark on a resource mobilization strategy which includes the judicious use of the reserves, as well as a fundraising campaign to provide the additional capital investment required.** As current financial management norms in the CGIAR do not permit adequate financing for the replacement of ageing infrastructure through depreciation costs, IRRI is encouraged to explore sources outside as well as inside its traditional donor group. The Panel notes and applauds the innovative resource mobilization effort underway in the creation of the IRRI Fund.

This, the 7th IRRI EPMR has focused on documenting IRRI's accomplishments over the past five years, and on offering some suggestions for improving an already excellent institution in the future. However, that future is clouded by enough uncertainties that it is impossible to chart a clear course for IRRI in the coming decade. The challenges of climate change and resource degradation, uncertainties in the world economy and institutions, and the changing nature of poverty all make it difficult to map out long-term strategies. Similarly, IRRI must face trends and challenges in its more immediate environment, including changes in the character of its funding, the need to maintain its infrastructure and invest in the future, the continuing growth and capacity of NARS partners, and increased attention to the governance and accountability of international agricultural research. Nevertheless, IRRI has a series of strengths that will permit it to be resilient and creative in this uncertain environment. These reside in at least five major areas: its germplasm resources, the public access orientation and human elements of its partnerships, its ability to anticipate strategic opportunities in cropping systems and crop management research, its knowledge and information management, and its capacity to exert leadership in rice research. These strengths will serve IRRI well as it helps the world respond to the challenges facing rice growers and consumers in the next decade.

1 INTRODUCTION

Rice is indeed life - an essential commodity for the vast majority of Asians, and increasingly for many urban residents of sub-Saharan Africa. For almost 50 years the International Rice Research Institute (IRRI) has been at the heart of the global effort to stabilize and sustain the production of this key commodity. IRRI today is a modern rice research institution, based at Los Baños, Republic of the Philippines, with a global mandate to reduce poverty and hunger of resource-poor rice producers and consumers through focused research on improving rice production and productivity. Its products are considered to be International Public Goods (IPGs), available to all. The Institute's fitness for purpose for this task can potentially affect the welfare of many millions of the world's poorest inhabitants.

1.1 The EPMR process

An External Program and Management Review (EPMR) of each CGIAR Center is conducted every 5 years, and is organized jointly by the CGIAR Secretariat and the Science Council. The terms of reference of the current review are listed in Annex 1, but in brief the 7th EPMR is charged with assessing:

- IRRI's mission, strategy and priorities
- The quality and relevance of the science undertaken
- The effectiveness and efficiency of management, including quality control
- The accomplishments and impact of the Institute's research and related activities
- How IRRI can best fulfill its mandate in the future.

Specifically, the EPMR advises on changes in research strategy and objectives, modes of collaboration and partnership, and organizational changes in IRRI to improve effectiveness, efficiency and fitness for purpose in the context of the history of the Institute. Such reviews are an essential for maintaining institutional health. Institutional changes, however, do not occur in a vacuum. For this reason an assessment of the research environment within which IRRI operates forms much of the substance of the first two chapters of this report.

1.2 IRRI's path to today

Understanding IRRI's current orientation and emphases demands some appreciation of the critical factors that have shaped its past. The culture and ethos of a Center are an amalgam of its location, philosophy, past successes, challenges, leadership, values, and its relationships with partners. Similarly the current assets and liabilities of a Center reflect past strategies and budgets, and together with culture shape the Center we have today.

IRRI was established in 1960 by the Ford and Rockefeller Foundations, in cooperation with the Government of the Philippines, on a 252 ha property that is leased from the University of the Philippines. The Institute was built as a self-contained research community to a standard that would attract the world's best rice researchers. Today's legacy of that policy is considerable research success (described below) but also a large and ageing research infrastructure that has served IRRI's goals well.

Varietal improvement: IR8 and its successors

Early research emphases were on germplasm collection, evaluation, and the development of new high yielding short plant types that were fertilizer responsive and lodging resistant. In 1966 IR8 was released, and this set a new standard for yield and management responsiveness for rice in tropical Asia. Further releases of semidwarf rice varieties have changed the landscape of rice production in Asia. In 1976 IR36 was released, a variety that quickly became a "megavariety" because of its early maturity and stability. IRRI varieties spread rapidly, and by 1980 covered 50% or more of the irrigated rice growing areas of S and SE Asia. IR64, released in 1985, alone covered 8 m ha by 1995. Its successor, IR72, also a megavariety, was released in 1988. The breeding emphasis in the 80s and 90s moved from pest resistance, improved grain quality and more rapid maturity, to yield potential through the use of hybrids and the introgression of tropical japonicas to generate high yielding "new plant types" (NPTs).

Physiology and soil sciences, crop modeling and climate change

Developing rice germplasm for enhanced yield stability has become increasingly important in recent years. This has been paralleled by an increased emphasis on rainfed and aerobic rices, and by adding tolerances to water-related stresses (drought, salinity, submergence). At the same time, the physiology of rice was being extensively studied using field facilities, greenhouses and the Phytotron, built in 1974. These studies elucidated mechanisms that had given rise to yield increases in semi-dwarfs, identified traits associated with abiotic stress tolerance, provided a rational underpinning to the design of the NPTs, and quantified effects of climate change on rice yield. IRRI has developed a rice model, ORYZA2000, based on physiological and genetic relationships. Modeling has been used to supplement field experimentation in extrapolating performance under global warming scenarios, and the effects of altered source and sink activity on yield. Soils research at IRRI pioneered studies on straw and residue management under different cropping systems, fine-tuned optimal crop nutrition recommendations, evaluated long term cropping patterns, and continues to document management effects on greenhouse gas production. This research has positioned IRRI well to lead research on the effects of climate change on tropical rice environments and rice production.

Genetic resources and their distribution

Gains in yield potential and yield stability have depended heavily on the effective use of genetic resources at IRRI. Systematic collection, characterization and storage of rice landraces and wild relatives was greatly boosted by the establishment in 1976 of what is now known as the T.T Chang Genetic Resources Center that houses over 110,000 accessions. It is noteworthy that some 70,000 accessions from IRRI's Genebank have already been placed in the "Doomsday Vault" in Svalbard. The International Network for the Genetic Evaluation of Rice (INGER), established in 1975, has proven an excellent vehicle for sharing rice genetic resources among and between national programs. In recent years INGER collaborators reduced the number of varieties they contributed to the network because of intellectual property considerations, though that trend is now reversing. However, replicated yield trials are no longer distributed to national programs through INGER.

Biotechnology

Studies of genetic diversity and gene discovery were further expanded following the establishment of the Rice Biotechnology Program by Rockefeller Foundation in 1986. In IRRI, this resulted in the development of a range of new molecular tools, particularly molecular marker techniques, which led to a blooming of activity in genetic analysis and gene identification. This allowed the discovery of new and novel major genes and large-effect QTLs such as *SUB1* (submergence tolerance), *PUP1* (phosphorous uptake), and tolerance to drought and salinity. IRRI has also led in the development of transformation methods in rice, and continues to develop technology such as microRNA (miRNA) methods for gene silencing. Like other CGIAR Centers, marker-assisted selection is still not a generally established part of the mainline breeding program, and has yet to be scaled up. Following the recent CCER recommendation, the Institute is refocusing its efforts towards water-related traits, using association mapping based on whole genome SNP-based genotyping. Like most other institutions, IRRI's capacity for quality high throughput phenotyping under managed environments has not kept pace with its genotyping capacity, and may have lost ground over the past 5 years.

Information management

This has been a major contributor to IRRI's past and present successes. Initially, IRRI emphasized designs and analyses for efficient field experimentation, data archival and pedigree tracking for breeding programs, and later the management of molecular marker data through the International Rice Information System (IRIS). Under the IRRI-CIMMYT Alliance, this has expanded to become the International Crop Information System (ICIS) and a part of the Crop Research Information Laboratory (CRIL), focusing on tools to archive and exploit rice, wheat and maize data.

Crop agronomy and resource use

Exploiting the genetic potential of modern rice varieties through good crop management and sustaining high yields are major research emphases in Asia where land and water resources available for cropping are fixed or declining. Growing practices have been improved through site-specific nutrient application, and techniques to manage water, weeds and pests. Recent emphasis has been on cost reduction by direct seeding, and improving water and nutrient use efficiency. The long-term continuous cropping experiment, established at IRRI in 1963, continues to provide valuable information on trends in output of three irrigated rice crops per year (now in its 135th continuous crop season). It is one of several long term trials that IRRI conducts, some of which address emerging cropping systems such as rice-maize.

Crop protection and IPM

IRRI has led the way in breeding for genetic resistance to the common rice diseases (especially rice blast, tungro and bacterial blight) and insect pests (especially brown plant hopper, borers, and rice gall midge). It has led the way in Integrated Pest Management (IPM) research on pest control, with very significant environmental benefits. For example, from the mid 90s to 2008 the IRRI Experimental Farm reduced its insecticide application by 95%, but has concomitantly reduced the incidence of insects and insect-vectored diseases. Over the past 5 years IRRI's resources allocated to IPM and crop protection have diminished, and some of the earlier gains in IPM are being eroded by inadequate national policies.

Irrigated vs. rainfed rice environments

Globally, around 52% of rice area is irrigated, 39% is rainfed lowland and 9% rainfed upland. Initial emphasis at IRRI was rightly placed on improving outputs in irrigated rice environments that provide about 70% of the global rice harvest. In the 80s attention turned increasingly to rainfed production systems needing stress tolerant germplasm and water conserving production practices suited to less favored growing conditions. These have produced encouraging results in rainfed lowland environments, but research investments in the uplands have had less tangible impact. Upland environments are spatially variable, characterized by complex farming systems, high risk, low fertility (and low input use), drought, fragile shallow soils, and poverty. A recent Science Council-commissioned review of upland rice research at IRRI recommended that IRRI continue investment in 'rice in the uplands' rather than upland rice, implying that the most marginal of upland environments be ignored. Because of the location specificity of upland farming systems, participatory variety selection has proven useful in selecting suitable varieties.

Nutritional improvement of rice

From the mid-90s there was a growing consensus that improvement of the micronutrient and vitamin levels of rice grains at no cost to yield was an efficient way to improve the nutritional status of consumers who obtained a significant proportion of their calories from rice. "Golden Rice", with its transgenically-enhanced levels of β-carotene first reached IRRI in 1999, and the trait is being transferred to regional megavarieties by marker-assisted backcrossing. In collaboration with the HarvestPlus CP, IRRI has also developed iron- and zinc-enriched rice varieties.

Social Sciences

A social science capacity has been part of IRRI's research approach since the late 60s. It has provided analyses of the economics of new rice technologies and constraints to adoption; tracked the extent and impact of the adoption of new technologies; and provided a careful assessment of world rice statistics and the implications for rice research. In more recent years IRRI's social scientists have done further work on rice policy issues, provided analyses of the ways that rural livelihood patterns and gender roles interact with the uptake of rice technology, and provided evidence of the impact of IRRI's research. IRRI's social scientists face an increasing challenge of finding sufficient resources to provide an accurate picture of the rice sector, conduct ex-ante analyses of proposed research and assess the impact of technologies developed by IRRI.

Training

Trained manpower is an essential component of competent national rice research systems, and IRRI has over 14,000 alumni that have received training at the Institute. Today, because of funding constraints and changing needs, courses are fewer in number, shorter in duration, and focused on specific aspects of research. Many courses are conducted within country or region rather than in the Philippines. IRRI, through its digital online Rice Knowledge Bank, has created a wide array of internet-based training opportunities. IRRI has also placed its extensive in-house publications on line where most NARS researchers can gain easy access. This has been supplemented by the launch in 2002 of *Rice Today*. However, the reduced training effort in recent years is a concern given the age demographics of rice researchers in some key rice producing countries. A new generation of rice researchers is urgently required with a commitment to field work and efficient research skills.

Strategic partnerships, Africa and the CGIAR change process

Initially IRRI's partnerships with the NARS were networks with IRRI at the hub. These have matured to more nearly equal research partnerships through INGER and, more recently, through a series of consortia in which IRRI is the facilitating institution but is otherwise an equal partner with participating institutions. These consortia are key components in mediating IRRI's impact among its client countries. The two most important of these are the Consortium for Unfavorable

Rice Environments (CURE), established under a different name in 1992, and the Irrigated Rice Research Consortium (IRRC), established in 1996. An elaboration of existing consortia could provide a model for varietal development in target environments.

At the research Center level, the IRRI-CIMMYT Alliance (ICA), established in 2005, has brought resources of both Centers together to focus on sustaining the emerging rice-maize rotation of south Asia, and building on the successful Rice-Wheat Consortium that has involved IRRI and CIMMYT as partners since the 90s. The ICA also fosters the archival and analysis of crop research data, and the sharing of information and knowledge of rice, wheat and maize. In 2007 a formal agreement was reached between IRRI and WARDA on a joint strategy for improving rice production in sub-Saharan Africa (SSA), an agreement with far-reaching consequences for germplasm improvement and distribution, small-plot mechanization and improved growing practices. Further alignment in programs occurred in 2008 with the joint development of the East and Southern African Rice Program (ESARP). Transaction costs of such inter-Center alliances are high, and means must be sought to minimize them. However, they presage a much larger change underway in the CGIAR as it proposes to move towards a central research Fund, a consortium of crop Centers, and a centralized governance model with a CEO and a Board.

Institute staff, governance and research management

Today's staffing levels (102 IRS and 828 NRS) are quite similar to those at the time of the last EPMR, after significant reductions in the 90s. Approximately 10% of IRS and 7% of NRS are deployed outside of HQ. Changes in the Board of Trustees' size and function over time have been relatively small. Numbers have remained unchanged at 15 over the last 5 years, and there have been only slight changes in the Committee structure. Center research management has been vested primarily in the Director General since IRRI's inception. Today IRRI has two DDGs (Research; Operations and Support Services) and two Directors (Program Planning and Communications; Management Services). IRRI has long maintained a matrix management structure for scientific staff. In 2004 the Institute had five major Organizational Units and five smaller units, four research programs and 10 projects. Since that time, the Institute has undergone an extensive Strategic Planning Process, leading to the identification of seven Programs, supported by three Research Divisions, two research centers, two large units and two small units. The Medium Term Planning process, in place since the mid-90s, has provided additional endorsement of the Program structure, but the matrix structure of program x division remains.

Funding

IRRI's annual budget grew rapidly in the 70s, and was stable from 1978 through 1997, reaching a peak in the early 90s. From 1994 through 2004 the Institute budget fell by 50% in real terms, its fluctuations being buffered by a large reserve fund accumulated in the 90s (see Figure 1). The budget has expanded again in recent years and is projected to reach US$59 M in 2009. One major change has been the decline in unrestricted funding from 49% of Institute budget in 1997 to a predicted 21% in 2009. At the same time, the proportion of flow-through funds to collaborators has increased. Though the unrestricted budget has stayed relatively constant at US$12-15 M during this period, this emphasizes the critical need for full cost recovery from all specifically-funded projects, something that donors are coming to accept. A recent change of major significance is the additional restricted funding coming from a single donor, the Bill & Melinda Gates Foundation (BMGF). The contribution of BMGF will reach US$19 M in 2009, or 32% of the Institute's budget. Finally, IRRI needs to renovate, modernize or replace its basic facilities, many now more than 40 years old. The newly-formed IRRI Fund it is already making provisions to raise funds for such a step.

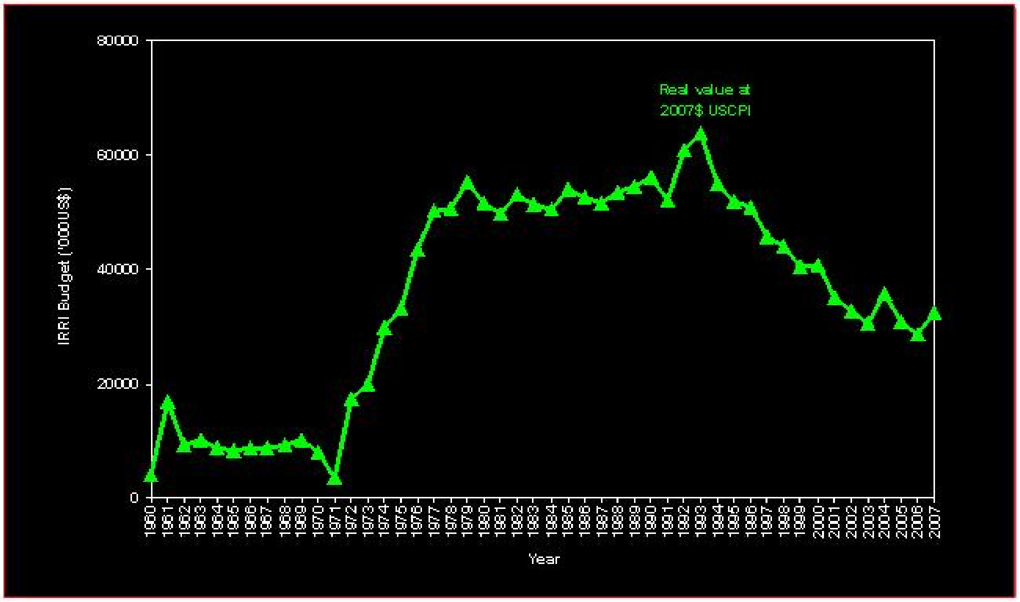

Figure 1 Historical funding to IRRI (million US$) showing the substantial decline in the period 1993 to 2003

1.3 Rice in today's world: the challenges of production and demand

Current statistics on population and rice production are summarized in Table 1.1. Almost 91% of rice production is in Asia, with 29% in China alone. SSA produces 2.3% of global rice supply, and South America 3.6%. Since 2000, global rice production has been growing at an annual rate of 1.56% (9.5 m tons/year) with 87% of that increase derived from Asia. Growth rates over the same period have been 2.1% in Asia without China, and almost 6% annually in SSA.

Table 1.1 Population and rice production statistics averaged for the period 2005-2007. Caloric intake is for 2004 (Source: IRRISTAT, 2009; US Census data).

	World	Asia	Asia without China	South America	SSA
Population (m)	6554	3678	2336	382	746
Calories from rice (% total)	20	30		11	8
Production (mt)	642	582	398	23	15
Area (m ha)	156	139	110	5	9
Yield (t/ha)	4.12	4.19	3.63	4.30	1.80
Imports (m t)	27	13		1	8

Area increases over the same period have been non-significant in Asia, but have increased in SSA by 3.8% annually. IRRI estimates that an annual increase in global rice production of 10 m t will be needed over the next decade.

Since significant area expansion is likely only in SSA and South America, increased yields in Asia must be the source of its increased production. Rice yield has increased annually over the last eight years by 1.1% for the World, 1.1% for Asia, 1.6% for Asia less China, and 1.9% for SSA. Rates of yield gain are slightly less than that for population increase, which is of concern to IRRI. Rice accounts for 30% of caloric intake in Asia vs. 8% in SSA. More than one-third of SSA's rice consumption is imported, accounting for 30% of world rice trade.

Exports and imports of rice grew at around 4% annually from 1990-2007, but the rice market is exceptionally thin when compared with other major grain staples and only 4% of production is traded. This means that changes in supply and demand can drive significant price fluctuations, as happened in 2008. Gradually, over the past decade, rice stocks have declined and the volume traded increased. Policies that lead to a stabilizing of rice price fluctuations are urgently needed, and the need to produce more rice on less land and with less water seems certain to increase in urgency as time passes, particularly in Asia.

1.4 IRRI and its partners

In fulfilling its rice research for development mandate, IRRI cannot carry out its work in isolation. It operates through strategic partnerships, especially ones with national agricultural research systems (NARS) and NGOs in rice-producing countries. These rely on IRRI to supply new rice germplasm, resource-efficient and profitable production techniques, and suitable policies that enhance rice production in a manner that benefits the poor producer and consumer alike. Because of the importance of these partnerships, the Panel has visited a sample of key stakeholders, NARS and regional research programs to assess the strength, relevance and quality of this collaboration (Annex 4). Secondly, as a leader of cutting edge research in rice, it must also forge research agreements and alliances with advanced research institutes (ARIs), including sister CGIAR research Centers. A third critical series of partnerships is with investors. These are donors who see IRRI as best positioned to meet the longer term rice needs of the world's poorest producers and consumers. Finally, IRRI has a growing number of partners in the private sector that facilitate exchanges of technology and germplasm.

Research on crop production is a decades-long process, so stable and adequate donor support for IRRI's research and development programs is vital to its long-term research success. Equally important are sustained and healthy partnerships among collaborators based on trust and confidence in IRRI's products.

1.5 Progress since the last EPMR

The 6th EPMR, completed in 2004, made ten recommendations, and in general IRRI has attempted to carry these out with commendable dedication.

The first recommended that "IRRI stimulate the global community to establish gene-trait linkages in carefully selected germplasm….making results available to all….". In response, IRRI has used the International Rice Functional Genomics Consortium (IRFGC) as a vehicle for generating gene-trait linkages in collaboration with ARIs and NARS. Much of the emphasis has been on generating mutant populations focused on mapping abiotic and biotic stress tolerance, and microarray-based mapping – much of it in collaboration with the Generation Challenge Program (GCP). A total of 260,000 SNPs were identified from 20 diverse rice lines under the OryzaSNP project. This project will form the basis of an association genetics platform to evaluate diversity in 2000 rice lines. The Panel considers good progress has been made, but notes that the systematic application of molecular markers for selection remains to be validated and implemented.

The second recommendation requested that IRRI "link the high yield research in intensive rice production systems in Project 5 (water productivity) with the challenge of achieving higher yields in the most intensive production systems in the context of diminishing water supplies…… that IRRI extend its modeling and GIS research to optimize water-saving technologies..". These activities have been combined under the current Program 2. Three high yielding parental lines under aerobic conditions have been identified, and progeny evaluated under mild drought. Alternate wetting and drying (AWD) methodologies have been refined, and IRRI's rice model, ORYZA2000, is being further refined for irrigation management scenarios. The Panel considers that good progress has been made, and AWD has been adopted in parts of Vietnam and the Indo-Gangetic Plain (IGP). More extensive testing of aerobic rice segregates under representative conditions in NARS locations is highly desirable, given the projected future value of AWD methods.

Recommendation 3 asked that "IRRI include the results of ex-ante impact studies in unfavorable environments in its priority setting…. and that less emphasis be placed on uplands with low production potential…. and more emphasis on favorable non-flooded rice systems". An ExCo recommendation has led to a continuation of research on upland rice under the paradigm of "rice in the uplands". Formal ex-ante analysis of upland work has not yet been conducted, but the STRASA project (Stress Tolerant Rice for Asia and sub-Saharan Africa) funded by the Bill & Melinda Gates Foundation (BMGF) requires that this be done as a project requirement. This research has been transferred now to Program 1. The Panel regards IRRI's decision to continue working for upland environments within the context of Program 1 (Unfavorable environments) as the appropriate response, and the availability of donor funds to conduct this research is encouraging. IRRI however needs to carefully evaluate their continued commitment to this work in light of impacts.

In the fourth recommendation, IRRI was asked to move studies on constraints to adoption of improved rice technologies to the programs that were responsible for generating those specific technologies. Analysis of constraints to adoption has been moved to Programs 1 and 2, and Program 7 (Rice policy support and impact assessment for rice research) has been established to formally assess impact and develop appropriate policies. The Panel considers IRRI's response adequate and appropriate, though notes that Program 3 (Africa) merits similar attention in the relatively near term.

A fifth recommendation addressed the declining strength and effectiveness of INGER, and asked that IRRI establish a forum of rice-growing countries with the purpose of financing and revitalizing INGER. In response, IRRI organized INGER-related training courses in the Asian region, and formed regional clusters of INGER, linking them to WARDA and CIAT. After years of decline, the number of entries submitted by national programs for testing and sharing has increased in the last 2-3 years. The Panel finds that INGER is still a weakened vehicle for germplasm exchange among NARS partners, and has limited functionality as a wide area testing network. Further action is needed to strengthen and improve the effectiveness of this network if it is to provide appropriate feedback to IRRI's breeding programs.

Recommendation six proposed that IRRI commission a study ….“to assess the relative merits of the current model with some outreach activities and the majority of scientists in headquarters, as compared with a model with increased outreach research staff in all those rice producing countries where close proximity and visible presence are deemed necessary”. The Institute responded by conducting a CCER on optimal staff placement in outreach, and as an outcome IRRI established regional offices in the Greater Mekong subregion (GMS) (covering also two southern provinces in China, and based in Laos); and in South Asia, based in India. A third based in Tanzania is being established in 2009. The GMS office was established and closed a year later, in part because in IRRI’s view its Los Baños Headquarters could be an effective and lower cost hub for this region. In eastern and southern Africa, the regional office has been established initially Mozambique and will move to Tanzania. The Panel finds that IRRI has pursued a regional decentralization policy with mixed success and determination, and should carefully review its commitment to this process.

Recommendations seven through nine related to governance. Recommendation seven asked that the Nominating Committee develop a list of Trustee competencies required by IRRI over the next 5 years and use this to develop a list of potential candidates for vacancies and for second term renewals. This has been completed and is in use, and the Panel finds that selection of Trustees to be very satisfactory. Recommendation eight asked that IRRI provide members of the Finance and Audit Committee with monthly cash flow, investment, income and expenditure summaries, and quarterly financial data on projects. The decision has been taken by the Board to send these reports quarterly, one that the Panel believes is sensible. Recommendation nine requested that IRRI develop updated Investment Portfolio Guidelines and management guidelines and establish a system of risk assessment, risk management and reporting**.** This has been satisfactorily completed, and IRRI has established an office of Risk Management and Quality Assurance that reports to the Director General on any risks to the Institute’s financial and general security, its research process or to its reputation. The Panel is impressed by the Institute’s response to the need expressed by both the 6th EPMR and key donors for improved risk management and quality assurance.

The final recommendation requested that the two programs focusing on unfavorable and favorable rice environments become the flagship projects for IRRI with strong and articulate leaders who would have considerable powers over budget and staff numbers. This has essentially been carried out, and the two Programs (1 and 2) have already received substantial external support through the BMGF-supported projects STRASA (for stressed environments in Asia and Africa) and CSISA (for intensively cropped favorable environments in Asia). The Panel finds this a sensible division of work and notes that both programs are similar in size and profile – an appropriate outcome.

Other major milestones since the last EPMR are the successful development and implementation of the Strategic Plan, and the subsequent MTPs. IRRI has a new DG, Dr Robert Zeigler and successfully accomplished the transition from the previous DDGR, Dr. Ren Wang to the incumbent, Dr. Achim Dobermann ensuring that research momentum has been maintained. The Panel congratulates IRRI on its management of this transition.

IRRI has a long and rich history, and an enviable record in research effectiveness, efficiency and impact of which it can be justifiably proud. In a rapidly changing world, the future success of the Institute will depend on its ability to accommodate change while adhering to its core values.

2 RESEARCH PLANNING AND THE CHANGING CONTEXT FOR RICE SCIENCE

Rice is a staple food for half the world's population, and for the vast majority of the Asia's poorest inhabitants. The development, delivery and impact of rice-related technologies in farmers' fields and in markets are critical to their well-being, and will depend on a successful match of appropriate research outcomes with farmer circumstances.

2.1 IRRI's mission, strategy and priorities

These are expressed succinctly in IRRI's Strategic Plan 2007-2015 *Bringing Hope, Improving Lives*. IRRI's mission is:

> "To reduce poverty and hunger, improve the health of rice farmers and consumers, and ensure environmental sustainability through collaborative research, partnerships, and strengthening of national agricultural research and extension systems".

This translates to five goals that underpin IRRI's seven research programs. These are:

- Reduce poverty through improved and diversified rice-based systems
- Ensure that rice production is sustainable and stable, has minimal negative environmental impact, and can cope with climate change
- Improve the nutrition and health of poor rice consumers and rice farmers
- Provide equitable access to information and knowledge on rice and help develop the next generation of rice scientists
- Provide rice scientists and producers with the genetic information and material they need to develop improved technologies and enhance rice production

IRRI fulfils its mission through interdisciplinary, thematic and system-based programs, the maintenance of scientific strength in major disciplines, a willingness to explore new scientific opportunities, and the conservation and responsible use of rice genetic resources and other natural resources. As a publicly-funded institution, IRRI seeks to share freely its germplasm, technology and knowledge. Research planning and execution focus on partnerships with stakeholders, and encourage the participation of women in research and development. IRRI staff aim to fulfill these goals through innovation and dedication, while meeting high standards of excellence, integrity and accountability in science. Among other stated values is an adherence to a diversity of opinion, cultures and indigenous knowledge, teamwork and partnership and protection of the environment.

The alleviation of hunger and poverty through cheaper and more plentiful rice supplies is a central theme that will continue to guide IRRI as it focuses on the two major geographic areas of poverty – South Asia[1] and sub-Saharan Africa. The stewardship of natural resources is also an important guiding principle for IRRI's research agenda. Thus research priorities include enhancing productivity through the efficient use of water, and helping rice cope with water-related stresses such as drought, submergence and salinity in coastal or poorly irrigated areas. The seven programs and their relative sizes indicate where IRRI is placing most of its resources. In 2009 63% of IRRI's budget is allocated in almost equal amounts to Programs 1 and 2 (Unfavorable and Favorable rice environments), while 11% goes to Program 3 (SSA), and 4% to Program 4 (Rice and human health). Program 5 (Rice genetic diversity and discovery) attracts 12% of the budget, and 4% and 5% go to Program 6 (Information and Communication) and Program 7 (Policy support and impact assessment), respectively.

IRRI has clearly defined its mission, goals and values and has made them the yardstick against which the strategies of the Institute are translated into tactics. Institute priorities do not reflect the proportion of rice harvested under Programs 1, 2 and 3, but nor should they. Rather they reflect areas of research opportunity, potential impact on resource-poor consumers and producers, lack of alternative suppliers and donor interest.

2.2 Changes since the last Strategic Plan

Although the 2007-15 Strategic Plan foresaw a number of major changes in farmer circumstances, technologies and global research priorities, there have been several significant and relatively recent events and trends that could not have been predicted, and that could modify IRRI's strategies:

Rice price spike:

The price of rice doubled to US$350/ton from 2000 to 2007 as demand gradually overtook supply. However, increases in the first half of 2008 were almost three fold - a price spike that lasted for 3-4 months and peaked at around $1,000/ton before falling towards trend. Unfortunately, the underlying imbalance between supply and demand remains. IRRI, in responding to the price spike, helped focus international media attention on the relationship between research investments and yields, and in response a major donor increased its annual contribution.

[1] Regional divisions: South Asia: Bangladesh, Bhutan, India, Nepal, Pakistan and Sri Lanka. South East Asia: Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, East Timor and Vietnam. East Asia: China, Japan, Republic of Korea and the Democratic People's Republic of Korea.

Input price crisis

Other inputs used in rice farming, and especially those linked to the energy markets, also saw sharp price increases. Urea, normally US$300/ton, reached US$800/ton in May 2008, but had fallen to US$200/ton by December, 2008. High prices resulted in an estimated 35% drop in fertilizer applied to the monsoon rice crop in the Philippines. One favorable outcome was an increased focus on efficient application of nutrients by farmers.

Biofuel demands

Increases in oil prices in 2007-8 provoked broad debate on the potential of biofuels, especially crop-based ethanol and biodiesel. IRRI responded by examining possible uses of rice straw for bioenergy, since in some farming systems rice straw has little or no economic value. The debate has not altered IRRI's long term research priorities.

Donor trends

The 2007 Strategic Plan did not foresee the rapid rise in investments in rice technology by the Bill & Melinda Gates Foundation (BMGF). Its contributions, reaching an estimated US$19 M in 2009, have occurred at a time of increased commitments by traditional donors, especially Japan, USA, Canada and Australia. This provided new impetus for researchers and hope for resource-poor rice farmers, especially those in unfavorable production environments in south Asia and SSA. In responding to these challenges, and with the prospect of donor support for IRRI's endeavors in rice research, the Panel senses a new level of confidence among IRRI staff and management.

Rapid expansion in IRRI's research agenda in SSA

The new engagement, and the development of a research agenda for rice in eastern and southern Africa, have been direct consequences of the recent excellent collaboration between IRRI and WARDA. This has been at the management and scientist levels, and has aligned research strategies, boosted investor confidence and instilled in staff of both institutions a new sense of hope. The Panel recognizes collaborations of this nature take considerable and sustained effort, and often depend on key individuals before becoming part of the institutional culture.

Economic recession: impact on the poor and on funding

The current (i.e. 2009) global recession will likely generate a new tranche of consumers who will be less able to afford food, and farmers who are adversely affected by instability of prices for inputs and products. It could also lead to reduced donor support for IRRI over the next several years.

2.3 External challenges for rice research – the changing R & D environment

The development of appropriate research goals and methodology, and their likely impact are directly related to the biophysical, scientific and economic environment, the likelihood of success, and the availability of alternative suppliers – in short the environment in which IRRI's rice research is being conducted. IRRI's research agenda is shaped in part by these external factors and a number of these factors are considered here.

Comparative biology, genomics and molecular markers

The genetic improvement of the rice crop lies at the heart of IRRI's research strategy, and this process is being aided by molecular-level tools that are now becoming available. The publication of the fully annotated rice genome sequence for indica and japonica rice subspecies in 2003, and rice's small genome have made it the most highly studied crop genome. This in turn has also shed light on chromosome duplications, rearrangements and genome evolution which have led to the crop species we now know. New developments with potential for enhancing molecular breeding in rice are summarized in Box 2.1.

Where does IRRI fit in this picture? Despite extensive knowledge of gene order and sequences, the association of specific genes with function in the field and their expression and/or silencing are known for less than 1% of rice genes, and remains the challenge of 21st century biology. A recent project, the Oryza Map Alignment Project (OMAP) was launched to build a framework for comparative biology in the Oryza genus. IRRI has supplied germplasm to this project, and is well positioned to benefit from it. In proposing an International Functional Rice Genomics Project Zhang and co-authors (2008) [2] plan to "identify functional diversity of alleles for agriculturally useful genes" through collections of mutants, full length cDNA sequences and artificial miRNAs. This would require systematic phenotyping of the mutants and core collection of genotypes from germplasm collections in diverse environments followed by QTL analysis and QTL cloning. Precise phenotyping capability under field conditions is a unique contribution that IRRI could provide to this process. The generation of high quality phenotypic data sets from within the breeding program is seen as an essential step to association mapping studies and the implementation of genome-wide mapping and MARS selection schemes, and IRRI could set the standard for field-based phenotypic data for this crop species.

[2] Zhang, Q., J. Li, Y. Xue, B. Han, and X.W. Deng. 2008. Rice 2020: A call for an international coordinated effort in rice functional genomics. Molecular Plant 1: 715-719. et al. (2008) (to complete)

Box 2.1 New developments in molecular breeding

Large investments in molecular biology and molecular breeding are yielding an array of new genetic information and tools with considerable potential for accelerating the genetic improvement of the rice crop. Recent research on small regulatory RNAs has greatly improved our understanding of the control of gene expression and epigenetic phenomena. About 300 miRNAs have been identified in rice and many are conserved across species for function, sequence and target. Small interfering or silencing RNAs (siRNAs) are very numerous in rice (with over 200,000 identified) and are widely distributed across all chromosomes. Micro-array techniques have expanded greatly our understanding of development and whole genome responses to the environment, and sets of oligonucleotides from around 40,000 rice genes are now available on a single chip. Transcript abundance determined after the plant is subject to a specific environmental challenge can be tracked to specific genes, though considerable care must be exercised in managing the intensity and rapidity of that challenge. Transcript abundance of gene families can now be mapped as an expression QTL and used in marker-assisted selection (MAS). With the advent of high density maps and relatively cheap high throughput assays for single nucleotide polymorphisms (SNPs), whole genome marker approaches to selection of traits and varieties are increasingly feasible. In industry it is not uncommon to have genetic maps of thousands of SNP markers available for whole genome scans, and these can be used during marker-assisted recurrent selection (MARS). "Mapping as-you-go" offers real time QTL identification and use within a pedigree breeding system. IRRI's collaborators in the Chinese Academy of Agricultural Sciences (CAAS) are planning a 4500 SNP genotyping chip, along with a simplified system of SNP-typing suitable for NARS, as part of the BMGF-funded "Green Super Rice" Project. Other techniques also offer promise for rice breeding programs. With the development of the comprehensive rice map, around 1500 genes have been identified that are associated with traits of interest. Non-destructive DNA sampling of seeds can sharply reduce the number of segregants that are planted at each generation, and may be applicable to rice. Association mapping procedures have advanced rapidly, and now can be routinely conducted provided there is a marker-dense map of the crop genome available, accurate pedigree information to determine degree of relatedness, and high quality phenoptypic data available from diverse genotypes and environments.

Transgenic rice

Genetic engineering can be used to introduce genes, usually from another species, into the rice crop to provide additional but valuables traits. Research on transgenic research in rice is well advanced in Asia, and most countries now have biosafety regulations in place to manage the national testing and release of transgenes. Bt[3] versions of cotton have been released in a number of countries, notably India and China, and Bt rice is poised for release in China. Transformation techniques continue to become more predictable and routine. Current research is resulting in greater control of the insertion location, the number of copies inserted, and the selective deletion of targeted transgenes. There remains much public resistance to GM technology in Europe and in parts of SSA, but rather less resistance in Asia, largely because of the success of Bt cotton. Asian governments are still hesitant to release GM versions of staple food crops, especially rice, if these are to be exported. Societal anxiety concerning safety of transgenes is reflected in the exorbitant price of the information package needed to deregulate transgenes in most countries. However, for unique traits such as specific forms of insect and herbicide resistance, and for grain nutritional quality, transgenics offer a unique and highly effective solution. IRRI has had a long history of involvement in rice transgenic research. The question therefore arises as to whether IRRI should promote transgenic technology alongside its conventional breeding approaches, and take more advantage of the considerable body of information and technology being generated in this field. IRRI could join forces with other independent public sector institutions like the CGIAR, Rockefeller Foundation and BMGF to encourage multinationals to provide expanded technology sharing and royalty waivers, especially for the poorest countries in Asia and SSA. The negotiated waiver of intellectual property constraints for high provitamin A transgenic rice (Golden Rice - see Chapter 3) provides an important precedent in this respect.

Intellectual property (IP)

Protection of IP through patents and other means is a mechanism of ensuring that investment in research continues, since royalties and proper attribution represent a type of return on investment. IP protection can also prevent loss of access to IPGs by NARS by ensuring that the technology remains in the public arena. New technologies, especially those associated with transformation and genomics, are normally fully protected, and access by IRRI and NARS is restricted and must be negotiated. In the next decade, the legal basis for determining genetic IP will almost all be depend on DNA-based diagnostic tests and, with this, the fear of theft of inbreds and transgenes from seed production fields will diminish. It is likely that some form of negotiated agreement for shared benefits will have to be worked out on a case-by-case basis in order to ensure appropriate access by resource-poor farmers where IPGs have been developed with proprietary genetic material.

Sharing of germplasm held in gene banks is similarly constrained by IP considerations. Plant

[3] Bt refers to a gene from *Bacillus thuringiensis* which encodes a proteinaceous insecticidal endotoxin. Incorporation of the gene into plants provides can induce resistance to certain insect pests.

Variety Protection (PVP), a mechanism for allowing the institution that develops a variety to manage its distribution and to get appropriate attribution, is under discussion at IRRI. Adopting PVP will allow IRRI to collaborate more effectively with the private sector. Constraints are also placed on the sharing of accessions in Gene Banks. In 2007, designated germplasm held in trust in the IRRI genebank was placed under the purview of the International Treaty on Plant Genetic Resources for Food and Agriculture. Any shipment of seed from the gene bank or from NARS through INGER must be accompanied by a Standard Material Transfer Agreement (SMTA). A growing fear of the loss of IP was a disincentive for germplasm exchange through IRRI's International Network for Genetic Exchange in Rice (INGER), and led to a reduction in NARS entries in networks such as INGER. More recently, the SMTA provision has reassured NARS that adequate protection is in place, and numbers of NARS entries shared through INGER is again increasing.

Environmental degradation

The quality of soils and water has major effects on the sustainability of rice production. One review[4] of soil degradation concludes that in Asia the quality of more than half the soils used for production has been stable for the past 50 years. Degradation in the remainder has resulted in an overall 13% decline in productivity of crop land. Degradation is mainly through poor irrigation practices and erosion on slopes. Compaction from puddling of rice crops is a challenge to rice-wheat and rice-maize rotations on irrigated land. Salinization of soils has reduced productivity in semi-arid areas where irrigation water is scarce or expensive, such as Pakistan, NE Thailand and China. Future projections using IFPRI's IMPACT model suggest that the net effect of soil degradation over the next decade will be a significant loss of income on marginal sloping soils in areas of high population density (e.g., hills of Nepal). The most severe losses in soil quality may be under rice-wheat and rice maize systems using conventional tillage, where losses in soil organic matter can be expected, and the need to remove residues from these systems for forage and biofuel should be carefully assessed. Because land area is extremely limited in Asia, there will be a need to focus research on the long-term nature of these changes, and the costs associated with reversing them – emphases that fit well with IRRI's long-term trials philosophy. Most soils in SSA are considered degraded with a low fertility status, and there continues to be a net loss of soil nutrients from the region because of the very low rates of nutrient replacement. Erosion on slopes has benefited fertility of many valleys where rice is grown. Expansion in land area suitable for rice in SSA has no immediate constraints, though infrastructure to support such an expansion is lacking. Clean drinking and irrigation water are becoming increasingly important. High levels

[4] Scherr, S.J. 1999. Soil degradation: a threat to developing-country food security by 2020? Food, Agriculture, and the Environment Discussion Paper 27. IFPRI, Washington D.C.

of nitrates have already been detected in the groundwater of the Indian Punjab and in areas of China. Upper limits on rates of application of N and certain classes of pesticides will almost certainly be introduced in the more intensive Asian farming systems in the next decade. Water quality is of concern in the heavily industrialized areas of east and south Asia, and in areas where high levels of natural contaminants in irrigated water (e.g., arsenic in Bangladesh and Myanmar) result in elevated levels in harvested grain. Finally, methane and nitrous oxide emissions from rice fields, because of global warming considerations, may well attract greater attention of researchers and legislators in Asian countries over the next decade.

Water resources and the relative importance of rainfed systems

Because rice is a semi-aquatic grass, a sustained water supply is especially essential to its growth, and an estimated 75% of the world's rice production comes from irrigated fields. About 150 m ha of irrigated land, or 59% the global total, is in Asia. In SSA, irrigated land totals 6 m ha, with nearly three-quarters of this in three countries (Sudan, South Africa and Madagascar). Yields of irrigated areas are often twice those of rainfed areas. Further expansion of irrigated area is restricted by fresh water supplies, and demand for water for domestic, recreational and industrial uses. Limitations to irrigation in Asia are mainly because of the low efficiency of irrigation systems due to poorly maintained irrigation infrastructure rather than to a physical shortage of water. Nevertheless, increased demand for irrigation has seen water tables fall steadily with time in the IGP, and the development of large scale water diversion systems in China to supply its dry northeast region.

IFPRI has projected water use to 2025. Predictions suggest that under a "business as usual" scenario, despite a need to increase rice production in Asia by about 15-20% in the next decade, the use of water for irrigation in Asia will increase by only about 4% [5]. In short, there will be considerable pressure placed on irrigation water supplies, and an increased incidence of drought stress is one likely outcome. Historically rice area has increased at 0.3% annually in Asia, and this is also the predicted rate of increase in total irrigated land area. The availability of stable, adapted drought tolerant rice cultivars with high yield potential is a key component of stabilizing or increasing rice production under this scenario. The type of crop and its agronomic management affects water use. Transpiration efficiency of rice is lower than most other C_3[6] cereals and about 50% that of C_4 cereals. When rice is grown under flooded conditions, loss of irrigation water in

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[5] Rosegrant, M.W., Ximing Cai, and S.A. Cline. 2002. Global water outlook to 2025: averting an impending crisis. IFPRI, Washington DC. 36pp.

[6] C3 and C4 refer to two different types of photosynthesis commonly found in crop plants

paddies through drainage and evaporation may reduce the water use efficiency of rice to one third of cereals that grow in aerobic soil environments. In summary, water resources available to rice in Asia will come under growing pressure from increased demand and alternative uses, and will be exacerbated by climate change. Irrigation resources in SSA are still poorly developed, with 75% of the irrigated area concentrated in three countries (only one of which has a significant rice area). The implications of these trends for IRRI are an increasing need for improved water use efficiency and drought tolerance in lowland rice, and growing practices that minimize water wastage. It seems inevitable that there will be increased emphasis on production in rainfed lowland and upland environments as well.

Intensification of cropping

In the absence of irrigation, rice is normally grown once a year, during the rainy season. As irrigation has become available, a second rice crop has become possible during the dry winter in the lowland tropics. In cooler winter climates, such as the Indo-Gangetic Plain (IGP), the preferred winter crop has been wheat. Today the rice-wheat rotation is estimated to cover 17 m ha in the IGP and in southern China, and is extremely important to regional food security. Sustaining and increasing productivity of this important cropping system is the focus of the Rice-Wheat Consortium, facilitated by IRRI. Wheat root growth is constrained by puddling requirements of rice, and long-term studies of rice-wheat cropping systems in the IGP have shown a small but significant decline in rice yields over time. Rice-maize rotations are also found in areas with milder winters (e.g., Bangladesh), and may result in a loss of soil organic matter over time compared with a continuous rice rotation. The trend to intensification will undoubtedly continue, especially in Asia, as additional irrigation resources or shorter duration crops become available.

Consequences of climate change

There is a broad consensus emerging that climate change is underway. By 2050 temperatures in Asia are expected to have risen 2.5-3.0 ^{o}C, with increases being greater in the winter than the summer, especially at night. This will shorten the duration of present rice varieties and reduce their yields, while higher temperatures *per se* call for added drought and heat tolerance. Summers may well become drier and hotter. Predictions suggest a 15% increase in irrigation demands in SE Asia, and that the monsoons of tropical Asia will become more variable. Warmer winters in the IGP over the past decade have led to low wheat yields in Bangladesh, accelerating the expansion of winter maize. Increases in night temperature and declining daytime radiation could also arise from "global dimming", caused by atmospheric aerosols, dust from land preparation and industrial activity, and smoke from burning crop residues and dung.

Other consequences of predicted climate change in Asia are changes in the balance and incidence of pests (and their predators) and diseases, and an increase in storage insects. Sea level rise may threaten rice areas in low lying river deltas found in parts of Bangladesh, Myanmar, India, Vietnam and Thailand. Saltwater intrusions from typhoons will become more frequent, and salt tolerance in rice grown on flood plains will likely be useful insurance. Since rainfall variability will increase, submergence tolerance will be a valuable trait. Policies increasing carbon sequestration through reduced tillage, biofuels, residue incorporation and biochar production could affect rice management practices in Asia. There are some benefits from climate change: increasing atmospheric CO_2 will result in a 1-2% increase in C_3 crop yields in the next decade, and rice could to be cultivated at higher elevations as temperatures rise. However, the net effect in Asia and SSA is likely to be increased food vulnerability of resource-poor farm families living in their present locations. Major impacts are not predicted to be felt until after 2030. This scenario portrays a need for IRRI to focus on increased tolerance to heat and abiotic stresses, and a need for active research in tracking changes in insect and disease incidence. By anticipating likely changes now, it seems probable that rice breeding can keep up with the pace of climate change at least for the next few decades.

Global focus on sub-Saharan Africa (SSA)

In comparison with Asia, SSA is generally characterized by low crop yields, low input use, poor infrastructure, lack of irrigated land, weak institutions, a lack of rice researchers, political instability, weak seed systems and a poorly developed private sector. Increasing crop production in much of SSA is therefore quite challenging. The increased demand for rice in this region has already been noted (Chapter 1). IRRI has responded, and is in the process of committing significant resources to improving rice production in the region. It would be misleading and perhaps dangerous to make simple comparisons between conditions in SSA and Asia in its pre-Green Revolution days. There is, however, considerable potential for rice cultivation and extensive areas suitable for irrigation exist. WARDA has had many years of experience in West Africa, and has developed indica x *O. glaberrima* crosses – the New Rice for Africa or Nericas – that are early maturing and well suited to rainfed conditions. For IRRI, appropriate rice research for SSA will be significantly further downstream than for Asia, focusing on basics of good crop management, robust labor-saving machinery, development of stress-tolerant varieties, the training of researchers and establishing simple and reliable seed systems. There is significant donor interest in IRRI's programs in eastern and southern Africa (see Chapter 3).

Information and communications

In the past two decades the storage and manipulation of data, and our capacity to communicate electronically, have been revolutionized. These sweeping changes are very obvious in Asia, but they are having profound effects in SSA as well. Computing power continues to increase exponentially and decline in price, and our capacity to store and manipulate data is no longer a limitation. Our ability to analyze, digest and interpret this information, however, continues to remain a major constraint to its use. There has been a revolution in telecommunications in the developing world in the past decade. Cell phones will soon become a major portal for internet access in the more remote areas of Asia and SSA. In the next decade it is not unreasonable to envisage an extension officer accessing the Rice Knowledge Bank by cell phone while standing in a farmer's rice field. There are greatly enhanced opportunities for distance learning, and for data entry in real time. For IRRI, this suggests that current investments in simplifying the IRRI website portal should yield immediate benefits, and tools to assist in the selection of priority information will be a continuing task. Real time data entry from remote sites will allow more timely analysis of information needed for breeding decisions. Transaction costs among the widely distributed partners of IRRI's consortia and among sister institutes should continue to fall as videoconferencing via public internet software becomes a viable alternative. Special relationships between IRRI and large information management companies could drive these costs even lower. Most of IRRI's publications and key library accessions will be available as downloadable documents on their website in the future, a development that is already well underway.

The private sector

Commercial enterprises affecting rice production are mostly related to information availability and input supply, especially seeds. Private companies such as Google have shown a willingness to share information technology with public organizations such as IRRI. The private seed sector has rapidly expanded in Asia from its foundations in the 1970s, based on millet and maize seed hybrid sales. A similar picture is beginning to emerge for rice as hybrids gain momentum. Most of the private Asian rice seed companies are based in China and India, but there are small to medium sized national seed companies involved in production and sale of seed throughout Asia. Most of the companies in the subcontinent and south China are using IRRI germplasm or depend on an IRRI inbred as one hybrid parent. Hybrids currently on offer in Asia are largely developed by private seed companies in China who mainly develop their own lines and hybrids. Relatively few regional seed companies outside China selling hybrids have true breeding programs, depending instead on inbreds from the public sector, or on imported and repackaged hybrid seed. Some national seed companies have developed their own biotechnology capacity, or have entered into technology sharing agreements with multinational seed companies.

Multinational seed companies selling rice hybrids are active in Asia, have their own breeding programs and move seed internationally. Multinationals have several advantages over national seed companies that make them more closely resemble IRRI: access to global germplasm resources: yield and stress tolerance genes that can be introduced from any continent or program; access to data from large regional testing networks; rapid data turnaround; high quality seed; molecular breeding technologies integrated into breeding programs; access to candidate genes and to transgenic technologies, financial resources and marketing experience. All this makes them formidable competitors. Yet food security concerns argue strongly in favor of a strong set of national or regional seed companies that sell a superior seed product in a national or niche market. Public sector seed suppliers provide a lower cost product, but too often it is also of lower quality. For IRRI, connections with the private sector are becoming more intense, and the Hybrid Rice Research and Development Consortium (HRDC) is providing an interesting prospect of a win-win-win outcome for IRRI, private companies and rice farmers. IRRI is also collaborating with several seed companies through Scientific Know-how and Exchange Programs (SKEPs). While successful examples of public-private partnerships are still rare, IRRI can reasonably expect them to become a more frequent and increasingly important requirements to fulfilling its mission.

CGIAR Change Process

A major reform in the CGIAR is underway, and this will directly affect the governance and possibly the priorities of IRRI's research. It is hoped that the new structure will improve coordination and collaboration among Centers and result in a significant increase in donor funds to the IARCs. The transition from the present structure will take several years. While the period under review was not affected by this process, IRRI's future operating environment could be altered substantially by its outcomes (see Chapter 8).

The donor scene

In the past four years the steady rise in food commodity prices has reinforced the relationship between poverty and food supply. The spike in food prices in 2008 further convinced donors that food security remains an issue. IRRI's interventions during that period helped convince donors that investments in research on rice productivity will take 10-15 years to "fill the pipeline". Nonetheless, donor contributions to support research on basic staples remains somewhat erratic. This is in part because of exchange rate fluctuations and a degree of uncertainty over the timing and scale of annual payments, making long term research planning difficult. The decision of the BMGF in 2005 to invest in agricultural research in the developing world has boosted the confidence of other donors as well. It is hoped that this, coupled with the new urgency engendered by price increases and the CGIAR Change Process, will result in a significantly increased commitment by the donor community to support the much needed research that IRRI has executed with distinction over the past almost 50 years. There is broad investor support for IRRI's research agenda, though milestones indicating progress towards reducing poverty on long term research programs are always valued by donors who must answer to their legislators. In general, donors are enthusiastic in their support for IRRI's commitment to Africa, recognize many of the challenges faced by IRRI as it enters this period of CGIAR reforms, and remain committed to supporting rice research for the poor. The current recession, however, will likely reduce donors' capacities to expand or even sustain their current level of support.

Final comments

The external factors shaping IRRI's research agenda call for a high degree of responsiveness and agility in Center research management, while IRRI, at the same time, remains committed to fulfilling its mission. Each of these factors could be formidable on its own, but the current IRRI Strategic Plan provides the Institute with an adequate set of guidelines as it tackles its changing operating environment. IRRI's experienced, talented and committed scientific staff and Center leadership, accompanied by prudent financial management, should allow IRRI to adjust well to these changes. IRRI's long experience in the rice sector, and its global leadership have helped it respond effectively to the recent price spikes, to distinguish short term fluctuations from long term trends, and to respond appropriately. IRRI, thus far, has been careful not to duplicate what the private sector in Asia is doing, and has developed a good working relationship with the seed sector, based on comparative advantage.

IRRI's investment in Africa is exposing the Institute to a different set of external factors, and infrastructural and institutional challenges. Its first step should be to understand these circumstances as fully as possible, from the farm and farmer to the policy maker, and adjust its tactics accordingly. This may be the right time to consider transferring resources from the stronger NARS in Asia to areas of greater need in SSA. The consequent move downstream in SSA, yet the need to access the best research tools upstream are calling for a more diverse set of skills and a broader range of expertise among Institute staff.

IRRI's focus on stewardship of natural resources, from germplasm conservation to water and soil conservation, seem especially appropriate in an environment of ever increasing crop intensification, loss of land to industry and erosion, and competition for water needed for crop production. In the near term it appears that IRRI's germplasm can be adapted adequately to the trends caused by climate change, provided the best available breeding methods are being employed.

Relationships will continue to be keys to IRRI's ability to fulfil its mission. Partnerships, already critical to IRRI's success, will become increasingly important, and new partners in Africa, in NARS and the private sector, and among donors and NGOs, will need to be engaged. Although there is an information and communication revolution underway, there is no complete technological substitute for face-to-face meetings and exchange visits among scientists – the human factor -- something that IRRI has facilitated to great effect in the past.

3 RESEARCH ORGANIZATION AND OUTPUTS

This chapter examines the way in which IRRI conducts its research, the results of that research, and how they are delivered. IRRI's research management structure is a matrix consisting of eight Operational Units (OUs) and seven Programs (see Annex 5). The Programs, defined in the current IRRI Medium Term Plan, are responsible for conducting relevant thematic research for development under a team structure that draws from the appropriate OUs. The OUs are responsible for ensuring high quality science. This chapter considers each Program and two types of Operational Unit: Research Divisions, and Research and Support Groups. In each case the narrative describes basic responsibilities and accomplishments and offers observations and suggestions for possible modifications. Further information on the infrastructure of the Research and Support Units is provided in Chapter 5.

3.1 Programs

Program 1. Raising Productivity in Rainfed Environments: attacking the roots of poverty

Rainfed rice systems cover a large area where rice yield is generally low and variable and poverty is prevalent. Most of the work conducted in Program 1 is for rainfed lowland rice ecosystems, reflecting the importance of this ecosystem in South and Southeast Asia. Some work is also dedicated to the upland rice system. In these rainfed farming systems, the major physical constraints for rice production are lack of water availability and adverse soil conditions, and hence research to overcome these constraints forms the major thrust of the research in the Program. The newly developed STRASA project has greatly broadened IRRI's activities in this research area in Africa and South Asia.

The Program focuses on genetic improvement and crop management technology for rainfed rice-growing environments. The Outputs (and number of IRS equivalents assigned to each one) are:

- Output 1 Germplasm and crop management for water-short rainfed environments (4.0)
- Output 2 Germplasm and management options to overcome submergence stress (3.0)
- Output 3 Germplasm with tolerance of salinity and other soil problems and suitable management options (1.75)
- Output 4 Germplasm and improved management for uplands (3.15)
- Output 5 Resource management for intensification and diversification (1.4)

In Outputs 1-3 the main emphasis is on selection of adapted genotypes, particularly using MAS, complemented by land and crop management research to minimize the adverse effects of drought, submergence, salinity and other adverse soil conditions. In Output 4, the approach is similar, with perhaps less emphasis on MAS and more emphasis on development of crop and natural resource management. Output 5, on the other hand, is focused solely on management options, although the use of earlier maturing varieties is often a key factor for intensification and diversification of rice based agricultural systems.

Output 1. Drought and aerobic rice

The program has identified promising lines that could have 1-2 t/ha yield advantage over existing cultivars under drought stress. Most breeding work is done by selecting directly for yield, and the use of other traits for indirect selection is so far limited. Some QTLs with large effects have been identified recently for upland and lowland rice but they need to be tested under varying drought conditions.

IRRI's Drought Frontier Project was formed after a meeting of a number of experts in the field in 2006 to promote drought research, particularly the development of drought resistant varieties. The project was originally supported by IRRI's unrestricted funding but currently it is supported by three grants. One is STRASA, which is a downstream project where varieties adapted to drought environments are screened in Africa and South Asia. Another is an upstream project funded by the Japanese Government where a large number of constructs are developed and tested by different international organizations, including IRRI, for transformation in rice. The third is funded by GCP for more physiology-based activities where large-scale screening is conducted for determination of superior root systems in rice under drought conditions and identification of genotypes with improved water uptake characteristics. This work is being conducted in collaboration with WARDA, NARES (India Drought Breeding Network) and several ARI partners and is well set for the difficult task of identifying drought resistant characteristics and lines that possess such characters.

One of the difficulties in selecting drought tolerant lines is the existence of a large genotype by environment (g × e) interaction for yield in rainfed lowland rice, and hence genotypes and traits that contribute to their performance are likely to be environment dependent. Better environment characterization for rainfed lowlands would assist identification of repeatable g × e and this will improve efficiency of the breeding program. Similarly, water stress and nutrient availability interactions is another important research area that could be emphasized further. For example, phosphorus availability decreases with loss of standing water in rainfed lowlands because of greater P sorption under aerobic conditions. The recent demonstration of the importance of *PUP1* in drought- prone areas are an example of this interaction. Continued efforts should be made to improve our understanding of these interactions.

IRRI headquarters is not located in a drought-prone area and this makes it difficult to work on drought problems under natural conditions. While some field work can be done to improve physiological understanding of drought, phenotyping facilities are limited at IRRI headquarters, and this slows down the progress in drought phenotyping. The Panel suggests that efforts should be made to utilize these naturally occurring drought hot spots as phenotyping sites in collaboration with NARES. (The need for developing adequate phenotyping sites is noted elsewhere in this Chapter as well.)

Output 1 also includes aerobic rice. The basic conditions for successful aerobic rice production systems, where rice is grown under favorable water conditions without standing water in paddies, have been identified. The key advantage of this system is a large saving of water for rice cultivation. However, recent work in IRRI indicates difficulties in sustaining high yield under continuous aerobic conditions. This is related to increased incidence of soil borne diseases and pests and problems associated with nutrient availability, and these issues deserve further attention.

Output 2. Submergence

The major focus here has been identification of the usefulness of a major gene (*SUB1)* for vegetative stage tolerance to submergence. The gene has been incorporated into several mega-varieties and their performance has been shown to be better than those varieties without *SUB1* in controlled experiments. Use of tolerant varieties with improved management methods are being further tested by members of CURE. New genes with additive effects to *SUB1* are being sought to improve tolerance to prolonged conditions of submergence. Tolerance to submergence at the germination stage will also be an important character for improved production in rainfed lowlands, particularly for direct seeded crops.

IRRI's key role in the mapping and cloning of *SUB1*, its subsequent incorporation in mega varieties, and the testing and promotion of those varieties is an excellent example of the value of international agricultural research, and the Panel commends IRRI on these accomplishments.

Output 3. Salinity and other problem soils

Salinity tolerant varieties have been developed through participatory variety selection (PVS) with the Bangladesh Rice Research Institute, and they are now being promoted through the national network. The traits associated with tolerance to salt stress are being identified and physiological and biochemical studies have elucidated mechanisms for such tolerance. Numerous QTLs have been mapped for both seedling and reproductive stage tolerance and some are identified as having major effects. They are now being pyramided into lines through marker-aided backcrossing. Crop and resource management options are also being developed and tested.

Professor Guy Kirk in his recent review (2007) of IRRI's research for soil nutrient and water quality proposed that the QTL for P-deficiency tolerance *PUP1* has real potential for making a breakthrough in rainfed lowland rice. Decreased phosphorus availability is a major constraint for rice production in rainfed lowlands, but proper deployment of *PUP1* can reduce this constraint. The Panel endorses further exploration of this opportunity.

Output 4. Uplands

Box 3.1 Uplands

Because of declining soil fertility and weed problems associated with continuous rice cropping in upland systems, weed control methods and rotations involving a legume have been major foci of research for uplands. Another area of focus is testing improved varieties through PVS, and a number of promising lines have been identified in several countries. Adoption of such varieties and the use of appropriate resource and crop management options for sustainable upland rice production have been promoted through CURE. Socioeconomic baseline studies have shown the importance of rice in upland ecosystems in Vietnam, Laos, India, Nepal and the Philippines. However, progress has been slow and the investment in uplands research is controversial.

Output 4 currently has an allocation of 3.3 IRS, but they are working at several locations. This division of resources is understandable, given the complexity and diversity of upland systems, but the strategy may not yield significant results. An IRS in a country program may not be fully supported from headquarters, particularly if the location is in a remote area as is often the case with upland research. Communication with headquarters is often limited, e.g. difficulty in accessing the IRRI library. In addition, IRRI requires strong NARES partners in upland rice research; there needs to be commitment and dependable provision of research infrastructure by the host country. One possibility is that the IRS works closely with the upland working group activities of CURE, so that there is a critical mass of resources available, particularly in the area of technology transfer

The Panel suggests that IRRI ensures a critical mass of scientists, adequate infrastructure (including strong support from host countries), and careful selection of priority upland systems if research on crop and resource management of upland rice is to continue.

Box 3.2 The Challenge of Upland Rice Research

Because of the relatively small upland rice area in Asia, IRRI's investment in this area had been small and the Science Council recommended discontinuation of research in upland rice as a result of a recommendation of the 6th EPMR. However, a major review by Franz Heidhues and Benjavan Rerkasem on IRRI's upland research in early 2006 was supportive of IRRI continuing upland rice research because, among other reasons, the area where upland rice is grown has serious poverty problems and IRRI's research involvement in uplands can improve the livelihoods of people in these areas. The report however acknowledges the difficulty of upland research due to lack of physical infrastructure and points out that because of complexity in upland rice ecosystems, outscaling of research results is difficult and hence the impact of research has generally been small. The report recommended that 3 IRS (breeder, agronomist and economist) work on on 'rice in the uplands', i.e. rice as a part of the upland farming system, rather than 'upland rice' as such.

One of IRRI's principal comparative advantages in upland rice research is its vast collection of upland rice varieties and landraces, and this effort should continue. Another advantage of IRRI's is its history of cooperation in rice research in many Asian countries. However, IRRI's comparative advantage is less obvious in upland-based ecosystem research in Asia where the upland rice area is much smaller than the area of rainfed lowland rice.

The review report's suggestion of 3 IRS for upland research supported from unrestricted funding may be difficult to fulfill with the recent budgetary restrictions. IRRI needs to marshal its available resources for carefully focused upland research. Variety development and its adoption can take better advantage of IRRI's investment in CURE. In order to effectively conduct research on crop and resource management in the uplands, a critical mass of scientists is required and their activities need to be strongly supported by IRRI and the host country. This implies some difficult decisions about where IRRI's uplands research should be concentrated. Because of the heterogeneity of upland environments and the important poverty linkages, tradeoffs will need to be identified and addressed. For instance, it might be argued that research should focus more on favorable flat valley bottoms where results are likely to be more transferable to similar environments, but such environments might not have as high a proportion of poor people as found in remote and steeply sloping upland rice areas. On the other hand, concentration on more isolated areas where rice is a higher proportion of poor people's incomes might lead to more measurable poverty impact, but in a much smaller area and with less chance of being applied elsewhere.

Output 5. Intensification and Diversification

Rainfed rice systems are more fragmented and diverse than irrigated systems. They have less intense land use with less chemical inputs, but are more fragile and need management that is often site specific. Output 5 examines intensification and diversification issues of rainfed environments against these backgrounds.

Adoption of earlier maturing varieties is a key for intensification of rice- based rainfed systems, particularly for areas with short and erratic monsoons. More systematic study of crop intensification and diversification is necessary. The Output currently involves little more than 1 IRS equivalent and no IRS appears to have a majority of his/her time allocated to this activity.

The Consortium for Unfavorable Rice Environments (CURE).

Under Program 1 CURE is the main vehicle for research partnerships between NARES and IRRI. Technologies developed by IRRI and others are being tested in appropriate areas through CURE. Technology adoption is also promoted through CURE. NARES partners may further modify the technologies and promote them within their own domain. Thus CURE constitutes IRRI's impact pathway for rice technologies for unfavorable environments.

One key aspect of CURE activities is testing new lines developed by IRRI, especially varieties carrying *SUB1* and *SALTOL*. Variety selection is done through PVS, facilitating the adoption of varieties that are eventually released. CURE works mostly on advanced lines that can be released into areas of good adaptation. Some varieties tested have produced higher yields than traditional varieties and have been well accepted by participating farmers. Similarly, a number of crop and resource management methods have been tested through CURE activities and some (e.g. use of older seedlings in salt affected areas) are well accepted by farmers in the test sites.

As CURE expands it will require more resources. Part of the resource requirements are met by NARES. As it expands its membership and covers the countries that IRRI has targeted, IRRI needs to ensure its own resources, particularly IRS, are efficiently utilized. For example, with so many sites CURE may require a full time IRS to organize its activities. Now appears to be a good time to consider the future of CURE, particularly in view of IRRI's growing involvement in technology transfer in the target countries. It may be that a joint arrangement for CURE and IRRC could pave the way for IRRI to be efficiently involved in technology transfer issues in its target countries. The Panel therefore suggests that IRRI further consider efficient partnership arrangements that are rice systems specific, through the frameworks of CURE and IRRC.

In addition, the Panel suggests that IRRI devote more resources to understanding and addressing the constraints to the delivery of the varieties that are tested and the crop management techniques that are developed at CURE sites. The site strategy is an excellent way of involving farmers and of providing a realistic assessment of the performance of new technology, but unless more resources are devoted to monitoring and evaluating the experience with these technologies on a wider scale then the full potential of the investment will not be realized.

In summary, good progress has been made in Program 1 in the development of varieties tolerant to abiotic stress for rainfed lowlands. Embracing marker assisted breeding and the development of sound crop management should be continued for key abiotic stresses. Improved, stress-tolerant varieties combined with crop management recommendations should be promoted for achieving maximum impact. Continued efforts should be made to improve knowledge on tolerance to various stresses and the environmental conditions that modify crop responses to a specific stress. This latter applies particularly to drought tolerance, and interaction between water and nutrient availability needs to be further elucidated. Upland rice activities should be carefully monitored and possibly re-oriented depending on resource availability; one option is to scale down the involvement in upland ecosystem research as such but strengthen CURE to partially cover that area, particularly where NARES involvement appears strong.

Program 2: Sustaining Productivity in Intensive Rice-Based Systems

Intensive rice systems account for over 70% of the world's production and are essential in providing affordable food for the world's poor. Raising productivity in these environments is a key element in stabilizing food supplies and prices. Program 2 is a cornerstone of IRRI's efforts for alleviating poverty across all of its target countries by the provision of improved germplasm and sustainable crop and soil management systems. The Program is thus a continuation of IRRI's long history and successes in providing superior germplasm and improved agricultural systems.

The Program is organized to achieve five inter-related outputs (with IRS equivalents):

- Output 1: Production of improved rice germplasm less affected by biotic and abiotic constraints, and provision of management practices to enhance yield potential and achieve sustainable productivity (8.5).
- Output 2: Provision of integrated management solutions for sustainable development through intensification, diversification, and water management (4.55).
- Output 3: Provision of technologies for improving environmental sustainability in rice-based landscapes through studies at the field to landscape level (0.7).
- Output 4: Provision of methodologies for adapting and mitigating changes due to climate change (3.3).
- Output 5: The dissemination of new technologies to facilitate greater uptake and impact of research through the IRRC, and to strengthen NARES consortia to facilitate the development of appropriate technologies (1.95).

The Program works through a network of strong partnerships built up over many years of interactions and trust with stakeholders. More recently the Program has been addressing emerging issues concerning the sustainability of rice production in terms of reduced water availability, the need to reduce the environmental footprint of agriculture, and uncertainties concerning the effects of climate change, particularly increases in weather extremes.

The Program seeks to exploit existing and novel germplasm using conventional and molecular breeding approaches to produce enhanced germplasm with better yields and enhanced biotic and abiotic stress tolerance adapted to existing and new improved agricultural systems. Products are delivered to clients through a number of formal partnerships, particularly INGER and the Hybrid Rice Research and Development Consortium (HRDC), although the extent of multi-location testing is currently quite limited in these networks. Production technology options are extended and adaptive research undertaken with NARES through consortia, including the Irrigated Rice Research Consortium (IRRC), the IRRI-CIMMYT Alliance (ICA), and the Rice Wheat Consortium (RWC) and the new project Crop Systems Intensification for South Asia (CSISA). As the availability of water is an increasingly major issue in these target environments, close links are being fostered with the Challenge Program on Water and Food. To meet the threats posed by climate change, it appears likely that there will be a on Rice and Climate Change Consortium.

Program outputs clearly match the aspirations and skills of IRRI. The program is well thought out and ambitious in its scope and breadth. It is well aligned to CGIAR priorities. It contains skilled and dedicated international staff and IRRI continues the long tradition of having a good cadre of dedicated breeders, agronomists, physiologists and support staff, well trained and motivated to succeed. The balance of resources to different activities appears generally appropriate, although the Panel has some concerns that IRRI's investment in hybrid rice is currently insufficient to bring the germplasm to levels of yield, biotic stress resistance, and grain quality to add value to other hybrid rice breeding programs.

The Program has a well conceived strategy feeding into extensive networks of collaborating and client institutions, particularly through the Irrigated Rice Research Consortium (IRRC), to deliver a package of germplasm plus suitable management practices. However, the IRRC makes no attempt to screen germplasm for suitability to specific production systems. The Program relies on networks to disseminate products, but some of these appear less efficient than they should be, partly because of a lack of multi-location testing.

A review of IRRC Phase 3 conducted in 2007 was very positive about the achievements. They found that the IRRC has made excellent progress in strengthening research and research-extension partnerships, and has made a significant contribution to capacity building in the partner countries, particularly in those with rather poorer resources. Some technologies tested and promoted by IRRC were well adopted in the project areas although often they did not diffuse more widely. In the cases where adoption extended to larger areas in the country, such as SSNM in southern Vietnam, there were concerted efforts in extension to achieve technology transfer. The benefit of adoption of most of the technologies to date is rather small and hence good promotion efforts are required for wider adaption. The review team suggested that technology transfer could be much more effective if the IRRC were connected with more efficient in-country extension systems. IRRI responded positively to these recommendations, and IRRI is making efforts to further improve the efficiency of IRRC. IRRI has an important role in monitoring progress and identifying bottlenecks in extending innovations beyond IRRC sites.

The involvement in the 'Green Super Rice' project with China is also an important mechanism for germplasm enhancement through the use of IRRI's extensive networks in SE Asia, and the developing networks (with WARDA) in Africa. Collaboration with other providers of rice germplasm and technologies such as China and India needs to be carefully considered in IRRI's future strategy, and in the types of partnerships that IRRI develops with them.

The Program builds on IRRI's previous successes in developing Green Revolution germplasm, particularly in terms of inbred line development, and has a number of novel themes, such as '2nd Generation New Plant Type', and 'Ecological Engineering', which IRRI is uniquely placed to develop. Although there have been problems with the under-performance of 'New Plant Type' (NPT) germplasm in yield trials - largely because grains were only partially filled - a redesign of the ideotype based on physiological models and genetic analysis is being undertaken. This work, combined with genetic analysis of yield and yield potential should allow the further integration of genomic tools into the breeding programs. The NPT research was a worthwhile experiment and it has introduced new germplasm which is being exploited by IRRI and its clients, but the Panel supports a more pragmatic approach to yield potential built on yield results and physiological and genetics studies, rather than simply on ideotype design.

The main focus of the Program is on inbred line development through conventional and marker-assisted breeding approaches. IRRI's research into hybrid rice (as measured by its investment of IRS time) has diminished relative to some other countries (particularly China) and multinational corporations (MNCs). Yield potential does not seem to be increasing significantly over the last ten years, so that redefining a high yielding ideotype and moving ahead with new pragmatic approaches based on yield potential *per se* are priorities. The Panel strongly supports efforts to increase resources directed to hybrid rice, and to develop strong partnerships in this technology with public and private organizations as a means of enhancing the yield potential of its products.

The Program has a strong research effort in identifying and tagging disease and pest resistance genes, allowing further use of MAS in breeding. Indeed, IRRI is seen to be leading in efforts to use MAS in rice breeding, as witnessed by the number of genes for abiotic and biotic stress undergoing MAS. The products of improved disease and stress resistant germplasm will be integral to sustainable inbreds, and for hybrid research these are a strong incentive for creating partnerships, such as within the HRDC. The Panel strongly endorses continued efforts in gene discovery and gene tagging at IRRI and with collaborating ARIs, and also endorses the development of a phenotyping platform for 'recalcitrant' rice diseases. More general concerns about the level of IPM capabilities at IRRI are discussed later in this chapter.

The Program is also working to develop technologies to mitigate post-harvest losses, both by helping to develop improved farm machinery for harvesting and drying grain, and by training extension workers and farmers in techniques for quality testing and the hermetic storage of grain, as demonstrated by work in Vietnam. The Panel endorses the usefulness of this work in ensuring that the outputs of plant breeding and sustainable production systems can result in an economically viable product for the farmer. The Panel is also impressed with the foresight in the Program in initiating research towards mitigating the possible effects of climate change through participation in the Rice and Climate Change Consortium (RCCC).

There has been rapid development of technologies for sustainable intensive rice production systems. One development in technologies for reduced water use is alternate wetting and drying (AWD), and IRRI has conducted research on this theme in collaboration with the Challenge Program on Water and Food (CPWF). The technology is well developed at the field level, and it is now widely adopted by farmers in southern Vietnam and China. Because of the nature of community sharing of water in irrigated areas, a large scale impact is likely to occur only when many farmers work together and the technologies are considered at the broader-scale hydrological and landscape settings. There will also be a requirement for refining disease and insect control and nutrient management methods to maximize the benefit of AWD. In addition, it will be worthwhile examining the need to modify variety testing in relation to this new type of production environment. Another technology development is site specific nutrient management (SSNM), which is utilized to identify optimum nutrient inputs for intensive lowland rice production. This technology is being used to rectify the problem of N overuse, which is a major issue in countries such as China and Vietnam.

Program 1 and Program 2 include the majority of IRRI's rice breeding activity. The Panel has identified two concerns regarding the management of rice breeding that deserve serious consideration.

The Panel recommends that IRRI re-evaluate the scope and extent of its methodologies for yield testing, and that it expand multi-location yield testing for major classes of irrigated and rainfed germplasm. This will enable IRRI to accurately phenotype and quantify the yield advantages of new advanced germplasm, and assess whether genotype x environment interaction is significant over and within its target environments. The system should also include strategies for phenotyping within target environments through a shuttle breeding approach, particularly aimed at systematically exposing segregating lines to the production systems of the future where less water will be available.

The Panel recommends that IRRI develops a greater capacity to produce superior F1 hybrids by improving the agronomic and grain quality characteristics, and broadening the genetic variability, of parental inbred lines. Research on the genetics and physiology of rice floral biology will be an important component of achieving crossability characteristics leading to more efficient seed production. IRRI should also determine the underlying patterns of combining ability and heterosis in germplasm, building on current work, and assess whether the stability of hybrids is superior to inbreds through multi-location testing.

Program 3. East and Southern Africa: rice for rural incomes and an affordable urban staple

Sub-Saharan Africa (SSA) is second only to South Asia as home to a large number of the world's poor. Although maize and cassava are the traditional staples in this area, rice is rapidly increasing in importance as an urban "fast food". SSA's annual increase in demand for rice is 6% per annum, more than double the rate of increase in supply. About 8 m tons of rice are imported annually to SSA. IRRI, during the development of its current Strategic Plan, recognized SSA as a strategic priority, and has worked with commendable commitment and sensitivity to build a program focused on East and southern Africa (ESA), initially funded from Center reserves. IRRI is focusing mainly on ESA, where four countries (Mozambique, Tanzania, Burundi, and Uganda) have signed MOAs with IRRI. The leading rice producers in ESA are Madagascar (3.5 m t/yr) followed by Tanzania (0.9 m t/yr), and Mozambique and Uganda (each 0.2 m t/yr), while Rwanda, Burundi and Kenya all produce less than 0.1 m t/yr.

The current Outputs (and IRS commitments) in Program 3 are:

- Output 1. Formulation of research priorities and policy options
- Output 2. Validation of elite lines with stress-tolerant genes (1.1)
- Output 3. Validation of sustainable production and post-harvest technologies (0.8)
- Output 4. Capacity building for rice scientists, technicians and extension staff (0.7)

Output 1 focuses on identifying research priorities and policy options by characterizing the rice production environment with regard to environmental stresses, production potential, and their role in poverty alleviation. Progress has been made in identifying a network of key researchers and policy makers. Initial research has focused on farmer surveys at the Chokwe irrigation scheme in Mozambique and have also been extended to the central Provinces of Quelimane and Sofala.

Output 2 seeks to identify elite rice lines, including *O. glaberrima* derivatives, that carry stress tolerance. This relies on the introduction of IRRI lines and Nerica rices developed by WARDA. Some 2500 lines from ESA, Latin America and IRRI are being screened in Mozambique and Tanzania, where sources of resistance to common diseases have been identified, and training provided for local pathologists. Under STRASA, screening of germplasm for drought tolerance is being conducted at Ikenne, Nigeria in collaboration with WARDA. Initiatives are needed to harmonize varietal release procedures across the region. Delivery of improved seeds to farmers remains a challenge in SSA, but engagement with the BMGF-funded PASS program, government seed agencies, NGOs and private companies must become a priority if the goals of STRASA are to be met.

Output 3 develops sustainable production and post harvest rice-based technologies for both seed and grain farms. A regional on-farm experimentation program appears justified, and research on crop establishment, grain storage and pest management has yet to get underway.

Output 4 concentrates on increasing the capacity of key rice technicians and extension staff to conduct research and disseminate technologies. Enhancing the capacity of existing regional training centers such as KATC, Tanzania, and establishing a regional version of the Rice Knowledge Bank should be priorities.

The SSA region differs remarkably from much of Asia. Rainfed ecosystems comprise 90% of the rice area in SSA, and 40% of rice area is upland. Yields are low, and rice crops are often subject to drought, low N status, iron toxicity, and occasional submergence. Credit is hard to obtain, and varieties are generally outdated and susceptible to bacterial blight. Stress tolerant germplasm and improved growing practices using simple farm machinery are needed. Technical capacity of national programs is at a low level, inputs are expensive or not available, and infrastructure is generally poor. Extension services are weak or non-existent, and government policies tend to favor importation rather than production of rice.

WARDA (or the African Rice Center) has operated in West Africa for the past 37 years, and has recently expanded its mandate eastwards as far as Uganda. IRRI has taken concrete steps to collaborate with WARDA to develop a coherent research and development plan for SSA. In 2008 the Eastern and Southern Africa Rice Program (ESARP) was implemented jointly with WARDA and participating NARS of the six targeted countries. This has been complemented by substantial donor contributions. IRRI's component of ESARP is essentially the work of Program 3. There has been some history of germplasm exchange with Africa through INGER, and 23 IRRI varieties have been released in 29 African countries to date.

Program 3 has a current annual budget of US$3.4 M, rising to US$5.5 M in 2011. Major funding sources at present are BMGF, IFAD and unrestricted funds, in roughly equal proportions. BMGF funds are provided under two projects, STRASA (for stress tolerant germplasm) and Green Super Rice (for high yielding stable germplasm). Additional funding for technology transfer is expected from Japan through CARD, the Coalition for African Rice Development.

Africa-based staffing at the time of writing consists of 2 IRS -- a plant breeder based with WARDA at IITA, Nigeria, and the project coordinator/agronomist, based in Mozambique. They are supported by an international consultant breeder in Mozambique, an NRS breeder in Tanzania, and four NRS support staff in Mozambique. The Mozambique office is established at the host institution, IIAM. A joint IRRI/WARDA office is planned for Tanzania in 2009, with a breeder, agronomist, mechanization expert and trainer from the IRRI side, as well as a postdoctoral economist, plus complementary WARDA staff.

We commend IRRI for its successful establishment of a rice program in ESA, for cordial collaboration with WARDA, and for its efforts in improving facilities at key test sites in Mozambique and IITA. Research for development at an appropriate level for ESA will move IRRI downstream on the research spectrum and expose it to cultures and farmer circumstances that differ considerably from Asia. Hiring suitable staff, flexible administration policies and procedures, and strengthened support from HQ will be needed for IRRI to succeed in ESA. It is also essential that IRRI recognize that it is only one player in the complex institutional scenario of African agricultural development, and that many of the other participants have much more experience and local presence. In addition, the welcome arrival of IRRI's technical expertise and training resources must be tempered by a recognition of SSA's limited absorptive capacity. The Panel encourages IRRI to establish its regional office in Tanzania as soon as possible and to develop a complementary relationship between ESARP and the PASS program to assist in effective seed distribution. Appropriate involvement of Madagascar's NARES will help ensure a successful regional program. Good agronomic practices, including water management, will be the easiest way to boost yields initially. Additional social science resources will be needed in ESA if appropriate research is to be conducted on the scale required. The Panel concludes that there is considerable potential for significantly increasing rice production in ESA, and endorses IRRI's African initiatives.

The Panel recommends that without delay IRRI, with WARDA, establish an East and Southern

Africa regional office and a fully-supported multidisciplinary research team in Tanzania; that it engages with Madagascar's NARS, and develops partnerships with key institutions in ESA, especially in the seed sector.

Program 4. Rice and Human Health: overcoming the consequences of poverty

It is estimated that 1.2 billion people in Asia and sub-Saharan Africa suffer from extreme poverty, a major cause of inadequate nutrition. A major Millennium Development Goal is to relieve this problem by the provision of more nutritious diets. Program 4 is the IRRI response to this challenge and addresses several important human health problems related to rice consumption.

Program 4 includes the following Outputs (and IRS staff):

- Output 1. Nutritionally-enhanced germplasm (1.9)
- Output 2. Strategies for the development, promotion and delivery of biofortified rice (0.3)
- Output 3. Increased understanding of the role of macromolecules for caloric efficiency (0.1)
- Output 4. Strategies to reduce contamination of rice grains (0.15)

The vast majority of current Program work is devoted to increasing the content of three micronutrients (Vitamin A, iron, zinc) in rice. These are causes of important nutritional deficiencies and represent significant public health problems. This work has attracted much interest from donors and is largely funded externally, through initiatives such as the Harvest Plus Challenge Program (Harvest Plus CP), USAID, BMGF, and other donors. Program 4 is a very active partner in the Harvest Plus CP, which provides funds for research and also provides access to skills in areas such as nutrition and consumer acceptance that are not available in IRRI.

A small amount of work is currently devoted to two other problems: mycotoxin contamination in grain storage; and toxic metal (arsenic, cadmium) contamination from water used to irrigate rice fields or cook rice. An additional research thrust (for which funds are being sought) hopes to examine the role of macromolecules in rice digestibility and storability.

Output 1, which aims to develop nutritionally enhanced germplasm, accounts for over 90% of program time. The Program continues the high profile efforts to enhance vitamin A content through transgenic 'Golden Rice' (GR), which is, however, taking much longer than initially planned. There have been setbacks in the amount and expression of the initial transgenic events which have delayed the efforts towards the development of a suitable product. Progress now appears to be back on track following the donation of Syngenta lines (events) that significantly raise the levels of provitamin A compared to earlier lines of GR. These lines are being backcrossed with popular rice varieties cultivated in the Philippines, India and Bangladesh, and a breeding program is being conducted to produce agronomically suitable material but of GR quality. The plan is that some of these varieties would be available for release by 2011-12 in the Philippines. However, considerable work still needs to be done in understanding the material, and the Program is to be applauded for its cautious approach to the release of the materials only following biosafety studies and intensive investigations of the storage/cooking stability and bioavailability of vitamin A. Biosafety studies are being carried out with advanced institutions in Asia and the EU, as well as interactions with national regulatory systems for the development and submission of data for regulatory review. Work on grain qualities and bioavailability would profit from closer collaboration with the Grain Quality lab (GQNPC – see later in this Chapter).

There is also progress in developing non-transgenic lines of rice with enhanced zinc and iron content through the identification of suitable germplasm. Tropical japonicas and Korean lines have been identified and an accelerated breeding process using doubled haploids is underway. Genetic studies for marker assisted selection will also augment this approach. These efforts are well thought through and well executed, and the target of enhancing zinc content by 50% has been met, although the more ambitious target of increasing iron content more than five-fold is only about half accomplished. Work is planned (in collaboration with several other institutions, and through Harvest Plus CP) to investigate zinc bioavailability in Bangladesh. The Program is sensibly keeping the option open of future transgenic approaches to increasing iron and zinc contents by seeking candidate genes as targets for modifying expression and transport. Work on ferritins appears promising and is an approach that IRRI is encouraged to pursue.

Output 2, aimed at devising strategies for the development, promotion and delivery of biofortified rice, currently absorbs 0.3 IRS. Most of the activities related to testing the bioavailability and acceptability of nutritionally-fortified rice is being done by other institutions, but several large grants (beginning in 2009) will help promote the deployment of GR, including meeting some of the costs of biosafety regulation. This high profile project is important for IRRI's image and for demonstrating the application of GM technology in the developing world. The Panel believes that it is extremely important that the necessary resources (from IRRI and elsewhere) be invested to ensure that products that are the subject of public attention perform as expected and can be delivered in a way that achieves a measureable impact.

It is unreasonable to expect that nutritionally-enhanced crop staples alone will completely solve the problems of micronutrient deficiency, but they could make important contributions. The strategy of nutritionally enhancing rice by backcrossing QTL for increased levels of minerals into the most popular rice varieties makes sense, although precise targeting to end users may be difficult. For instance, if the goal is to incorporate enhanced nutrition in varieties grown or purchased by the poorest people (and it is important to quantify the relative extent of the deficiency among growers versus buyers) then one needs information on the varieties eaten by various classes of farmers and consumers to achieve adequate targeting. Program 5 is collaborating with the Harvest Plus CP on these issues.

There will be different challenges for the delivery of GR and for high Fe/Zn rice. GR announces itself by its yellow color. In the best of cases this will be an effective brand, attracting a wide range of consumers to nutritionally-enhanced rice. In the worst of cases it will be a handy target for anti-GM campaigners to scare people away, or will be taken as the mark of rice "for poor people". The Panel urges that sufficient resources are devoted to looking into these issues and designing appropriate strategies. (IRRI has initiated a field study and a meta-review on this issue in the Philippines.) On the other hand, something like high Fe rice will be indistinguishable from normal rice, and the costs of identifying, separating, and targeting these varieties to those in need will be considerable. Unless these traits can be easily transferred to at least a few widely popular varieties, then the impact is liable to be modest. Harvest Plus CP can help investigate these delivery and targeting issues related to high Fe or Zn varieties, but because Harvest Plus CP does not include GR, IRRI needs to ensure that it can identify adequate partnerships for the delivery of this high-priority product.

Output 3, examining macromolecules in digestability and storability, is currently seeking funding and involves a minimum of staff time.

Output 4 currently accounts for only 0.15 IRS. The work on aflatoxin seems to have already identified principles for grain harvest and storage that significantly reduce the risks, but the challenge will be to make these understandable and accessible to the people who are most at risk. It will be useful to have information on the extent of the problem among different types of growers or in different rice marketing channels. Arsenic contamination is an important public health problem in several countries and it is important to identify the major sources of this risk.

Program 5: Rice Genetic Diversity and Discovery

Rice is a model species for genetic and genomic studies in cereals not only because of its agricultural importance, but also because of its small genome size (relative to other cultivated cereals) and the availability of genetic resources. International investment, building on earlier work by the Rockefeller Foundation's Rice Biotechnology Program, established the basis for rice biotechnology advances. The development of the full annotated rice genome sequence in this century has made rice the crop species with the best available genetic and genomic resources. Program 5 builds on this investment and IRRI, in collaboration with its many partners in ARIs and NARS, continues to be a leading center in the conservation, genetic characterization and exploitation of rice genetic resources for rice improvement, using state-of-the art genomic tools and resources. The Program includes 20 people providing 8.15 IRS equivalents, and is suitably focused on areas of strengths, realizing that IRRI is now only one player in a large international community of rice genetic and genomic endeavors. The Program is organized to produce 5 outputs which adequately reflect the skills and resources available to IRRI scientists:

1. Development of a genetic diversity platform for gene function identification in domestic and wild rice gene pools (1.0)
2. Development of specialized genetic stocks for trait dissection (1.05)
3. Dissection of the genetic pathways for selected traits using genome-wide and comparative biology approaches with priorities on stress tolerance, nutrition and grain quality, and yield. (3.95)
4. Expanding and enhancing the *ex situ* conservation of rice germplasm through better understanding of the genetic diversity within and between collections in a global network. (1.25)
5. Long-term broadening of access to genomic resources and associated tools, particularly for NARES. (0.9)

A large proportion of funding for Program 5 comes from restricted funds, including the Generation Challenge Program, with which it has been closely aligned. The Program has a key role in developing new, publicly-available, forward and reverse genomic resources to enhance genetic dissection of key traits by direct genetic analysis and comparative genomics approaches. A significant development is the Oryza SNP project designed to develop a cross-genome SNP chip. This will be used to establish a SNP platform so that community breeders and geneticists can quantify the allelic variation within their particular gene pools by association genetics. It is hoped that the platform will represent genetic diversity in target germplasm, although it needs to be seen to be inclusive of a range of key germplasm that target countries use. The Program also interacts with other major investments, for example the Oryza map alignment project of the University of Arizona.

IRRI's continued great strength is the breadth, depth and the understanding of the germplasm that it holds, and Program 5 provides genetic analysis, including a key role in developing specialized stocks for genetic analysis of key traits. It is developing segmental chromosome substitution lines, specialized mapping populations and isogenic lines, and Multi-parent Advanced Generation InterCross (MAGIC) populations tailored to breeding applications. All of these are likely to be useful for advancing studies of key traits. The Program should continue such investment and develop resources in its areas of competence, such as the development of TILLING populations, which have been slow to be developed in rice. The Program also enhances the characterization and use of the IRRI Gene Bank, which remains the best collection of rice germplasm in the world and a major asset of IRRI. This now has about 110,000 accessions. The Genetic Resources Center is highly capable and active, and is effectively leveraging IRRI genomic sources for better characterization and use of the germplasm. In parallel it is organizing increased use of collections in a global network to contribute to long term conservation efforts, harmonized with genebanks in other CGIAR centers.

Traditionally, IRRI has led in the development and application of rice transformation systems. However in recent years it has been eclipsed in capability by many other institutions around the world. It is essential that IRRI maintains key competence in this area and it is pleasing that new staff appointments should enable it to do so. Its ambitions to enlarge the range of transformable germplasm and find new high value targets, as well as using the systems to develop useful functional genomics tools for use by IRRI geneticists and the international community, are strongly supported by the Panel.

IRRI has set itself ambitious targets in terms of the genetic analysis of key traits. It has notable successes, including *SUB1, PUP1*, genes for virus and blast resistance, and QTL for drought tolerance. It continues to identify high value targets and has the skills to translate these into tools for marker-assisted selection. This is an essential goal which IRRI should continue to pursue in its own research and with partners. To do so requires excellent phenotypying facilities. Although some of these are available in the field, the glasshouse and controlled environment facilities are no longer state-of-the art and IRRI must decide whether to spend more funds on greenhouses or spend them instead on high quality field facilities where the target stress could be managed effectively. Interactions with partners continue to be important in facilitating the discovery of germplasm carrying genes for key traits, particularly through the International Network for Genetic Evaluation of Rice (INGER).

An important component of Program 5 is providing genomic services across the IRRI site to other programs and partners requiring genotyping and mapping facilities, and training staff to use the technology. The GAMMA Lab concept is a welcome initiative in this respect and appears well organized and suitable for purpose, although continual periodic upgrading will be needed to keep pace with technological advances.

IRRI has the breadth of experience and resources to undertake novel and speculative projects and the BMGF-supported program to develop 'C$_4$ rice' is a grand challenge that IRRI is well positioned to pursue and coordinate (Box 3.3). The Panel notes that "Constructing C$_4$ Rice" is a high-reward, high-risk venture, likely to take at least 15 years to complete. It will require the ingenuity and skills of researchers from around the world. We regard the process of hypothesis development, establishment of an IRRI-funded Frontier Project, the establishment of the research Consortium, and the donor support of subsequent work as an exemplary IRRI-led approach to focusing research on a critically important but risky process that could have profound effects on rice yields in the decades to come. It is entirely appropriate that this be funded externally, since, despite its promise, it has the potential to become both expensive and diversionary from IRRI's main task.

Box 3.3 C_4 Rice

Faced with a projected 30% increase in rice production by 2020, a conference held in 1999 on redesigning rice photosynthesis[7] identified the C_4 photosynthetic pathway as the most likely means of increasing grain yields by 30-50% in this time frame. This involves a change in the photosynthetic pathway that increases radiation and water and nitrogen use efficiencies, and maintains photosynthetic output in a warming environment. The presence of C_3 and C_4 photosynthesis systems in different species of the same genus suggests this change has occurred during crop evolution, and could be induced through transformation with C_4 genes and/or overexpression of existing C_4 genes in a line carrying very close leaf venation. Thereafter a field-ready version of C_4 rice could be developed through conventional field adaptive breeding. A further conference on the feasibility of developing C_4 rice[8] was held in 2006. A C_4 Rice Consortium was formed among interested ARIs, advanced NARS and IRRI, and following the development of IRRI's Strategic Plan, a C_4 Rice Frontier Project, funded from reserves, was launched in 2006. This served as the basis for a successful funding proposal to BMGF, approved in 2008, that aims to identify key genes responsible for C_4 Kranz anatomy and its metabolic and anatomical components among wild relatives and mutants of rice. It is expected that proof of concept could be completed by 2010, and a C_4 rice could be available by 2016-2021.

Work on previous projects, particularly apomictic rice, has greatly decreased, and it seems prudent to abandon this ambition.

Program 6: Information and communication: convening a global rice research community

Program 6 builds on many global investments on information and technology within and outside the CGIAR to enable IRRI research programs to provide equitable access to information and knowledge on rice and to help develop the next generation of rice scientists.

There are four outputs (with associated IRS):

- Output 1: The rice component of the Crop Science Information Resource (an initiative of the IRRI-CIMMYT Alliance) which is a global community-created repository and network of public crop science information resources (0.85)
- Output 2: The Cereals Knowledge Bank, an online resource of knowledge on cereal

[7] Redesigning Rice Photosynthesis to Increase Yield. Proceedings of a Workshop, 30 Nov.-3 Dec. 1999, Los Baños, Laguna, Philippines. J. Sheehy, P. Mitchell, and B. Hardy (Eds).

[8] Charting New Pathways to C4 Rice. 2007. J.E. Sheehy, P.L. Mitchell, and B. Hardy (Eds). Los Baños (Philippines): IRRI. 422 p.

production for rice, maize, and wheat, containing rice information from IRRI's Rice Knowledge Bank (1.10)
- Output 3: The World Rice Community Network Presence using Internet technology for access to information and for interaction on rice by supporting self-organizing communities and multilateral communication operation (0.45).
- Output 4: Phase 1 of the Informatics and Communication Service for Crop Science, which is a public research, development, and dissemination service for informatics and communication technology targeting agricultural scientific research completed (2.45).

The Program is run by the Crop Research Informatics Laboratory (which is a product of the IRRI-CIMMYT Alliance) and the Training Center.

The Crop Science Information Resource is under development under Output 1. Although the envisioned scope of this resource is to generally cover all aspects of rice science including natural resource management, agronomy and related basic crop sciences, the initial effort has focused on integrating germplasm information relating to genetic resources (IRGCIS from the TT Chang GRC), breeding (International Rice Information System (IRIS), international trials (INGERIS for INGER) and genomics research (IRFGC and GCP), and is consolidating information on crop research conducted by IRRI, CIMMYT and other centers. Germplasm information from IRGCIS and from INGER, is now merged into the International Rice Information System (IRIS).

Similarly, a catalogue of stress genes is now available that facilitates comparative genomics. Considerable progress has been made toward the development of ICIS as the common crop information system for rice, maize and wheat in IRRI and CIMMYT. Version 5.5 of ICIS was released recently. ICIS is being developed for more breeding applications, and stronger inputs from breeders would hasten progress. This IRRI-led activity has resulted in wide adoption of ICIS for wheat at CIMMYT, but less so for maize. ICIS implementation is now occurring in large scale outside IRRI and CIMMYT in the genetic resources community, such as in the Global Crop Diversity Trust and the private sector. All these applications are likely to further enhance the functionality and utility of ICIS. Output 1 activities also support ongoing efforts to develop digital resources within the IRRI library, both in terms of expanding the IRRI Rice Bibliography database and in terms of obtaining and indexing PDF versions of articles into a local "rice bibliome".

IRRI has developed the Rice Knowledge Bank (RKB) that contains basic and applied rice information that is useful for technology transfer targeted to extension workers and farmers. The RKB is the primary product under Output 2. It is now extended to include wheat and maize and the Cereals Knowledge Bank is now available as a result of a joint effort between IRRI and CIMMYT. There are also Country Knowledge Banks that contain country-specific information and indigenous knowledge. Indeed, the Knowledge Bank functions most effectively when there is strong national-level commitment. In these cases the information is readily available in a CD in the local language. The NARES assume management roles in each country, and this is a good way of ensuring that country-specific information is included. These are established in 10 Asian countries and two more are committed for such establishment. Similarly IRRI and WARDA are committed to working together on an RKB application for Africa. The Panel commends IRRI for the development of the Rice Knowledge Bank and encourages further efforts to ensure that as many countries as possible are able to take advantage of this resource.

Part of the role of Output 3 is to place Outputs 1 and 2 on the web with the most appropriate software available. In addition, Output 3 is coordinating, with CPS, an ambitious effort to develop a "next generation" IRRI web portal branding, architecture and content management using the Joomla! content management system (see http://beta.irri.org). Output 3 efforts have also enabled the free downloading service of books published by IRRI. On-line photo images of rice and associated materials are also well utilized, as a result of the recent agreement with private firms, and this is a great benefit to those working in rice science and industry.

Output 4 activities relating to the web are restricted to the development of Generation Challenge Program technology for web publication of data such as ICIS crop data. Output 4 in particular has more of a "hands on" service role, although it is recognized that this is not a routine IT service, which is available elsewhere in IRRI

Recent advances in ICT have created many opportunities for the application of informatics in rice science and technology transfer. This needs to be further developed to take full advantage of the wealth of rice research and technology information that IRRI and other groups have generated. The recent interaction with private firms on web technologies is to be commended. IRRI is well advanced in this area of crop informatics, and has a good opportunity to take the lead in ensuring that a CG system- wide information capacity is developed. On the other hand, it is important to regularly test the usefulness of technologies that are being developed. This applies to ICIS as well as to other activities of the Program. It is suggested that inclusion of IRS, particularly from the Plant Breeding, Genetics and Biotechnology Division, in the Program will help ensure that the products are relevant and widely utilized by IRRI and other client groups.

Program 7. Rice Policy Support and Impact Assessment for Rice Research

Program 7 is concerned with analyzing policies relevant to rice technology development, improving technology dissemination strategies, and assessing the impacts of rice technology utilization. These are important areas for an institution such as IRRI and respond well to the CGIAR's System Priority 5, "Improving Policies and Facilitating Institutional Innovation". The nature of the work demands both disciplinary specialization (which helps justify a separate program) and close integration with the biological research that drives technology development.

Program 7 includes five outputs (with IRS):

- Output 1. Sub-national and farm level databases relevant to rice policy and impact assessment (0.75)
- Output 2. Comprehensive knowledge of long-term dynamics of poverty and rural livelihood systems (2.1)
- Output 3. Policy reforms options based on long-term changes in comparative advantages in rice production (0.3)
- Output 4. Knowledge of potential and realized impacts of research on poverty reduction and sustainable management of natural resources (0.75)
- Output 5. Strategies, policies and principles for pro-poor dissemination of improved technologies (1.15)

In its short existence, Program 7 has carried forward a number of policy research activities and initiated several others. These include continuation of a significant amount of research examining the changing economic environments and livelihood options of Asian rice growers, the publication of research on rice markets and research resource allocation, an expansion of poverty mapping including the use of GIS to analyze rice production patterns, and the organization of a workshop (in 2008) on rice policy research.

One of the most notable features of Program 7 is the gap between the breadth of its mandate and the limited personnel available for the task. The current budget for Program 7 includes a total of 5.05 IRS equivalents (due to expand by 1 IRS in 2009); 1.75 of this is related to special projects that examine very specific areas (Bangladesh extension and Philippine water charging) while 0.6 person years is from a currently vacant impact assessment position in SSD, leaving less than 3 IRS years to take on the Program's broad objectives. Even the leader is only able to devote 60% of his time to the Program. This gap can be addressed in several ways. Some improvement can be expected when two positions in SSD are filled. In addition, it is worth asking if enough is being done to include non-SSD staff in activities of Program 7. But it is unlikely that any foreseeable personnel scenario could match the ambitious objectives of the program and so exceptionally strict prioritization of possible activities will be required, and the Program must be able to clearly articulate these priorities and their rationale.

Output 1. Sub-national and farm-level databases

Considerable work is already underway in several countries on this theme, and it has profited considerably from the GIS capacity in SSD. It would appear that additional funds from BMGF (through ICRISAT) will support further village-level studies in E. India and Bangladesh. Although large-scale surveys and poverty maps can potentially help set national research priorities and track progress, the Program should develop as much evidence as possible on the actual utilization of such data for research decision-making and demonstrate that the results are being delivered in a way that maximizes their potential utilization. Although this work can provide a good point of interaction with national program social scientists, the fact that these are in very short supply in most countries means that the demands on IRRI resources and supervision should be considered in assessing the future level of investment in this output.

Output 2. Knowledge of long-term dynamics of poverty and rural livelihood systems.

This output currently commands the largest time investment of the Program. It involves an exceptionally wide range of policy issues. Substantial, good quality work has already been done in several countries on livelihood, gender, and poverty correlates of rice production. It is important to translate this into clear messages regarding research decision-making, both for use by national partners and for IRRI priority setting. (Earlier work on the Bangladesh policy dialogue is one example of the former; the need for continuing dialogue within IRRI about the fate of upland rice research is an example of the latter.) IRRI must be conversant with the macro-level trends in labor and livelihoods that affect rice production, but the Program needs to focus its research on themes where there are direct implications for the kinds of rice technology being developed or the ways in which it should be delivered, while ensuring that it is conversant with research results on these themes provided by alternative suppliers. The current and planned work under Output 2 also includes areas that go beyond what would traditionally be considered under "poverty and livelihoods" such as water policy and mechanization. These are of direct relevance to the institute, and priorities need to be identified so that sufficient resources are available to make an impact.

Output 3. Policy reform options

This Output is focused on the analysis of data on rice production and markets (in the context of changing economic and climatic conditions). During the recent rice price crisis IRRI was able to provide a timely and coherent summary and analysis of the situation and to use this as a way of promoting its vision for greater support to rice research. This is an example of the utility of investing in this type of research. The substantial initiative of SSD to revive IRRI's capacity to provide and analyze global rice statistics is presumably included in this Output as well, and should be explicitly identified. It seems easiest to defend this type of work at the global level. Analyses of national rice markets would need to be done in response to very clear demands and possibilities for policy dialogue affecting rice technology generation, and taking into consideration possible alternative suppliers.

Output 4. Knowledge of impacts of rice and policy oriented research.

Although IRRI has done extensive work on impact analysis, current work in the Program is essentially on hold until the impact assessment position in SSD is filled. The MTP contemplates building national capacities in impact assessment as well as providing analyses that document IRRI impact. Again, priority themes need to be identified. Strategic decisions need to be taken regarding opportunities to demonstrate widespread impact of IRRI technologies or activities. Recent IRRI work on impact assessment has tended to concentrate on very restricted areas, such as project sites, or examine broad issues related to the spread of rice mega-varieties. Decisions on themes for impact analysis must be made in reference to information generated from the monitoring and evaluation cycle within other Programs. Cases where potentially broad impact is not identified can help identify weaknesses in technology generation and delivery that require more attention.

Output 5. Strategies for pro-poor dissemination of improved technologies.

This is another example of the importance of distinguishing Program 7's mandate from that of other Programs. If the principle is accepted that Program 7 should concentrate on cross-cutting results, then the challenge is to respond to widespread calls for "scaling up" technology delivery. The fact that such calls have been frequently made in the past decade without substantial progress indicates that it is a more difficult assignment than it might appear, probably requiring more investment than a simple synthesis. IRRI's role in many innovative activities in technology generation and delivery would seem to offer a considerable amount of raw material on which to base analyses, but going beyond the identification of general principles and actually contributing to institutional change means that IRRI would have to make substantial forays into areas such as extension, the seed industry, input delivery and machinery development. Because of the technology-specific nature of most of these themes, it is possible that much of this work would find more immediate application and uptake in other Programs.

The Panel has several observations about Program 7. First, there should be a clear identification of the delivery pathways for any policy analysis, an assurance of demand from potential recipients, and (in the case of national policy work) a clear strategy of ownership and continuity by national scientists and policymakers. Second, there should be a concerted attempt at achieving some kind of critical mass; translating policy analysis into actual policy change almost always requires a long-term (and multi-faceted) strategy. This implies that some difficult decisions will have to be made about priority areas, and contacts will have to be strengthened with other institutions (such as IFPRI and IWMI) that can collaborate on, or assume leadership in, some of the Program's interests. Third, it is important to identify potential targets for impact analysis over the next few years that will provide donors with evidence of widespread technological or policy change that translates into improving the welfare of the poor. Fourth, it will be helpful to articulate more carefully what distinguishes Program 7 activities from other IRRI work related to policies, uptake and impact. A possible guideline would be to confine Program 7 work to themes that cut across production environments and go beyond particular technologies, leaving more specific analyses to be carried out within other IRRI Programs. This guideline can only be approximate, but it may help draw a wider range of personnel into Program 7 activities, emphasize the relevance of policy, planning and assessment to all technology development, and help concentrate minds in selecting high priority areas for the Program's attention.

3.2 Research Divisions

Plant Breeding, Genetics and Biotechnology Division (PBGBD)

The Plant Breeding, Genetics and Biotechnology Division is at the heart of IRRI's research programs and mission to produce improved rice germplasm for all rice environments of the developing world. It currently includes 23 internationally recruited staff, 2 internationally recruited fellows and 7 postdoctoral fellows. Its mission is to conduct research and training on germplasm improvement for increased and sustainable yields in each of the major rice ecosystems. To fulfill this mission it has a cohort of internationally known scientists covering a range of disciplines from conventional breeding, genetics, cytogenetics, genomics, molecular biology, tissue culture and transformation technologies. It has sustained scientific excellence in a range of disciplines impinging on crop improvement and applied these to developing and utilizing new tools, strategies and knowledge. The Division has a long and distinguished history in these endeavours, continually producing improved germplasm from the start of the Green Revolution to the present. It has pioneered new technologies – wide hybridization, molecular markers, doubled haploids, genetic engineering -- and has discovered a range of novel genes controlling key traits. The Division has numerous collaborative links with institutions in industrialized and developing countries. In particular, it has interacted closely with NARS in terms of collaborative breeding, varietal release and new technologies, and has supported technology transfer and training to build core competencies in its partner institutions. These activities are all continuing today, and the Panel is impressed with the scientific excellence, commitment and focus shown throughout the Division.

The Division focuses on several inter-linked approaches to crop improvement with cross-cutting interactions between them:

- Conventional inbred-line pedigree breeding and selection in its target environments supplemented with lab-based marker-assisted selection
- Hybrid rice development
- Understanding the genetics of biotic and abiotic stress resistance
- Analysis of wild relatives and strategies for alien gene introgression
- Genetic analysis, from major gene and QTL discovery through to fine-mapping, candidate gene identification for target traits, especially for biotic and abiotic stress and nutritional quality
- Genomics for crop improvement
- Doubled-haploid and transformation technologies and GM rice
- Genetic engineering for nutritional quality

The major focus of the high potential irrigated rice breeding program has not changed very much over the history of IRRI, with a continuing emphasis on higher yield potential, resistances to the major pests and diseases in the target environments, and grain quality for consumer acceptance. The overall resources for the breeding program have diminished over the years, and are probably at the minimum necessary to sustain a competitive program. Nevertheless, the program still handles around 800 crosses per year and has extensive nurseries at F_2 and subsequent generations in each season at IRRI, leading to 500-600 entries in yield trials at F_6/F_7. The extent of multi-location testing is limited, and the Panel suggests that more attention is required for adequate screening (Box 3.4).

Box 3.4 Precision phenotyping: sampling the target environment

Advances in plant breeding depend on the ability to estimate genotype (G) from phenotype (P) as given in the classical equation P = G + E + GxE, where E is the environmental effect. Under conditions where the breeder's selection nursery reflects the farmer's target environment, the correlation between performance in plots and in farmers' fields is expected to be good. Precision in phenotyping depends on adequate replication, randomization, and uniform plot conditions, especially for traits of low heritability, such as yield. Most rice breeding in the early generations is done by practicing visual selection of yield components complemented by screening for biotic and grain quality related traits. In later generations yield is selected for directly based on multi-location yield trials. Thus, efficient yield selection is likely to hinge on IRRI breeders establishing precise phenotyping environments in a range of representative locations. However, in IRRI's germplasm distribution network, INGER, unreplicated observation nurseries rather than replicated yield trials are being distributed.

The environmental conditions and locations used for selecting superior segregants in the high potential irrigated rice breeding program have not changed very much over the history of IRRI. The extent of multi-location yield testing is limited, and most yield trials are carried out only at IRRI in the wet and dry seasons over several years. Through cooperation with PhilRice, a limited sample of advanced lines goes for testing at 8-10 locations. If there is no GxE, this may be adequate, but limited yield gains could suggest otherwise. A series of well designed multi-location trials could be used to identify superior parents for new crosses, determine if there are distinct megaenvironments based on GxE patterns, and provide quality phenoptypic data for further association mapping studies.

IRRI has had notable success in developing screening for submergence tolerance, and this is reflected in the progress made in releasing *SUB1* megavarieties. With respect to phenotyping for yield performance under drought, IRRI faces challenges. IRRI headquarters is not located in a drought-prone area and this makes it difficult to work on drought problems under natural conditions. Development of rainout shelters, rhizotrons, and other drought facilities at IRRI headquarters is likely to hasten progress in this area. However investments in these facilities at Los Baños must be balanced against investments made in locations representative of the target environment, where drought occurs reliably. It is heartening to see that a drought screening network exists under the Rainfed Lowland breeding program at 8-10 sites in India, but there is considerable scope for developing phenotyping capabilities at additional "hot-spot" drought-prone locations in S and SE Asia in collaboration with NARS. Such a testing network would expose germplasm to different timing and intensity of drought stress. With irrigation facilities these can be made predictable and repeatable so that meaningful patterns of G X E can be identified and exploited in the breeding program. Field drought phenotyping can also benefit from physiological analysis where large scale screening is conducted for determination of traits such as superior root systems in rice under drought conditions.

New developments in rice management systems can also bring challenges for plant breeding progress unless the selection environment reflects the target environment. Examples are direct seeding, alternate wetting and drying, and aerobic rice. The physiological basis for successful aerobic rice production systems where rice is grown under favorable water conditions without standing water in paddies has been identified. Careful GxE analysis over locations will confirm if specific genetic adaptation to these systems is needed. If so, then this suggests the need for additional phenotypic screens in the ecologies the varieties are designed to serve.

The breeding program aimed at upland and rainfed lowland environments is on a slightly smaller scale then the irrigated program, but like the irrigated rice program it has a clear and carefully thought out strategy with knowledgeable and committed staff. In recent years the program has, in the Panel's judgment, wisely adjusted its strategy to initially focus on yield potential of selected material rather than its stress tolerance *per se* as the major characteristic for selection. Through networks in India, both upland and rainfed lowland testing sites are available for selection of advanced lines in target environments, although the problems of seed exchanges between IRRI and India continue to inhibit efficient shuttle testing. This process is being expanded to earlier generations, and the Panel strongly supports the establishment of an active and efficient shuttle breeding program for these environments.

Hybrid rice breeding at IRRI started in 1978 but activity is currently at a relatively low level, despite the considerable gains being made in hybrid rice yields in China and some other countries. This trend is changing, fuelled by the Hybrid Rice Research and Development Consortium (HRDC), a partnership between IRRI and private breeding and seed companies. However, IRRI is now probably some years behind other major rice breeders in the development of suitable A, B, R and S inbred lines. Reports from partners suggest limited genetic variability in IRRI's inbreds in terms of yield potential, but an appreciation for useful disease and pest resistances. Despite these limitations IRRI parents are being used in current commercial hybrids. Given the problems of achieving increases in yield potential in the conventional irrigated rice breeding program, the Panel strongly supports investment and initiatives that IRRI can make to increase its activities in hybrid rice development, particularly by the breeding of new A inbred lines, improving cross-pollination and hence reducing seed production costs, and developing strategies to create heterotic pools. Although there are several important alternative providers of hybrid rice technology, it is important to recognize that IRRI is the only major player whose technology is an international public good; IRRI's strategies must strengthen this advantage.

Throughout its history, a major focus of IRRIs breeding and genetics activities has been to discover new genes for disease and pest resistance and to use innovative methods for their introduction and deployment in new varieties. This rightly continues to be a major focus with a multidisciplinary approach towards gene discovery, gene function analysis and MAS. However, IRRI's overall expertise in plant pathology did decline in recent years, although it has now been restored to 5 IRS plant pathologists. Although field screening methodologies are still efficient and effective, for example, for blast, bacterial leaf blight, brown plant hopper and tungro, basic research on disease and pest epidemiology has decreased. The emergence of new problems, such as loose smut, exacerbate the problem. IRRI also only has limited work (0.2 FTE) on nematology, likely a problem in restricting or lowering yields in many ecosystems where water is becoming limited. Although the Panel appreciated that IRRI does have limited resources, its limited capacity for IPM deserves attention by management.

The Panel recommends that IRRI commission a CCER on Integrated Pest Management to assess the current capabilities and future needs of IRRI and to enhance the Institute's position in developing IPM for rice production systems. IRRI has increased its capabilities in plant pathology, but the Panel hasconcerns that IRRI's capabilities in IPM have declined to a level that is inhibiting a systems approach to sustainable pest and disease management.

A unique strength of the PBGB Division is its knowledge of and exploitation of the wild rice related species for alien introgression. IRRI has led internationally in this field and is now starting to reap the benefits by the discovery of novel variation for biotic and abiotic resistances which are transferred into conventional varieties. Similarly, the PBGBD has led the world in exploiting the genetic diversity of its collections of *Oryza sativa* and the *japonica* subspecies, with several firsts in the discovery of novel genes and QTL for important sustainability traits, *SUB1* being one of the most notable. It is reassuring to the Panel that the PBGBD has active research in mapping, fine mapping and cloning of key target genes for abiotic stress tolerance, and high profile publications in this area. These discoveries have been possible because PBGBD scientists have been at the forefront of developments in rice genetics and genomics. They continue to enthusiastically exploit the opportunities afforded by the technological developments in plant molecular biology. They have also been innovative in helping to drive the technological revolution in rice molecular biology with the expertise and foresight to produce new molecular tools for MAS and gene function analysis, particularly in SNP discovery and transcriptome analysis. Much of this activity has been in partnership with the Generation Challenge Program where IRRI was a founding partner.

Although the area planted to transgenic crops continues to be dominated by a few species, there are some other opportunities for the release of GM varieties in other crops, and GM rice will be available in the near future. IRRI must play an important role in this development, although its strategies must continue to be subject to the guidance of its Board. For many years IRRI was a pioneer in the technological development of transgene methodologies in rice, but recently activity had diminished. It is pleasing that the PBGBD is re-invigorating this activity, both as a means of testing gene function, and for creating a test bed for possible new products. IRRI-private partnerships are one obvious route where IRRI can gain access to useful genes, but IRRI has to be aware of country sensitivities with the technology. It is reassuring that IRRI already has a well developed Biosafety policy and SOPs for the handling of GM rice, and that it has assisted some other governments in the region to establish biosafety frameworks. Current opportunities in enhancing the nutritional properties of rice offer IRRI the opportunity to demonstrate its skills in the technology.

Overall, the PBGB Division has maintained and enhanced its inherited strengths. It has an excellent mix of skills from lab to field, allowing a modern multi-disciplinary approach to crop improvement, and the agility to quickly absorb and apply new technological developments in rice biology. Weaknesses in the current skill set are due to limited resources at IRRI rather than the strategic directions the Division has taken. The Division's strategy was endorsed by the 2008 CCER on Biotechnology which recognized the significant contribution made by the scientists in the Division to the global efforts in applying modern genomic tools towards rice genetics and breeding. However, the CCER recommended that there needs to be a narrowed focus, with priority being given to water-related traits, and an upgrading of facilities for field phenotypying. The Panel strongly endorses the conclusions and recommendations of the CCER.

Conventional breeding is a long-term activity which requires sustained efforts and is resource-demanding in terms of land and manpower. It is not time bound or easily amenable to external project funding and thus requires a large allocation of unrestricted funds. The Panel endorses the strong support for breeding work from management and supports a stable funding basis, perhaps through the new CGIAR structure. There is also the question of whether there are sufficient resources invested in the program, particularly in hybrid rice where there is an expanding demand for inbred lines of a defined heterotic group, and well characterized combining ability, maturity and abiotic and biotic stress resistance.

Crop and Environment Science Division (CESD)

The Division comprises 22 IRS/IRF and 14 PD/VRF and is clustered into 4 groups; Plant and Crop Physiology (7 IRS/IRF), Soil and Water (9 IRS/IRF), Pest Management (5 IRS) and Climate Research (1 IRS). It has responsibility for a number of consortia, including IRRC, CURE, the Rice and Climate Change Consortium (RCCC), the C_4 Rice Consortium and the Rice-Wheat

Consortium (RWC). It provides strong inputs to Programs 1 and 2, and some to Programs 5 and 7. With increased activities in Africa, it is expected that the Division will become active in Program 3 in the near future.

CESD covers the scientific discipline areas of plant and crop physiology, agronomy, soil science, water science, environmental science, weed science, entomology, nematology and rodent ecology. The research thrusts it focuses on are:

- Crop and resource management to enhance productivity and sustain the resource base of intensive rice based systems.
- Physiological and genetic approaches to improving yield under abiotic stresses in fragile environments.
- Cropping system and resource management for improving and stabilizing productivity under rainfed lowlands, uplands, and coastal lands.
- Direct seeding and weed management options to reduce labor bottlenecks and improve productivity.
- Enhancing ecological services and mitigating negative impacts of rice on the environment.
- Exploration of innovative approaches for adapting rice for climate change.
- Developing rice production systems that maintain high yield and use less water.
- Delivering well-tested, productivity enhancing and environmentally benign technologies to farmers through partnerships.

CESD members have been responsible for several significant achievements in advancing science and scientific methodologies, and in developing and transferring technologies. A number of these achievements are highlighted below with some comments, suggestions, and notes on emerging issues.

Scientific advances

One major achievement of the Division is the demonstration of sustainability of lowland rice cropping and elucidation of mechanisms for such sustainability. For example, yields in rice double or triple cropping under lowland paddy conditions have been sustained at IRRI headquarters with effective nitrogen fertilizer management. Long term sustainability of soil organic matter and the soil's ability to maintain the capacity to supply nitrogen has been documented. Optimum crop residue management practices in rice-based lowland cropping systems have also been developed, and this adds to the sustainability of rice-based lowland systems, though it has implications for methane production.

The sustainability of continuous rice cropping under lowland conditions is in contrast to cropping systems where anaerobic rice cropping is alternated with aerobic non-rice cropping. With anticipated increases in crop intensification and diversification with maize and other non-rice crops in rice-based lowland systems, a more detailed understanding of soil physical, chemical and biological changes in rice-based lowland conditions is required.

Aerobic rice is a system of growing rice without flooded water in the field (see Box 3.5), and IRRI scientists have demonstrated that this concept can work. They have shown that aerobic rice can produce 70-80% of the yields under fully flooded conventional rice, with more than 50% reduced water use and hence increased water productivity. There are some promising lines that are currently being developed at IRRI, and when they become available they will further improve the water productivity of aerobic rice.

However, the sustainability of rice cropping is not always maintained when rice culture is shifted from anaerobic paddy conditions to aerobic field conditions. Continuous aerobic cropping may in some cases result in lower yields relative to fully flooded rice. IRRI-led research with NARS has shown that this is caused by increased weed infestation; soil-borne pests and diseases including nematodes, fungi and root aphids; and reduced nutrient availability and soil organic matter decline. Thus there is need for further research to minimize these adverse effects if this technology is to be promoted on a large scale to save water in the tropics. It is important to identify growing environments where aerobic rice is suited, and the need to screen varieties for these modified production conditions should be clear. Alternatively, techniques that are intermediate between aerobic and permanently flooded conditions such as AWD and saturated soil culture may need to be examined further to develop sustainable water-conserving cultural systems.

IRRI plant and crop physiologists have demonstrated the usefulness of abiotic stress tolerant lines and have provided physiological understanding of abiotic stress tolerance mechanisms. Physiological bases of tolerance to flooding during the vegetative stage are well established, including the role of ethylene, carbohydrates and chlorophyll retention. Similarly, salinity tolerance mechanisms have been identified including efficient compartmentalization in roots or older tissues (resulting in minimum influx of Na^+ in young shoots), tissue tolerance (keeping salt in the apoplast), and efficient antioxidant systems against reactive oxygen species.

In recent years temperatures have increased, with a generally adverse effect on rice yield in traditional tropical rice growing areas. CESD scientists have found direct evidence of decreased rice yields from increased night time temperature in IRRI field experiments where total dry matter production also decreased, presumably as a result of increased respiratory loss and hastened development. These findings need wider testing through field experimentation and simulation modeling to establish their accuracy and general applicability, but these preliminary results will promote efforts to improve high temperature tolerance in order to reduce the global warming effect on productivity.

Technology and methodology development

CESD scientists have developed agronomic methods to minimize adverse effects of abiotic stresses. Management options for submergence tolerant varieties include the use of lower seeding rates and use of older seedlings for transplanting. Similarly, appropriate crop and resource management practices for salt affected areas, such as the use of older seedlings and dense transplanting, have been developed and will increase the effectiveness of salt tolerant varieties. It should be pointed out however that these methods may reduce potential yield, and hence if stress does not occur yield may be reduced. It is therefore necessary to consider the chance of occurrence and magnitude of the stress before the technology package is fully recommended.

Another achievement is the development of a method to determine effective fertilizer application rates for rainfed lowlands where soil fertility varies according to the paddy position in the toposequence. A simple model was developed and tested for NE Thailand conditions. Widespread testing of the recommended fertilizer management method under different environments including drought and favorable conditions is required before these methods can be recommended more widely.

Water saving is another area of technology development (Box 3.5). The case of aerobic rice has already been mentioned. Alternate drying and wetting (AWD) technology has been developed recently. One advantage of AWD is that it significantly reduces methane emissions. Nitrous oxide emissions are able to be kept at a low level, similar to continuously flooded conditions.

Box 3.5. Rice and Water

Rice, as a semi-aquatic plant, is more sensitive to water shortages than most other crops. To protect lowland rice crops being exposed to water shortage, rice fields are commonly surrounded by bunds, and rainfall or irrigation water is stored in the field as standing water, so a continuous supply of water is assured. This causes the soil to be continuously saturated and anaerobic. On a global scale irrigated lowland rice covers 79 million ha, and rainfed lowland rice some 54 million ha. Rainfed crops are grown during the wet season, and the crop experiences drought when rainfall is not sufficient. In the dry season irrigation water is required. An estimated 11m ha of lowland rice is subject to flooding. Upland rice, comprising 14 million ha, on the other hand is rainfed, does not have standing water most of the time, and may be on sloping land with aerobic soils.

In lowland systems, a high proportion of water is not transpired, and is lost through evaporation from standing water, or percolates to deeper soil layers. Efficiency of water use is therefore reduced, and total water input to lowland rice can be 2-3 times more than for other cereals. Heavy clay soils and puddling (compacting) prior to planting reduce water losses by percolation and increase water use efficiency. Water losses are also reduced by lowering the level of standing water to below the soil surface, or by eliminating soil water saturation altogether (aerobic rice), giving an increase in water use efficiency ("crop per drop") of up to 30%. The crop becomes more exposed to drought, yields are generally lower than in lowland flooded systems, and there is more risk associated with production unless irrigation is available. As water becomes less available or more expensive, water saving emerges as a major objective of rice farm management and rice research.

Lowland rice crops are prone to submergence when there is intense rainfall. Rice plants can withstand partial submergence, but complete submergence for several days can cause severe damage. It is not uncommon for a rainfed lowland rice crop to encounter both submergence and drought in the same season.

Because of frequent occurrence of drought and submergence, varieties that are tolerant of drought or submergence are required. Targeted breeding of varieties that produce higher yields in drought- or flood- prone environments is perhaps the most efficient means to increase water use efficiency and food security under these conditions. These stresses can be managed by breeders to provide a repeatable but representative stress in their evaluation plots, or varieties can be tested at sites where these stresses naturally occur in a less predictable manner.

Water can move readily downward or laterally from field to field, particularly on sloping land or when the ground water table is high. In lowland systems, therefore, it is important to look at water use beyond individual fields. This concept is particularly important in irrigated areas where irrigation water is shared, and a community-based approach is required to increase overall efficiency of water use.

Drought screening methods have been established, including those for phenotyping root traits. A number of trials for phenotyping drought tolerance have been conducted using materials that have already been genotyped. Various simulation models have been developed by the CESD scientists which can be used to identify cropping options or use of different varieties under different growing conditions. For example ORYZA2000 has been developed and validated for more than 10 contrasting varieties. The effects of climate change can be quantified with the use of this model, a technique that helps to identify appropriate research directions.

Technology transfer

With development of agronomic methods to minimize the adverse effects of abiotic and biotic stresses in fragile environments and to maximize effectiveness of resource inputs under favorable conditions, the Division has been active in the development of various technology transfer instruments. Technology transfer has been conducted primarily through international consortia (IRRC and CURE) and through NARES.

Site specific nutrient management (SSNM) technology for rice-based cropping system is now widely promoted; 40 location-specific SSNM recommendations have been developed for nearly 20 major rice-growing areas across Asia. The decision support system 'Nutrient Manager' has been released in Indonesia and in the Philippines in the local language; they are available in CD. The leaf color chart for nitrogen management has been distributed to over 650,000 farmers.

A simple tool has been devised for 'Safe AWD practice' in Vietnam, Philippines and Bangladesh which uses a perforated tube inserted in the soil where the water level can be seen; irrigation is recommended when the water goes below a threshold level. These technologies have been demonstrated to over 90,000 farmers in the Mekong Delta area in Vietnam and in the Philippines.

Another case of technology development and transfer is the use of dry direct seeding before commencement of the wet season, allowing double cropping of rice or rotation with non-rice crops, as practiced by thousands of farmers in Bangladesh and India. This dry direct seeding method is further examined in the Rice-Wheat Consortium for areas where shortages of water and labor are major constraints for rice-wheat double cropping.

Similarly, integrated pest management (IPM) methods have been developed and promoted in several countries. For example the adoption of IPM reached more than 3 million farmers in Vietnam. It also included reduced nitrogen inputs that helped reduce insect populations. This integrated crop management program has contributed to increased income for farmers and to reduced environmental pollution.

Some issues

The example of IPM in Vietnam is one of the few cases of recent CESD management technologies that have been assessed on a large scale. The lack of such studies may indicate a lack of effective management within the relevant Programs, and a lack of input from SSD. There are a number of research issues related to the potential uptake and impact of these innovations on a large scale. These include concerns such as the extent to which SSNM promotion takes account of rice and fertilizer prices, including subsidies; the labor and community coordination required for AWD; the role of the local machinery industry in developing new seeding methods; and the most efficient methods for delivering and maintaining IPM knowledge among farmers.

The challenge of effective resource use, particularly water, is likely to remain a key area in rice crop and environmental sciences. Specific areas of additional scientific research would include identification of soil and weather conditions where these different technologies are suitable, and quantification of water balance components in different systems to identify any further sources of water saving that can be achieved.

The Panel recommends that IRRI encourage a unified and coherent approach to the efforts of scientists from all Divisions to develop suitable lowland cropping systems and germplasm to

meet the challenge of the changing water environment; and that water is used as a strong organizing principle across the whole Institute to develop new products for the future. Research for the development of sustainable cropping systems and germplasm to address water shortage may include (but not be limited to): plant and soil factors that determine water uptake and underpin new cropping systems; genotypic adaptation and physiological mechanisms for genotypic variation; interactions of genotypes with nutrient availability and weeds; socioeconomic factors related to farmers' adoption of new practices and varieties; and development of new strategies for technology transfer.

Another important area of future research is crop diversification in rice-based lowlands. Inclusion of non-rice crops in the rice-based lowlands requires a good understanding of soil physical conditions including root growth and water balance. One area of research required may be root development under various soil strength conditions in lowlands, and its implications for water and nutrient capture for maize and legumes.

The area under rice-maize double cropping is likely to increase due to increased demand for maize in Asia and elsewhere. The fate of organic matter in the rice-maize cropping system is now well understood as a result of activities in the Division, and this needs to be translated into development of sound management systems for the tropics when the anaerobic soil conditions in the wet season alternate with aerobic conditions in the dry season.

Another area that needs consideration is the area of plant pathology and IPM. Despite the importance of diseases in rice ecosystems, the area is not included in the Division and inclusion of plant pathology will strengthen development of healthy crop management methods. This decline in the number of plant pathologists parallels a similar trend in NARS in recent years, and underlines the importance of considering future strategies in IPM.

Given that many of the most important opportunities for increasing rice production in Africa will come from crop management innovation, it is important that CESD be prepared to make increasingly strong contributions to Program 3.

Direct seeding has become common with the shortage of labor in intensive lowland rice cropping. While cost saving through reduced use of labor is achieved with direct seeding, the problem of weeds often increases. The ecology of lowland paddy weeds has been examined recently, and the complexity of weed ecology has been revealed; for example weeds vary in their adaptation to various crop establishment methods. This underlines the importance of sound weed management practices, and further work in this area is encouraged.

In 2007 the CGIAR called for pre-proposals for Challenge Programs on several issues, including climate change. In 2008 the CGIAR Challenge Program, *Climate Change, Agriculture and Food Security (CCCP)* was approved and will be launched in 2009. The Panel notes that the goals of this CP are consistent with IRRI's focus on the use of advanced breeding tools to improve water use efficiency and tolerance of high temperatures, and its historical research on green house gas production in rice fields. The Panel encourages IRRI to consider hosting the CCCP, provided governance issues relating to IRRI's charter can be resolved and full and transparent cost recovery from the CCCP can be ensured. Although early indications point to challenges in adequate funding for the CCCP, the panel is confident of its need and its relevance to IRRI's overall research agenda.

Social Sciences Division

IRRI's Social Sciences Division (SSD) currently includes 6 IRS, 1 IRF and 7 PDF. It was established in 1990 and inherited the mandate and substantial reputation of the former Agricultural Economics Department. In recent years SSD has continued to provide some of the Department's traditional products such as studies of farm-level constraints, village studies, impact assessment, and rice sector analysis (although the latter is at a lower level than previously). It has also expanded into newer areas, examining the implications of livelihood diversification and gender roles on rice production, contributing to more systems-oriented research (as with the upland rice research), and playing an important role in developing participatory research methodologies. It has also continued to place considerable emphasis on training and capacity building.

The work of SSD is widely appreciated within IRRI and its activities are quite well integrated with the rest of the institute's work. Despite considerable staffing changes and losses in recent years, a few staff members have been able to provide continuity and institutional memory.

SSD's importance was illustrated most recently by its ability to marshal statistics and analysis that were crucial in helping IRRI articulate a clear response to the rapid increase in world rice prices. SSD has made a number of significant contributions in recent years. It has conducted several studies that have provided insights into the relationship between livelihood diversity and rice production strategies, including work on migration in E. India and village studies in Bangladesh. This work carried forward SSD's commitment to practical gender analysis and broadened IRRI's knowledge of the impact of changing economic conditions on rice management. A large study documented the costs of drought (and drought-avoidance) to rice productivity. Significant involvement in projects in Bangladesh led to an important contribution to local policy discussions on a number of topics. Analysis of rice markets in the Philippines and Thailand helped clarify differences in efficiency between those markets. Extensive involvement in several large IRRI projects that involved developing and testing technology at key sites meant that SSD staff have helped conduct baseline and follow-up analyses at those sites (often involving training of local collaborators). The site-specific work was also an opportunity for SSD to make significant contributions to methodologies for participatory technology testing, particularly participatory variety selection (PVS). The former holder of the impact assessment position produced a protocol for ex-ante assessment of impact that IRRI found useful and has begun to use in its own planning.

A CCER for IRRI Social Sciences was conducted in early 2007. The review was done at a particularly critical time, when the Division head's post had just been vacated and several other staff had left or were about to leave. The CCER was conducted by four exceptionally experienced people with intimate knowledge of IRRI social science work. This was a very useful review and the recommendations were largely accepted by IRRI, although the Panel has a few concerns (see below).

SSD is seriously constrained by its current low staffing level. Although IRRI is committed to maintaining SSD, much of future expansion will have to be based on restricted grants The challenge with positions supported by restricted grants (especially when they are components of donor projects that have already defined their goals for social science input) is avoiding a mixed and constantly shifting set of personnel and priorities that interfere with the ability to support coherent research themes.

A further constraint is the shortage of strong NARES collaborators. Social scientists have always been in short supply in NARES (and even when present are often ineffectively managed and motivated). SSD thus faces a dual challenge of identifying appropriate partners and ensuring that those people's work is appreciated and utilized by their own institutes. One answer might be additional training, but this does not address the larger problem of attracting competent social scientists to join public research institutes, and the training demands on SSD are already considerable.

For its future work, it is important that SSD be able to articulate which activities fall within Program 7 (largely dominated by SSD research) and which activities will be carried out within other Programs. The 2007 CCER division between "independent research" (i.e. Program 7) and "support to biological programs" is not particularly helpful in this regard. This makes all work done outside Program 7 sound as if it is a second-class, service function. Given that much of the future support for SSD staff is going to come through donor projects that have a biological (technology development) focus, SSD needs to adopt a strategy that increases its role in planning those projects, going beyond standard baselines and final surveys to also provide feedback and monitoring, and pushing for work on policies and institutions that would carry impact well beyond the confines of project sites.

Because most of SSD's total staff activity is outside Program 7 (and this is every bit as important as the Program 7 activities), the CCER suggestion for consolidating the leadership of Program 7 and SSD may not be a high priority. The Panel believes that it is more important for the head of SSD to provide leadership and clarity to ensure that all social science activity is well integrated into IRRI's work across Programs and that careful priority setting avoids the danger of having limited social science capacity spread too thinly to achieve impact.

Identifying issues and strategies for the "non-Program 7" part of SSD work is particularly important. The danger is that a series of large donor projects will bring opportunities for social science work but will not add up to a coherent work program (indeed, becoming a mere "support" service). There is more than a person-year of senior SSD staff time in Program 1 (and 0.5 in Program 2), and six person-years of SSD PDF/IRF input also go to Program 1 (with two more positions vacant). It is important that SSD is able to take full advantage of this investment and work towards mutually re-enforcing work plans. Both the SSD CCER and a recent review of the Rice-Wheat Consortium urge more attention towards "scaling up" from these projects. But this entails much more than summarizing "what works and what doesn't". In most cases it implies much more active involvement at earlier stages of monitoring and feedback during the earlier stages of technology development and diffusion that allows for mid-course corrections and contributes to broader and more sustained uptake.

There are a number of other priorities for SSD. The new division head is moving towards revitalizing IRRI's capacity to present and analyze rice production and marketing data. This involves the use of others' (FAO and USDA) databases as well as making available IRRI studies (past and present). It will be important to carefully choose the themes for concentration, as the possibilities for analysis and can easily outstrip Division resources. Choices for analysis (e.g. on rice markets) should take advantage of the fact that SSD is part of the world's leading source of rice technology. Analysis that takes advantage of, and contributes to, that link should be emphasized while additional themes should be left to others.

The currently vacant impact assessment position will be filled in mid-2009, as there is strong demand throughout IRRI for these skills. It is worthwhile noting that the previous incumbent designed a planning matrix that has found considerable acceptance in IRRI. The position should be able to carry forward this link between planning and impact assessment. Further refinement within IRRI would provide excellent material for building national program skills as well. Recruitment is underway for a second position to cover econometrics.

IRRI's recent entry into Africa presents particular challenges for SSD. The CCER rightly warns that this will bring IRRI into contact with a host of constraints that have slowed the introduction of new technologies to that continent over the past several decades. There is certainly a need for SSD skills in Africa, but IRRI has no experience there, the work does not lend itself to a Los Baños-based position (full or part-time), and the need for analysis and input cuts across a wide range of themes. Some of the choices may be made by the special projects that would almost certainly fund such work (through Program 3), but care is needed in identifying SSD's comparative advantage in this arena. An "all-purpose" socio-economics position within a special project through Program 3 runs the danger of simply doing things like baseline studies that others could do and that don't offer IRRI a chance to take advantage of, and further develop, specific expertise. The Panel believes that it will be necessary to map out a social science strategy that includes a number of other institutions (many better placed than IRRI for Africa-based research) while defining IRRI's specific contributions that take advantage of its particular skills and interests, such as work around specific technological thrusts like small-scale mechanization, or work in domains such as rice marketing (both improving local efficiency and understanding the nature of Africa's rice import market).

The demands on social science will only increase in the coming years and the Panel urges IRRI to consider possibilities for increasing unrestricted resources for the Division. Although a number of special projects will bring short-term social science input, unless there is a critical mass of stable, experienced leadership these added external resources are unlikely to be used efficiently.

The Panel recommends that IRRI strengthen the delivery of its research products by refocusing the strategies of the Social Sciences Division. This includes the identification of high priority issues for policy research and impact studies; and greater emphasis on research on technology generation to ensure that IRRI's innovations are actually reaching farmers. Policy research opportunities should be identified that have the highest probability of actionable follow-up, and impact studies should focus on broad-based gains. Research on technology generation would include attention to monitoring and adoption studies, greater recognition of the iterative nature of technology development, and the analysis of national-level policy constraints. As SSD activities are re-prioritized and focused, IRRI should actively pursue mechanisms for providing more unrestricted funding for the Division.

3.3 Research and Support Units

Genetic Resources Center

The TT Chang Genetic Resources Center (GRC) at IRRI manages and curates the world's largest collection of cultivated and wild rice germplasm with about 110,000 accessions from 128 countries, including cultivated rice and all 22 species of the wild relatives. It is currently staffed by 2 IRS. The contribution of its collections to the development of IRRI's improved germplasm is unquestionable. GRC accessions are in the pedigree of 4317 released varieties and have contributed to approximately 62,000 IRRI crosses. The GRC carefully maintains its role as a facility for the curation and dissemination of germplasm to breeders and researchers in developing and industrialized nations. The GRC also has a very active research program for the phenotypic, genetic and genomic characterization of the germplasm that leads to greater use of the germplasm through knowledge of its gene structure and allele content. The GRC has a cohort of skilled and dedicated staff. Collection of new germplasm is still proceeding to fill gaps for specific eco-geographic locations, although the collection is not likely to increase substantially in the future. Future research efforts will focus on a long-term research program for the comprehensive characterization of the genetic variation in the collections through its contributions to IRRI Program 5.

Over many years the GRC has developed a strong research culture to understand and exploit the collections and this now appears to be well integrated with IRRI's genomics research groups in the Plant Breeding, Genetics and Biotechnology Division. Special emphasis has been placed over several years on biosystematics and the classification of the wild rice species using a range of cytogenetical and biochemical methodologies. With the development of genomic technologies this work has become more extensive and more precise, and much of the wild germplasm has now been characterized with SSR markers. This work is continuing through the development of SNPs, and will be essential to the integration of phenotypic, eco-geographical and genetic information with sequence-based understanding of gene function in cultivated and wild rice species. In this respect the GRC should continue to interact with other major investments, particularly the USA's NSF-funded Oryza Map Alignment Project (www.omap.org). This project is developing a range of functional genomic resources, particularly BAC libraries and sequence information on cultivated and wide species from different genomes. This both complements current research in the GRC and allows further opportunities for IRRI to characterize its wild species germplasm at the sequence level.

The GRC is also making a major commitment to the phenotypic characterization of its germplasm through cross-site collaborations, and has developed solutions to rationalize the limited numbers that can be handled. A focus on using association genetics approaches with SNP genotyping as the marker platform is strongly supported since other studies show that linkage disequilibrium in rice is sufficient to allow the location of regions controlling target traits. As in other research areas at IRRI, this will rely increasingly on the availability of phenotyping facilities and protocols. The GRC has identified key sets of traits in consultation with breeders, geneticists, physiologists and pathologist on the basis of priority for crop improvement and the need to find novel variants. Phenotyping protocols are under development and are being subjected to validation to test their effectiveness. This approach was endorsed by the Biotechnology CCER, which suggested a narrower focus than presently followed. An emphasis on root traits is potentially very useful also as the Program moves into a more detailed understanding of abiotic stresses and improved performance in water-limited environments.

The development of genetic and genomics resources at IRRI (and in other labs worldwide) will require the curation of new materials, such as precise genetic stocks (mapping populations, TILLING populations, isogenic lines, alien introgression lines) and DNA resources (BAC libraries, marker primers). Decisions will need to be made whether this is the province of the GRC or another part of IRRI. In addition, the level of commitment that the GRC makes to establish itself as a major center of genomic as well as genetic resources for the international community needs to be carefully considered. This also requires coordination with and endorsement by the Global Diversity Trust Fund. There is also a recognized need to develop an integrated network of rice genebanks and it is important that IRRI continues the process of system-wide integration of the IRRI GRC with WARDA and CIAT, and helps to establish an inventory of world rice germplasm. Projects funded by the World Bank, such as the Genebank Upgrading Project and the recently initiated system-wide Public Goods II project are very welcome in this context. The GRC also needs to maintain its role in training others in the collection, curation and dissemination of plant genetic resources so that its best practices get disseminated to IRRI's stakeholders and collaborators.

Grain Quality, Nutrition and Post Harvest Center (GQNPC)

The Quality Lab, with 1 IRS and 22 NRS, provides grain quality and related marker data to the breeding program, and is founder of the modestly funded International Network on Quality in Rice (INQR). This network shares information on grain quality attributes and coordinates the testing of a set of standard grain samples with 44 labs worldwide (see Section 5.1 for details on traits assayed and capacity). In addition to their service role, staff conduct research and have identified major genes for aroma, including alleles for one having a major effect (*BADH2*). Genetic and phenotypic analysis of RILs from the Genebank have led to the identification of markers for amylose content, gelatinization temperature and aroma, and these are being tested for effect using NILs. Starch type and branch length affects the Type 2 diabetes potential (or glycemic index) of rice varieties, and four haplotypes have been identified for the gene that contributes most to variation in gelatinization temperature. Basmati and jasmine aromatic rices can now be distinguished on the basis of their aroma signatures, though not by molecular diagnosis.

Grain Quality lab staff are active participants in Programs 1, 2, 3 and 5, but not Program 4 (Rice and Human Health) where grain nutrition research might be expected to have considerable relevance. It appears that marker and grain quality data developed by this lab are little used in the breeding program, though they should be valuable when selecting parents of crosses. The Panel suggests that the GQNPC staff be involved in fewer Programs, and rather be linked to either Program 4 or 5.

The Post Harvest section functions were merged with Grain Quality in 2006. It comprises 1 IRS and 4 NRS, deals mainly with rice mill owners focusing on means of improving recovery efficiency and milled grain quality; and farm and extension groups using machine harvesting and drying, laser leveling and simple hermetic storage methods (the “super bag”) for seed and grain. Training is also given in policy issues and marketing. Contacts are fostered with equipment manufacturers to make essential but simple equipment on site. Successful Post Harvest training programs have been conducted in Myanmar, Cambodia and Lao with measurable impact.

Crop Research Informatics Laboratory (CRIL)

The Crop Research Informatics Laboratory (CRIL) was created as a part of the IRRI-CIMMYT Alliance in January 2006. The total budget in 2008 was $2.76 m ($1.23 m for IRRI). There were 4 IRS in June 2008 at IRRI; a biometrics specialist, information systems specialist, bioinformatics specialist and bioinformatics software project manager; the biometrics specialist (and head) has since left IRRI. CRIL also has 4 postdoctoral fellows.

The IRRI-CIMMYT Alliance has created a critical mass in the area of biometrics and bioinformatics. However the physical distance and difference in corporate culture and research agenda between the two Centers meant there is scope for improvement in integration of complementary expertise.

There were 5 outputs for CRIL described in the MTP 2006-2008 when CRIL was formed, and these functions remain its main activity at the present time:

- Research support and quality assurance
- Institutional research data management

- Crop information systems for rice, wheat and maize
- Bioinformatics, computational biology and comparative genomics
- Decision support tools for crop improvement

CRIL has made good progress in many research areas, including integration of INGER to IRIS and development of common crop information management systems based on the International Crop Information System (ICIS), as described in more detail under Program 6. CRIL also provides services in biometrics, bioinformatics and research data management (see Section 5.1).

Members of CRIL have recognized technical leadership in the Crop Information System platform of the Generation Challenge Program with lead authorship on publication of the framework. They also contributed to the development and publication of a refined gene annotation of the IRGSP rice genome 'Rice Annotation Project'. With this and other recognition that they have earned, there has been strong demand for CRIL's research and services. This has resulted in CRIL expanding its activities in IRRI and CIMMYT, as well as for others who require specific expertise of CRIL members.

It may be, however, that CRIL activities are exceeding its sustainable capacities. The major challenge is to maintain service and research activities at a time when unrestricted funding is declining. While there has been strong support from GCP for the work in CRIL, this is not sufficient to maintain the level of current activities. Because of the service nature of the work in CRIL, securing funds is a major task. CRIL, however, should be supported as an indirect cost rather than attempting full cost recovery, which would be a disincentive for the use of the service.

Another possibility for the future is for CRIL to become a CGIAR systemwide unit, the hub of a possible Crop Research Informatics Network with IRRI leading the unit. CRIL's central role in bioinformatics is well recognized in GCP and elsewhere. This change will not only reduce the cost to IRRI, but also integrate activities of all CGIAR centers in this research area. However it may be argued that this centralized role should be played by GCP, and IRRI should receive the benefit of the results of activities of the centralized body. A better strategy may be that the IRRI-CIMMYT Alliance, perhaps including other Centers with direct interest in rice, maize and wheat, should concentrate on improving and utilizing ICIS to gain high returns with a relatively small further investment. For example, appointment of an ICIS project manager may prioritize the direction and continued development of ICIS and improve its usage.

If CRIL is not well funded, biometry services may need to rely solely on capable NARS biometricians, a situation the Panel would find unsatisfactory. One problem is a high turnover of national staff because of more attractive remuneration packages available outside IRRI for those with informatics skills.

4 IRRI'S PARTNERSHIPS

In the rice research and development world of today, in contrast to the 1960s when IRRI was formed, there are many more players having an increased diversity of goals. Critical partners in research at that time were NARS, and relatively few Universities in Asia and industrialized countries. Seed production was managed mainly by public seed organizations, and extension was largely through Government agencies. Today the NARS still play an essential role, but there is a plethora of ARIs who are also engaged in rice research, in many cases not as a crop but rather as a genomics model. Other IARCs are active partners in addressing the needs of rice based cropping systems. Governmental extension services have been sharply reduced, and some of that role has been taken by a diverse group of NGOs and, increasingly, the private sector. Traditional communications media of radio and television are being replaced by the internet and by cell phone technology. The role of governments in seed dissemination has diminished, but in their place is a rapidly diversifying private seed industry. Roles in partnerships have also changed. Large NARS, such as China and India, have research and national development programs of increasing scope which may share germplasm and are able to commission research. Donors in general have increasingly focused on supporting specific aspects of research work rather than supporting an institution *per se*. For these reasons the nature and health of these multiple relationships are of growing importance to IRRI as it fulfils its mission.

4.1 Engaging partners: Networks and consortia

IRRI's primary direct clients are the NARS of target countries. Public (and increasingly private) organizations of the national research systems adapt IRRI's products of improved rice germplasm, crop management technologies, and knowledge about the rice crop into components suitable for farmer' circumstances, and ensure these are transferred to farmers. Exchanges between individual scientists in NARS and at IRRI, through visits and training, have formed a strong basis for personal research partnerships, and will continue to be a very important factor driving collaboration. As national research programs have strengthened, relationships between IRRI and NARS have assumed a more democratic basis as consortia of various types have developed. In most consortia, an IRRI IRS functions part-time as the facilitator, but involves NARS in much of the decision making. In some instances leading NARS have been providers of technology to IRRI and to other consortium partners. While NARS are quick to acknowledge the very considerable contributions of IRRI, they also desire recognition and credit for their contributions.

The design of appropriate technologies requires that the Institute responds to real farmer needs. It is important that the flow of information to IRRI scientists - informing them accurately of farmer circumstances - forms part of an information loop that is used to identify appropriate technologies and to fine tune them during the experimentation and testing phases. Over the past decade, IRRI has continued to move upstream in the research continuum, and budget constraints have placed limits on direct interaction with NARS. Thus the need for accurate understanding of farmer circumstances as they change is perhaps even more acute today than a decade ago.

IRRI has initiated a series of networks and consortia to serve as a vehicle for sharing germplasm and generating and testing production technology. A complete list of these is given in Annex 6 and reference has already been made previously to the research functions of the most important of these. The focus in this chapter is less on their research agendas and more on the effectiveness in servicing partnerships.

The International Network for Genetic Evaluation of Rice (INGER)

INGER's goals are to share global genetic resources with all rice scientists. Numbers of participating countries have fallen from 85 countries at its peak to 39 today, and only about 45% of nurseries return data. Weaker NARS cannot always afford to run the trials, and some germplasm distributed is poorly adapted and of less interest to NARS that want finished varieties. INGER trials also declined in popularity because of an unwillingness by NARS (following the adoption of the Convention on Biological Diversity) to share germplasm because of IP concerns, and a lack of feedback of data to NARS. IRRI breeders also complain that data comes too late to influence breeding decisions. Recent changes in data entry procedures and the use of the SMTA with germplasm transfer have increased confidence and INGER's popularity, and it appears that INGER will continue to provide a useful service to the rice breeding community. The Panel, however, does not think that INGER is the best vehicle for distributing replicated yield trials, preferring instead the development of a carefully designed multi-location testing network with clear breeding goals.

Irrigated Rice Research Consortium (IRRC)

Now in its 12th year, IRRC focuses on improving irrigated rice production practices at sites in its 11 partner countries in Asia. Its objectives are to validate innovative resource conserving and post-harvest technologies for lowland irrigated rice, and to facilitate their adoption. Its research addresses efficient nutrient and water use, pest management and IPM with special attention to the environment and to sociological factors. IRRC participating scientists meet annually to exchange results and plan joint research projects. However, the Panel notes that IRRC does not evaluate varieties.

Consortium for Unfavorable Rice Environments (CURE)

This network, created in 2002 as a successor to the Rainfed Lowland Rice Research Consortium (1992) and functioning in 10 countries, focuses on low yielding, rainfed lowland and upland rice farming systems where yields are often unstable because of abiotic stresses. CURE develops the consortium concept further by moving control of the network to the NARS. This consortium does include limited comparisons of varieties, mostly carrying *SUB1*, *SALTOL* or QTLs for drought tolerance. There is institutional investment by the NARS at each research site, and the network provides funds for each trial. A key component is participatory variety selection (PVS) by farmers. It is encouraging that some CURE sites are already being used for germplasm evaluation by the Rainfed Lowland Breeding Program.

Rice-Wheat Consortium for the Indo-Gangetic Plains (RWC)

The Rice-Wheat Consortium for the Indo-Gangetic Plains (IGP) includes as its principal members the national agricultural research systems of Bangladesh, India, Nepal, and Pakistan and several IARCs (principally CIMMYT and IRRI, with smaller contributions from ICRISAT, ILRI, CIP and IWMI), several ARIs, and the private sector in the IGP. It is currently convened by IRRI but managed by NARS. Its main goal is to develop and deploy more productive and sustainable technologies for areas dominated by the rice-wheat crop rotation by using research partnerships among members. Especially impressive are the linkages between the RWC and private machinery manufacturers that have led to a major increase in direct seeded, zero-tilled wheat.

Other equally important partnerships are those between Universities and the RWC. Much of the research undertaken by the RWC will be subsumed under the new CSISA project that plans to use a number of RWC research sites. The Panel is pleased with this donor endorsement of the very considerable accomplishments of the RWC, but suggests that the consortium remain in existence throughout the life of CSISA.

IRRI has a number of other consortia and networks, but space precludes a full description (see however Annex 6) Their principles of operation are broadly similar to the consortia described above.

Panel Assessment: Consortia and transfer of research capacity

The establishment of consortia by IRRI has been an important means of strengthening NARS in Asia. These have generated a high level of collaboration among members, and have helped expand the research capacity of NARS. The exploitation of interactions between variety and resource-conserving management practices will be an important step forward, and one that IRRI should seriously consider.

Consortia have played a significant role in the transfer of some of IRRI's research functions to NARS. One example is the continued development and extension of resource-conserving technologies such as site-specific nutrient management and alternate wetting and drying methods that have been transferred to IRRC member countries through the consortium. The generation of direct seeding techniques under the RWC is a further example of growing NARS research and private sector strength in the IGP region. Finally, the development of country-specific rice knowledge banks based on IRRI's pioneering version is a further indication of transfer of function from IRRI to NARS. The Panel regards these and other examples as evidence that IRRI's strategy for developing partnerships with national programs through networks and consortia is enabling and empowering NARS scientists, and increasing the capacity of NARS to fulfill their mandates.

4.2 Roles and relationships with NARS

IRRI enters into a range of relationships with its different NARS partners. Traditionally IRRI has been a provider – of training, germplasm and technical advice – and NARS officials are consistently appreciative for the type of support that has been available. But the nature of NARS is changing, and the concomitant partnerships must also evolve. Many NARS are now linked (to each other and to IRRI) through networks for germplasm testing or for site-specific technology generation. NARS are anxious that these be treated as true partnerships and do not want to find that IRRI is merely using them as a means of collecting data. In other cases, particularly with advanced NARS such as China, it is necessary to identify the comparative advantages of the respective partners and to urge NARS with specialist capacities to make their outputs available as IPGs, possibly made accessible through IRRI. Indeed, the capacity of some centers of breeding and genetics research is much greater than that of IRRI's, and IRRI must seek to develop access to these through strategic partnerships and agreements.

The heterogeneity of Asian NARS means that it is impossible to map out a common strategy for these relationships, but there should be a clear IRRI strategy towards each of its national partners. For China and India, national rice research capacities are so extensive that planning IRRI relationships is probably best done on an individual project level, with periodic joint agreements that simply summarize and validate research collaboration. For some other countries, however, a national prioritization meeting (perhaps every five years) might be useful; not simply to formalize continuing partnerships with IRRI but to provide input to strategic discussions on rice research priorities. Although various IRRI activities may be taking place in a country, these should reflect a common IRRI stance towards development of the particular NARS. At present it is not clear who in IRRI should be responsible for such strategies. IPMO covers this to a certain extent, but as these strategies would embrace technical and institutional issues beyond the expertise of IPMO it may be that a different authority in IRRI, perhaps at a higher level in the Institute, will be required.

The relationships with national programs are made more difficult by the growing complexity of potential NARS (particularly NARES) partners. Not only may there be several types of rice research organization within a country, but the consortium and network approach is leading to new ways of doing business. For instance, as noted, the RWC is now managed by NARS. In addition, attention to delivery and impact increasingly means engagement with a much wider range of partners, including NGOs and the private sector who may or may not have good relations with traditional IRRI partners. Much of this downstream engagement currently takes place at the level of project sites belonging to a consortium. This strategy may serve to identify local collaborators who are most useful for a particular site but not necessarily for scaling up. This emphasizes the importance of some type of national-level diagnosis and strategy that ensures a consistent approach and an effective IRRI 'research for development' strategy in each country. The technologies that IRRI is instrumental in developing have a much higher chance of being promoted if there is a broad sense of national ownership. The Panel urges IRRI to consider appointing an IRS for 10-15% of his/her time to serve as a known focal point for issues that arise for each significant Asian rice producing country – a sort of "ambassador" for rice related issues, and "guardian" of data, trip reports, GIS analysis and other rice-related information that relate to a specific national system. This country contact would also facilitate the process of developing country plans as the need arose.

Many of these considerations about NARS relationships impinge on decisions about where IRRI posts its staff and what mandates are assigned to out-posted staff. In some countries, the fact that there are fewer IRRI scientists posted in-country is interpreted by NARS as a decline in interest by IRRI, even though the country may host several research sites under consortium approaches. If IRRI's presence is limited to attendance at meetings and collection of data, effective collaboration between IRRI and national partners may be impaired. The problem is not necessarily resolved by out-posting more people (and unless an IRRI post is well-supported by the national program it may not be productive either for the NARS or the staff member), but more attention is required to analyzing the advantages and disadvantages of having a somewhat higher proportion of staff posted outside of headquarters than is currently the case.

The CCER on Staff Placement recommended expansion of outreach positions and endorsed the concept of country liaison scientists. But there has been little movement towards posting more staff outside Headquarters and a brief experiment with a Mekong Basin regional office lasted little more than a year. IRRI still needs to consider its stance regarding out-posting. Liaison persons have proven to be useful positions, but they do not substitute for the need for IRRI to have a well-defined country strategy and sufficient presence (through in-country posts or significant collaborative activities) so that countries feel that they are true partners. As IRRI moves into Africa, it will be interacting with NARS with whom it has much less experience and many fewer links. IRRI will have its principal office in Tanzania but much of its relations with NARS should be mediated by the East and Southern Africa Rice Program (ESARP) which has been implemented jointly with WARDA and participating NARS of four targeted countries. Furthermore, IRRI's policy on career development and promotion must be seen to be equally applied to outposted scientific staff so that there is no perceived career risk in accepting these posts.

In summary, **The Panel recommends that IRRI better define its strategy and objectives for country and regional programs, and that the mandate and functions of the International Programs Management Office (IPMO) be clarified to support these objectives.** IRRI should have a well-defined strategy for each of its partner countries. IRRI should designate a staff member to serve as a focal point for each significant rice-producing country in Asia to coordinate information and contacts; for many countries, a meeting (approximately every five years) to discuss national rice research priorities will be useful. The examination of IRRI's interactions with NARS should also include the possibility of placing a larger proportion of staff outside of Headquarters.

4.3 Relationships with the CGIAR

General

IRRI's work on rice places it centrally within CGIAR efforts in germplasm improvement of staple crops for global food and nutrition security. IRRI's current strategic plan to 2015 sets out a program of increasing global scope which essentially describes the parameters of the CGIAR rice effort (see Section 4.3.1, below). There have also been several rounds of discussion with CIMMYT on the possibility of alignment of the two Centers' efforts on staple crops and there are increasing cross-Center initiatives either through three Challenge Programs in areas of common interest, or through specialist system-wide programs with sister Centers. There is potential for an increasing role in the Climate Change agenda of the CGIAR either through the developing CP or simply through its own research on adaptation to stress tolerance.

4.3.1 Rice and the CGIAR: IRRI, WARDA and CIAT

Three Centers of the CGIAR work on rice: IRRI with a global mandate but focusing largely in Asia; WARDA (also known as the Africa Rice Center), originally focused on the countries of West Africa but increasingly with broader SSA perspective, based in part on the success of the Nerica varieties; and CIAT in Latin America. In 2005, the IRRI Board of Trustees and management directed IRRI's attention towards Africa, and an IRRI scientist was posted to WARDA's program at IITA in 2006 . Despite earlier difficulties in relations, the two Centers have taken concrete steps to establish a common Africa rice research strategy and program. IRRI and WARDA managements signed a formal MOU in December 2005 in which the basic principles of cooperation were laid out. This has been endorsed by a letter of intent signed by WARDA's Council of Ministers. IRRI posted a senior scientist to Maputo in September 2006. Programmatic alignment will initially focus on improving and exchanging germplasm, and building a cadre of trained scientists, and on a broader scale it also includes CIAT[9]. Further meetings between the Centers included a rice "convening" in July 2007 by the BMGF. The result was a major grant by the Foundation to support an IRRI project (started March 2008) on developing abiotic stress tolerant rice (STRASA), in which WARDA will be a primary subcontractor. The Green Super Rice project grant, also supported by the Foundation, includes IRRI and WARDA as sub-grantees with China as the lead partner. Additional funding from the Government of Japan for rice breeding at the two Centers is currently under discussion. IRRI and WARDA have been making substantial progress in developing a common rice program for SSA during 2008 through attendance at each others' Board meetings, development of a joint proposal for the Japan TICAD IV undertaking, and the development of the East and Southern Africa Rice Program (ESARP). In addition there have been a number of exchange visits by top management to both Centers during 2007-8.

The situation for rice and the CGIAR in Latin America and the Caribbean (LAC) is less clearly defined. CIAT's rice program has been in steady decline since the mid-1990s after an excellent record in breeding for disease resistance and in training national scientists. Now, virtually the entire senior scientific staff for rice has either left or is near retirement. The future of the forward-looking partnership with the private sector (FLAR[10]) is unclear. IRRI is exploring a direct research relationship with EMBRAPA in the area of aerobic rice. Although this discussion is in its very early stages, the Panel encourages IRRI's interaction with this major research partner in the region.

The Panel congratulates the management of IRRI and WARDA on their leadership and commitment to developing a coherent program for Africa, and feels that IRRI is well positioned to lead the global rice research effort in the next decade, supported by the strong commitments to such a program that have already been made by WARDA and CIAT.

4.3.2 CIMMYT and the IRRI/CIMMYT Alliance

IRRI and CIMMYT have had long standing cooperative activities (e.g. the Rice-Wheat

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[9] IRRI views the WARDA, CIAT agreement as meeting, in part, the 5th Recommendation of the last EPMR i.e. that The Panel recommends that IRRI establish a forum of rice-growing countries with the purpose of financing and revitalizing INGER.

[10] The Latin American Fund for Irrigated Rice (FLAR) was created in 1995 to fill the gap left by CIAT's decision to shift its rice breeding priorities towards virtually exclusive concentration on marginal production zones. FLAR's budget is provided through members contributions and FLAR manages an extensive regional program of rice breeding directed by its members (eight countries plus CIAT) through the FLAR Board. FLAR's major contributor Brazil is developing its own hybrid rice research program.

Consortium), and following a joint declaration by both Boards in October 2003 the two Centers explored alternatives for closer collaboration or merger. It has also resulted in the appointment of joint Board members. Discussions were facilitated in 2004 by the Rockefeller Foundation which, after meetings in the presence of the CGIAR Oversight Committee, advised against a complete merger, and subsequently each Center has retained its "brand" identity.

The two Centers have jointly developed and implemented Alliance projects for each of the areas identified in the Rockefeller Foundation report. Each project is intended to have a unified budget and a project leader. Initiatives include the Crop Research and Information Laboratory (CRIL). Although operational issues relate to the large time difference between the headquarters of the two Centers (Philippines/Mexico), and the clarification of the management structure, there is further potential to enhance synergies in computational biology, bioinformatics; and comparative genomics. It appears likely that CRIL will evolve into a systemwide bioinformatics platform, a direction which the Panel urges IRRI to explore. The Cereal Knowledge Bank (CKB) concept has also resulted from the IRRI –CIMMYT Alliance, and is the world's leading repository of extension and training materials related to cereal production. A third initiative is the Intensive Production Systems for Asia (IPSA) whose activities have been described in the Rice-Wheat Consortium. IPSA has received significant support through the BMGF- and USAID-supported CSISA Project, and from GTZ project support for India and Bangladesh, amongst others. Together these projects have breathed new life into the IPSA initiative, and provided a natural vehicle for the further development of the CKB. The Panel finds that the Alliance has had a positive impact, and without its original work and significant research impacts (Chapter 3) the foundation upon which CSISA rests would be far less solid. The Panel agrees with the earlier analysis that institutional merger is not necessary for close working relationships.

Links with Challenge Programs

IRRI actively participates in three Challenge Programs: in the Generation CP (in both commissioned and competitively won projects); in Harvest Plus as the rice leader (almost entirely commissioned research); and in Water and Food as the managing Center and leader for Theme 1 (almost entirely competitive grants). Research at IRRI supported by the Challenge Programs is embedded within the seven programs, their outputs and output targets.

Generation CP (GCP)

The Generation Challenge Program, Unlocking Genetic Diversity in Crops for the Resource Poor, brings together a consortium of researchers from IARCs, NARES andARIs, and seeks to use genetic diversity and genomics research to solve difficult production problems, with a particular focus on drought. Thus GCP strategy aligns strongly with IRRI's, and until recently an IRRI IRS was the sub-Program 2 leader. IRRI has greatly benefited from the resources and collaboration opportunities brought about by involvement in GCP. Through several GCP projects and through targeted investments from IRRI's reserves, IRRI has completed analysis of the population structure of a substantial collection of rice germplasm, developed the OryzaSNP project, and made considerable progress towards establishing a functional SNP platform. The genomic resources and projects developed with GCP funding and cooperation were strongly endorsed by the recently concluded CCER on IRRI's Biotechnology program. The drought and salinity breeding networks initiated by IRRI have received strong support from the GCP, and the GCP helps improve infrastructure and use of marker applications at several NARES institutions (e.g., in Bangladesh, Indonesia, and India), and has sponsored degree and non-degree training of NARS scientists. An especially significant contribution of GCP to IRRI has been in expanding

IRRI's bioinformatics team and providing hardware for this, particularly in the development of Web interfaces to crop and genomics information within IRRI's database, IRIS. The GCP also contributes significantly to the staffing of the CRIL, and improves technical capability in the analysis of functional and comparative genomics data.

IRRI also views the GCP as an important mechanism for attracting intellectual contributions from scientists at ARIs. Although GCP is narrowing its list of target crops, rice remains one of its priorities. IRRI therefore expects to continue playing an important role in GCP priority activities, and in its future research strategy. Since the initiation of the GCP, IRRI has received grant support of approximately US$7 M (as of June 2008), averaging US$1.4 M per year, and is the largest recipient of GCP funds. Despite the close research links, the Panel senses that GCP appears to be viewed more as a donor than as a research partner supporting IRRI's strategic research initiatives The Panel urges IRRI to have high level strategic discussions with GCP, and to share equitably in attribution, and where possible, in research planning as well. This will become even more important as research on water-related traits matures, and a new round of gene discovery ensues.

Harvest Plus Challenge Program (Harvest Plus CP)

IRRI collaborates in the Harvest Plus Challenge Program on the development of nutritionally-enhanced rice germplasm and this is integral to the focus of IRRI Program 4. The work at IRRI brings together the ongoing and planned efforts on the development and deployment of rice germplasm with increased content and/or bio-availability of pro-vitamin A, iron, zinc, and Vitamin E, and with improved protein quality (higher lysine content). These outputs link IRRI's commitments under Harvest Plus to the Golden Rice Network, and to the BMGF-funded Grand Challenge #9 Project. IRRI is appreciative of the technical support it receives from the Harvest Plus CP in areas such as nutrition and consumer acceptance. It is expected that the work will extend to the evaluation of the needs and development of solutions to additional micronutrient deficiencies (e.g. vitamin B1). Grant funding received by IRRI from the Harvest Plus CP since its inception totals US$2.78 M.

The Water and Food Challenge Program (CPWF)

IRRI is a founder member of CPWF, and has maintained its Steering Committee membership since 2003. IRRI has led and helped shape the research agenda of Theme 1 (Improving crop water productivity; one of the 5 themes of the CPWF). Total funds for IRRI-led research and program leadership are US$5.4 M to date. IRRI's commitment to the goals of Theme 1 has gone well beyond its interest in rice, and their leadership into the effects of saltwater intrusions in coastal systems is considered exemplary. Participation in the CPWF allows IRRI to implement its core research agenda in coping with water scarcity with new partnerships that, in many cases, helped IRRI extend its research beyond the plant and field level. IRRI is seen by CPWF as a highly reliable research partner, and the Panel congratulates IRRI on this partnership. It notes that CPWF in its second phase will be focusing on the Limpopo Basin in south east Africa – a region with considerable potential for irrigated rice.

Systemwide programs: SGRP

IRRI's Genebank is an important contributor to the System-wide Genetic Resources Program of the CGIAR. Studies of genetic diversity in IRRI's and others' accessions should lead to a rationalized system for the conservation of rice genetic resources in collections worldwide, and is in collaboration with the Global Crop Diversity Trust. Through SGRP there are also particular linkages to WARDA and to CIAT to establish new approaches to jointly improve the efficiency of maintaining and delivering appropriate germplasm in Africa, Latin America and Asia.

Panel assessment

The Panel congratulates IRRI on its initiatives in partnership with other CGIAR Centers, and notes that IRRI is held in very high esteem by them. Especially noteworthy is the long-standing collaboration with CIMMYT now formulated as the IRRI-CIMMYT Alliance. The close working partnership that has been developed recently between IRRI and WARDA has already yielded additional generous support from investors, and the Panel urges IRRI to take all reasonable steps to institutionalize this partnership to ensure durability. We conclude that, on the basis of firm and cordial relationships with WARDA and CIAT, IRRI is well positioned to lead the CGIAR rice research agenda into the next decade. Within this relationship IRRI's comparative advantages in Asia will be the provision of adapted germplasm and complementary growing practices. For Africa, it will be primarily for lowland rainfed and irrigated germplasm, while uplands should remain the domain of WARDA.

Which Center, if any, has a clear mandate to lead upland rice research? There are limited opportunities for spillover from upland research conducted in one region to another because upland environments are typically heterogeneous in farming practices, cropping systems, climate and soils. For this reason the Panel concludes that there are few savings to be made by allocating responsibility for strategic upland rice research to any single Center. Germplasm should be regularly exchanged among all three Centers.

Challenge Programs have played an important part in supporting IRRI's agenda. IRRI has used these partnerships to good effect, and with the GCP and CPWF it leverages its research on water-related traits, bioinformatics and growing practices. Both Challenge Programs have found the level of IRRI's execution of goals and strategies at the project level to be very satisfactory. There has been some reduction in IRRI's direct research investment in the area of genomics and water management practices resulting from the increased support received from GCP and CPWF. Challenge Programs, however, need be viewed by IRRI as partners in developing and executing the Institute's research agenda, rather than simply sources of additional funds for projects within IRRI's core research strategy. The Panel urges IRRI to engage with the Challenge Programs through an annual consultation between its DDG-R and the Directors of each.

4.4 Relationships with Advanced Research Institutions (ARIs)

IRRI has historically, and currently maintains, a very large number of formal and informal cooperative research relationships with many scientists in ARIs spread out all over the world, in universities, Government-funded research institutions, NGOs, and research charities. Over the last decade, the emergence of rice as a major genetic and genomics model for cereal biology in general has attracted front-line scientists from many non-rice growing countries in the northern Hemisphere to invest in rice biology as a means of understanding plant processes. Much of this was started by participation of ARIs in the Rockefeller Foundation-funded Asian Rice Biotechnology Network - for example, the enduring relationship with Cornell University. IRRI's germplasm, technology and infrastructure continue to attract top expertise into collaborations, as recently demonstrated by the partners involved in the C_4 rice project, and this provides leverage to gain access to knowledge, resources and expertise that IRRI does not have. As in most scientific endeavours, collaboration is driven by mutual curiosity in aspects of plant biology, and joint proposals for cooperative work can arise from meetings at conferences and workshops, or from mutual interest in publications. The Panel strongly supports these links as a means of strengthening IRRI's mission to apply science to developing world agriculture. It encourages IRRI to continue to augment established links and to make new ones through both formal joint-funded projects or, more informally, through inviting peers from advanced research institutes to IRRI as visiting scientists for short or long visits

It is commendable that IRRI now has formalized research relationship with the major scientific institutions of the major rice growing countries, India and China. The recent (December 2008) meeting between 15 IRRI scientists and Chinese scientists in Hangzhou, China, funded by the National Natural Sciences Foundation of China, could lay the foundation for expanded cooperation with the top rice research labs in China, funded by the Chinese Government. IRRI should grasp the opportunity afforded by this link, and encourage a sharing of China's very considerable genomics and germplasm resources as IPGs for the benefit of resource-poor rice producers and consumers.

4.5 Relationships with the Private Sector

IRRI's activities with the private sector cover a range of interactions, from receiving funding for 'no strings attached' research activities, to joint projects for the development of products or understanding of mutual benefit, to negotiations for the acquisition and transfer of IP for IRRI-led program research activities. IRRI's current philosophy for collaboration is that the relationship must have clear relevance for IRRI's mission as indicated in its Strategic Plan, the interaction must enhance research capacity at IRRI, must not interfere with its collaborations with, and support of, NARS, must be on a non-exclusive basis and have full-cost recovery. IRRI rightly does not carry out contract research, such as 'product testing', or the promotion of products, nor activities that could contravene biosafety rules or host country laws.

The current interest in rice varieties and rice research, particularly genomic research, by national, regional and multinational seed and biotechnology companies, has created a complicated scenario. The delivery of IRRI hybrids by private seed companies has meant that IRRI germplasm is being registered and marketed by private companies; biotechnology companies have cloned genes or possess genomics information that could, potentially, greatly enhance IRRI's research and impact, for example on drought tolerance. The 6th EPMR encouraged IRRI to interact more with private industry to obtain access to advances in genetics and genomics. This new situation requires IRRI to reassess its 'rules of engagement' and how its freedom to operate, in terms of freedom to publish and freedom to release materials and results to traditional partners, can be balanced with the requirements for exclusivity and closer partnerships with individual companies. Several large multinational companies have recently approached IRRI for joint projects and IRRI needs a set of rules to provide common principles for contracts with different companies. It needs to consider how it can cooperate without contravening its basic philosophy; and determine what it wants back in terms of resources that are transparent and accountable to its stakeholders - i.e., to develop a risk-benefit approach.

A recent precedent has been set for private-public partnerships by the formation of the Hybrid Rice Research and Development Consortium (HRDC). This consortium was formed in 2008, and comprises a mix of private and public sector institutions which contribute to the cost of rice hybrid development conducted on their behalf by IRRI. Membership costs, paid as grants to IRRI, are determined by category of membership for private seed companies, but fees are not mandatory for public institution members (although voluntary contributions are possible). Right of access to germplasm developed by the HRDC reflects category of membership, though inbred lines developed by IRRI with HRDC funds will be supplied free in small amounts to public sector organizations on request, subject to conditions imposed by IRRI in the SMTA. The HRDC agreement is a carefully thought-out series of obligations and benefits to both sides, and could be a template for further such consortia. The Panel considers this an innovative private-public sector model for collaborative development of superior lines and hybrids that will serve well IRRI's goals to deliver superior rice germplasm to farmers. Because free access to public sector organizations to all classes of inbred lines has been maintained, the Panel sees no significant conflict between the provisions of the HRDC and the IPG requirements of the CGIAR product dissemination policy. If successful, the HRDC will continue to fund research aimed at increasing the genetic diversity of public and private hybrids, increasing heterosis and reducing the cost of hybrid seed. Ensuring that research results meet member expectations may require additional funding of HRDC by IRRI in its initial stages.

However, a standard agreement for individual bilateral relationships still needs to be developed further (building on a current 'one-off' agreement for joint work of mutual benefit with a major company on marker-assisted selection). This agreement would cover background and foreground IP, project oversight, due diligence, financial arrangements, licensing, data sharing, confidentiality, disclosure and publications, termination clauses, dispute procedures; and appears comprehensive in content. IRRI will also have to have mechanisms in place to make sure that confidential data are adequately protected.

Box 4.1 Hybrid Seed – issues in managing the HRDC

IRRI's interactions with the hybrid seed industry through the HRDC raise some difficult questions related to IPGs. In addressing these, it is helpful to recognize that hybrid rice has some characteristics that differentiate it from non-hybrid rice seed (whose distribution and IPG-related issues are more straightforward). Hybrid seed is relatively difficult and expensive to produce, and the experience is that to date few public seed operations are able to manage its production efficiently; it is not subject to seed saving, so it must be purchased each year, similar to many other inputs; and the very nature of hybrids brings a certain degree of in-built IP protection and the component inbreds of a particular hybrid can be considered trade secrets.

These differences imply that hybrid rice necessarily requires (and attracts) a much higher level of private sector interest than conventional rice seed, so that IRRI is required to develop and monitor strategies that facilitate its interaction with the private sector. The differences also illustrate that the definition of IPGs is not always perfectly clear (in the sense of technologies being freely and openly available). Rather than try to pursue some ideal definition of IPG, IRRI should ensure that its HRDC functions so that the products of its hybrid research reach the widest number of rice growers (and particularly low-income rice growers) at the lowest possible cost. The achievement of that goal depends on the nature of the hybrid rice seed sector, whose development and evolution is largely out of IRRI's hands. An ideal scenario is probably a relatively large number of small- to medium-size seed enterprises in all of IRRI's partner countries who are able to utilize the products of the HRDC and whose competition ensures efficiency and wide coverage.

Unfortunately, a number of factors challenge the realization of this scenario. First, plant breeding skills differ significantly among countries, so that the demands for finished products versus early breeding lines are not homogeneous. Thus IRRI needs to differentiate among HRDC clients and monitor progress among countries with different research capacities. Second, commercial seed production skills and resources also differ among countries, and some countries will either require significant investment or will have to rely on imported seed. Third, the role of scale economies in the hybrid rice seed industry is not yet clear, but there may be a "natural" movement toward concentration, making it important for IRRI to periodically review the nature of its clientele (and their capacities and interests in delivering products to resource-poor farmers). Fourth, it is not yet clear to what degree location specificity and "niche varieties" will determine the diffusion of hybrid rice; a large degree of heterogeneity may be a stimulus for a diverse, competitive seed market, but its interaction with a concentration trend may mean that a significant number of producers are left behind. Fifth, it must be recognized that the HRDC is not the only player in the hybrid rice field; the actions and successes of national breeding efforts in countries like China or India, or those of MNCs, may bring significant changes to the global hybrid rice seed market.

There do not seem to be any clear answers to these issues at this time, other than to encourage IRRI to continually monitor which members of the HRDC are taking best advantage of its products and the degree to which hybrid varieties and seed are reaching all those farmers who can benefit from them. Shifts in the hybrid seed industry and its performance may have to be met with modifications in the HRDC.

The protection and acquisition of specific, existing IP can be considered at two levels – first, the acquisition of IP from third parties for use in IRRI programs, and secondly, the protection and dissemination of IRRI's own IP for use by its traditional clients and private companies. Both of these areas require the development of policies which enable clear rules of engagement with the private sector which protect IRRI's freedom of operation in moving IPGs out and into use for the world's poor. A particularly sensitive area at the present time is the commercialization of IRRI-derived germplasm by private companies. At present, IRRI makes no distinction between the public and private sectors in the terms and conditions under which it supplies germplasm for breeding and research, covered by the SMTA under the International Treaty on Plant Genetic Resources for Food and Agriculture. However, NARS and companies have sometimes been releasing IRRI primary germplasm as protected varieties, and royalties are transferred to NARS. IRRI would like to seek some return on such activities. It can be argued that such commercialization is fulfilling IRRI's mandate and helping SMEs to develop products for the common good, and that materials are freely available to competitors. Additionally, using a separate MTA may contravene articles of the Treaty. IRRI is looking for ways in which it can initiate some "in kind" compensation (such as scholarships); though it is unlikely any *post hoc* agreement could be enforced.

Multi-national companies are accumulating a range of genomic resources and cloned genes that could benefit IRRI's rice improvement programs. The complex web of patents and cross-patents make this daunting, Golden Rice being a clear example. Some companies are willing to release materials under a humanitarian licence, but others will expect some type of return for their investment. IRRI needs to carefully audit what technologies it wishes to obtain, and the conditions it will accept to introduce these into its project portfolio - for example, genes for drought tolerance or disease resistance. The other side of the coin is that IRRI may develop a technology or clone a gene, such as *SUB1*, that multi-national companies may want to use in other species, such as wheat or maize. IRRI already has procedures to audit its IP, and needs to develop agreements to licence its IP outside of its mandate of rice. The Panel believes that IRRI should only use IP protection as a defensive mechanism in order to establish freedom to operate in its research and dissemination of products, and not primarily as a means of generating extra research income through royalties.

4.6 Final comments

Relationships with clients, fellow researchers, and sister institutions are the key pillars upon which IRRI's institutional success rests. They will undoubtedly become more important with time, as the number of players grows, and as communication among colleagues at all levels becomes easier. Establishing good partnerships requires a high level of trust, shared goals, good and frequent communication, mutual accountability and equitable attribution. IRRI continues to be highly respected as a collaborating institution that relates well to its partners. The Panel notes that partnerships should not be taken for granted as they are rarely static and need to be monitored in relation to regional and national developments. There will be an increasing diversity of partnerships for IRRI in the future, and each will require attention to be able to flourish. Keeping this in mind, the Panel expects IRRI to move forward in planning and executing its research agenda confident of the support and cooperation of its key partners.

5 RESEARCH SUPPORT AND INFRASTRUCTURE

This chapter describes and comments on the organizational units, regulatory services and infrastructure which support IRRI's research and related functions. Several of these units conduct research in their own right and contribute through the program structure and such activities are described under research in Chapter 3.

5.1 Science support

Genetic Resources Center

The GRC carefully maintains its dual role; as a facility for the curation and dissemination of germplasm to breeders and researchers in developing and industrialized nations worldwide but with a very active research program for the phenotypic, genetic and genomic characterization of the germplasm leading to greater use of the germplasm through knowledge of its gene structure and allele content.

From an operational perspective the gene bank is highly organized and efficient with a cohort of skilled and dedicated staff. Its functions are integrated with the Seed Health Unit, meeting the new standards for curation and seed distribution laid down in the International Treaty on Plant Genetic Resources for Food and Agriculture. The GRC is a passive and active disseminator of materials; either responding to direct, specific, requests for nominated lines, or meeting more general requests by using its experience and knowledge to send off lines appropriate to the request. Most processing backlogs have been eliminated, equipment upgraded, and in particular, there is an upgraded data management system integrated with CRIL software. Future efforts will continue on upgrading systems and information sources to allow efficient dissemination of the seed and quick response time to requests, and for providing quality passport and other data on accessions.

IRRI follows the biosafety guidelines and protocols prescribed by the National Committee on Biosafety of the Philippines (NCBP) which covers various biosafety issues related to transgenic (GM) research. This includes the physical separation of non-transgenic and transgenic materials at all stages of plant growth including harvesting, threshing and storage of seeds. IRRI should ensure planning is in hand for extra capacity of this sort should future research expand the number and type of genetically modified lines that are produced at IRRI and elsewhere.

Funding for the GRC has been problematical in the past and it is heartening that 75% of the funding for the fundamental activities of the genebank (curation and dissemination of germplasm and data) is now guaranteed, channelled through the Global Crop Diversity Trust. It is essential that complete funding of the GRC's capacity and activity be maintained in the future, given global instability and the status of other gene banks.

Laboratory support (GAMMA Lab, Transformation facility, Analytical Service Lab)

IRRI has centralized technology platforms that support cross-site scientific needs for routine wet chemistry and molecular biology analysis, in particular the Gene Array and Molecular Marker Application (GAMMA) laboratory, and the Analytical Service Laboratory (ASL). These provide facilities both for 'off-the-shelf' as well as tailored analysis and training. Training of both IRRI and NARES scientists develops technical skills and is providing applied knowledge to support breeding programs at IRRI and for NARES scientists in their home countries.

The GAMMA lab provides a hot-bench facility for competent IRRI staff and a source of training in plant molecular biology across site and to clients in NARES. In particular, it provides a hands-on capability and training on SSRs, chip-based genotyping technologies, and gene expression analysis. The facilities have recently been upgraded and are well designed and managed for the purpose. It has a dedicated manager who can schedule and organize services to maximise the efficiency and lower the cost of analysis. The GAMMA facility and its philosophy were strongly supported by the CCER in Biotechnology in 2008, and the Panel are impressed with its activities. Its long term future, however, will depend on CGIAR system-wide discussions on whether centralized or decentralized genomics facilities are the best working model for achieving high through-put and low cost. An allied transformation laboratory for high throughput transformation for gene function studies has recently been re-established and appears also to be functioning well.

The ASL provides services to IRRI researchers for routine, but high quality, analysis of plant, soil and water samples, both for IRRI and external partners, particularly UPLB, as well as being a user laboratory for non-routine analysis requiring specialized techniques. The ASL also carries responsibility for safety issues for radio-isotope work at IRRI. A CCER was carried out on the ASL in 2004 and made a list of 19 recommendations. Not all recommendations could be implemented immediately as they required quite substantial capital investment or development time, but now most have been actioned. Examples are the realignment of staff, developing a new in-house LIMS system in collaboration with UPLB, new on-line scheduling and information systems, and the purchase of equipment, such as a dual-view inductively coupled argon plasma machine for multi-element determinations. The Panel commends IRRI for continually seeking to maintain the highest standards of service in the ASL and making appropriate managerial adjustments to achieve this as is required because of developments in technology, instrumentation and scientific priorities.

Grain Quality, Nutrition and Post Harvest Center (GQNPC)

This impressive facility was built in 2004 utilising funds from the IRRI Capital Fund and was equipped with the assistance of a grant from Monsanto. The Quality Lab has the capacity to handle 60,000 samples per year using modern and largely automated equipment. Quality attributes assayed in the lab include imaged assessments of length, breadth, breakage and degree of chalk; aroma; gelatinization temperature; amylose content and average branch length in amylopectin; amino acid composition; rheological properties (e.g., stickiness); analytical X-ray analysis of micronutrients; vitamins; β-carotene; starch type and branch length; and DNA extraction and SNP marker identification of quality traits. There appears to be inconsistent use of these quality data in the breeding program, perhaps because databasing is not fully aligned with CRIL. The lab has unused capacity, and consideration should be given to accepting samples from outside IRRI on a chargeback basis. The Post Harvest section has designed a rice grain quality kit as a training tool for rice mill owners to reduce losses, and offers training in harvesting, seed and grain storage, and land levelling. The Post-Harvest section provides significant entry points through rice mills for technology transfer to farmers, and could be utilized more extensively for this purpose.

5.1.4 CRIL

Members of CRIL (the Crop Research Informatics Laboratory) offer support to IRRI's science community in the fields of statistics and data management. However, demands for CRIL activities are possibly exceeding its capacities. The recent resignation of the senior biometrician is of concern since this has been a real strength of IRRI in the past. Here and elsewhere in IRRI, a major challenge is to maintain service and research activities at the time when unrestricted funding is declining. Despite strong support from the Generation CP for the work in CRIL, this is not sufficient to maintain the level of current activities.

5.2 Information, communication and knowledge management

Library

The IRRI library is a long standing facility with the best collection of hard copy rice literature (books, journals, monographs, reports, magazines) in the world. It also has a wide range of digital literature. It regards itself as a facility for both the local and international communities as well as IRRI staff. It is well run, covering book and journal loans, management, administration and databasing. There is free computer access for students and locals. The library management system appears to need modernizing. The 'Millennium' system is supported locally and liked by staff, but is 'expensive to service' and management could be carried out more cheaply using the 'Software as a Service' system. With competition for unrestricted resources the Institute, has cut back on book purchases and journal subscriptions, which are reviewed annually. The Website aims to be the 'first port of call' for general and specific information. It is excellently presented and provides a huge amount of reference information and databases on rice which are of interest to staff. As the external review of library and communications at IRRI pointed out, the challenge will be to anticipate and to develop library services which meet the future (5-10 years) information needs tailored to a range of users.

IT systems

This unit provides hardware, software and support services to manage central systems, desk-top PCs, laptops, and intra- and internet communications traffic. IRRI has 1200 computers linked into a comprehensive, well-backed up LAN. There is generally reliable access with excess capacity broadband connection to the outside world, both cable and wireless connections covering most of the IRRI campus. UPLB also uses the triplicate servers with excess capacity to access internet and IRRI gains some cost recovery from grants for this service. This is a well thought-out and managed service which seems to anticipate future needs well. As noted elsewhere in this report, projected needs for IRRI include a new finance system. The various administrative systems need to be joined up, particularly linking human resources and finance software, for administrative and financial efficiency. Similarly, the sophisticated project management system needs to link to the financial systems in real time. The electricity costs from such extensive computing facilities are expensive.

Publications

The Communication and Publications Service unit (part of DPPC) coordinates the publication of IRRI research information, including scientific books, web sites, IRRI publications series, the Annual Report, International Rice Research Notes (IRRN), Rice Literature Update, and the magazine *Rice Today*. The unit also offers editing services to IRRI scientists in the preparation of journal articles, book chapters and other scientific papers for external publication, and for grant proposals and reports to donors. The unit publishes 4 - 6 books (monographs, proceedings, manuals, field guides) per year, with limited press runs targeted to IRRI partner libraries and those without access to the internet.

Since the last EPMR, IRRI publications policy has instituted the Creative Commons approach[11] to copyright. Creative Commons licensing allows sharing and adaptation of published work if due attribution is made to the original. Derivatives must make evident that the work is licensed, and the original and its derivatives are not used for commercial purposes. Nothing in this license impairs or restricts the originators (e.g. IRRI's) rights over use of the original. In 2006, the Board approved the move to release all information products as much as possible under open content license.

Since 2006, IRRI has also undertaken to make freely available all current and past publications through digitization. At present over 350 IRRI books are available fully downloadable on Google Books and thousands of IRRI photographs are available on the IRRI website and through Flickr. IRRI also publishes the magazine *Rice Today*, targeted at non-expert readers. In an effort to make the magazine self-sustaining, IRRI has entered a co-publishing agreement with Rice Trader, Inc. (Singapore). An external review undertaken in 2008 recommended a re-thinking of IRRI's overall communications policy and strategy, which IRRI has planned for 2009.

The Panel commends the strong and successful efforts made by IRRI to make use of recent technology innovations to ensure that information relevant to rice research is freely available as international public goods.

Partnership support: Training and capacity building

IRRI has an enviable record in training; virtually all NARES leaders speak with great respect about IRRI's training investment (and worry about the declining funds available for this activity). IRRI has managed to maintain much of its capacity to provide high quality training while moving to embrace new methods and modalities. Most CGIAR Centers have had to abandon the majority of their long-term, in-service training courses (and IRRI's largely empty dormitories are evidence of this shift) but the range and quality of IRRI's training staff and facilities have meant that the institute has the critical mass and flexibility to move effectively into the provision of short-term courses. The training staff includes people experienced in course facilitation and design, providing opportunities for collaboration with partner institutions in course development. Between 2004 and 2008 IRRI offered 91 short courses (at headquarters and in-country). These courses include the technical topics that one would expect and some important additional topics (such as scientific writing or leadership for Asian women) that help further IRRI's mission. Since 2007, all of this training has been done on a cost-recovery basis. One drawback is that poorer countries, especially those not part of major IRRI projects, may be unable to send participants, and

[11] http://creativecommons.org/licenses/by-nc-sa/3.0/

explorations are underway to identify funding sources to address this problem.

IRRI has also been a leader in providing and supervising post-graduate training, and the proximity of UPLB has facilitated this role. Between 2003 and 2008 IRRI facilitated 69 MSc and 110 PhD degrees. Previously, the lion's share of these degrees was awarded by UPLB but by last year scholars were registered with 23 different universities. Most are "sandwich" programs from universities in other countries. The provision of post-graduate supervision remains an important priority for IRRI, but the time demands on senior staff are considerable, especially for divisions like SSD with few senior staff.

There is concern about the aging population of rice scientists in national programs. Support for post-graduate training may help address this, although the problem has its roots in larger changes in national economies. It may be worthwhile for IRRI to attempt to document the extent to which the problem exists, note any differences across countries and disciplines, and draw lessons for training priorities. Further, it would appear that a considerable proportion of IRRI's training resources will soon be focused on Africa. There is certainly a need for training, although it will be important to do a careful assessment of actual needs and absorptive capacities, as some donors may find it easier to put money in training courses instead of facing more difficult policy and institutional development issues in Africa. The establishment of a well-organized rice production course at an African venue will be a high priority, especially since the number of trained rice scientists in SSA is very small.

5.3 Regulatory services

Seed health

The Seed Health Unit (SHU) is important to IRRI's overall function as it is the only portal through which seed can enter and leave IRRI in exchanges with collaborating partners and clients. It also deals with non-seed material such as DNA, RNA and bacterial cultures. It is staffed by extremely capable and dedicated staff with a strong sense of duty and responsibility. Under a Memorandum of Agreement between IRRI and the Philippines' Bureau of Plant Industry, SHU is authorized to conduct testing activities for phytosanitary certification and post entry clearance. The unit supervises quarantine and monitors field- and glasshouse-grown material to maturity after importation and germination. Seed Health protocols and standards are in accordance with the International Seed Testing Association (ISTA) and International Plant Protection Convention (IPPC). The SHU ensures that the IP protocols established by IRRI in line with the ITPGRFA are complied with. There is an extensive tracking database on all materials.

The rising volume of seed requests have resulted in the facility reaching capacity in terms of physical space and staff time. There is an existing protocol on importation and handling of wild rice seeds, vegetative materials and genetically modified organisms. So far there is no policy on the export of transgenic seed, as these are considered to fall under the biosafety regulations. There are still occasional breaches of quarantine by students, visitors and some IRRI staff, and IRRI needs to remain aware of the challenge to remain vigilant and to reinforce the use of the SOPs.

Biosafety

IRRI has extensive rice transgenic work for gene function studies and for the release of novel improved products, particularly Golden Rice. Other nutritionally enhanced products are planned, for iron, and agronomically enhanced products for drought (currently *DREB*) and C_4 rice. IRRI is subject to the Philippines National regulations on biosafety. To comply with National and International regulation and standards for such work, IRRI has in place comprehensive biosafety procedures including:

- Glasshouses and controlled environment cabinets complying to CS-01 and CS-04 standards
- A standing Biosafety Committee made up of independent IRRI, national and local interests, chaired by a senior scientist
- An approval process overseen by the Biosafety Committee
- Extensive documentation on 'Standard Operating Procedures' for GM work
- Screened field area for field release and testing

Given these appropriate safeguards, the Panel does not see any outstanding issues in the Institute's policy and approach to biosafety. Two practical matters will include a) determining the prospects of gene flows in areas with wild rices, and b) as transgenic work is taken up on a larger scale IRRI will have to plan for appropriate disposal of transgenic biomass.

IP policy

As a front-line research and development organization dedicated to the development of public goods, IRRI produces a range of products which could be, and would be in the private sector, subjected to intellectual property protection – germplasm, technologies, methodologies, data, software, instrumentation and machinery. As a general rule in the past, IRRI has not sought such protection, believing that its first duty is to release germplasm, technology, knowledge and information into the public domain as quickly, and as freely, as possible, for as wide a usage as practicable by its client organizations. IRRI, as required by the International Treaty on Plant Genetic Resources for Food and Agriculture, and in compliance with CGIAR-wide policy, uses the standard MTA when distributing germplasm. Also, a *laiser faire* policy can have unwanted consequences, as has recently happened with private seed companies placing variety protection on IRRI released germplasm in the Philippines and Indonesia.

At the present time, IRRI has an Intellectual Property Management Unit (IPMU) managed by an IRS (part time, *ad hoc* commitment) and containing 1.5 FTE NRS, and one month a year service from a professional attorney. The Unit prepares and reviews MTAs, trains IRRI staff and NARES on legal requirements for the movement of materials, particularly germplasm, and monitors compliance. IPMU offers training to NARS on IP and PVP issues, and links with INGER and CORRA to arrange for this. The Unit audits possible IP at IRRI and has been particularly concerned with issues around Golden Rice (below) and biosafety. However, its scope is narrow, and its work does not include taking on a broader strategic and scoping focus, for example, by examining the issue of plant variety protection (PVP), which IRRI does not exercise at the present time. However, IRRI is concerned about issues concerning PVP and have commissioned a position paper from the Head of GRC, due for presentation to the IRRI Board in April 2009. Similarly, IRRI does not have a policy on what protection to apply to cloned genes, genomic resources, or even software such a 'Nutrient Manager'. Unfortunately, there also does not seem to be a recent CGIAR-wide agreed policy on IP that could provide guidance to the Institute. A GRPC policy on IP paper presented at AGM08 was rejected by IRRI and other Centers, and will have to be reworked. The Panel believes that although IRRI has good and secure policies for certain IP policy aspects it should continue to strive for a more comprehensive policy and framework. This needs to cover all likely IP categories needing management, and this needs to be developed as a matter of urgency.

Golden Rice (GR) – IRRI has freedom to operate in relation to this product so that it can be used by IRRI and its cooperators, and PhilRice is able to licence it for use for a reasonable fee. A recent Rockefeller Foundation grant has been obtained to meet the regulatory requirements of GR in the Philippines, and several other countries as well. GR is now scheduled for release in 2012. There will be some acceptance in India of the Philippines regulatory package for GR – which provides pleasing indications of some initial regulatory harmonization across the region.

Third party IP is often associated with gene constructs for transgenesis. For example, future important traits include soy ferritin (Fe), and *DREB* and CSPB protein genes (both for drought) obtained from other partners. Bt rice will probably be developed by China, not through IRRI. Likely herbicide resistances relevant to rice include Basta resistance, and glyphosate resistance.

Recent releases have not included IR as the prefix to the designation, although the Institute will probably return to this means of identifying lines in future because of the value of the IR brand and the importance attached to this by stakeholders. Restorer lines in hybrids in China are mainly IRRI lines but become invisible without the name. INGER is currently DNA-fingerprinting all its materials so IRRI can identify its own lines.

Publications: the concept of Creative Commons (see above) encourages publication of an idea as a form of intellectual protection. For software; Advanta co-developed ICIS with IRRI, and gave IRRI access to the basic version, while using the extended version themselves. Thus, together with the legal support and Biosafety functions, IP issues are currently well addressed, and IRRI would benefit from the CGIAR agreeing on common policy and guidelines in this area. It is hoped that the proposed new CGIAR Consortium will take on this subject as a matter of urgency in consultation with all Centers. Practical issues at the Center-level will include defining who monitors regulatory compliance on IRRI IP.

Legal support

IRRI's office for legal services is staffed by two people and addresses two types of demand. Internally, it provides advice to OUs and the Board of Trustees on legal matters. It prepares and compiles templates for MOAs, MOUs, and other collaborative agreements, and has collaborated closely with the internal IPMU on the development of the Intellectual Property Rights (IPR) Policy Manual and MTAs. It reviews and updates supplier contracts, policies and guidelines, with staff participating in the Bids and Awards Committee.

Externally, legal and community relations staff provide liaison with various executive departments of the Philippine government and assist in monitoring legislative actions affecting

IRRI. It coordinates with external counsel in legal actions and maintenance of IPRs. The office is an important adjunct to IRRI's capacity in Biosafety, IP and labour relations.

5.4 Facilities

The Facilities Management Group (FMG) is part of Operations and Support Services, and reports to the DDG-Operations. It includes the Experimental Station (ES), the Physical Plant Services (PPS), Safety and Security Services (SSS), Transport services (TS), and the Food and Housing Services (FHS). The FMG was recently the subject of a CCER[12] It is managed by one IRS and supported by 191 full time NRS and *kabesilya* staff (of whom more than 1000 are identified although they work on a rotating contract basis).

Experimental Station (ES)

The ES provides support and operation of field research activities, grounds maintenance, farm labour arrangements, plant and equipment support, waste management, greenhouses, the CL4 containment laboratory, Phytotron and the rice mill. The headquarters station covers 252 ha, with about 210ha as plots, and 27 ha as grounds. It is currently conducting 163 separate experiments on 70 ha of land, and about 140 ha is dedicated to growing commercial rice for provision to staff. (The Rice Mill, started in 2003, supplies free of charge a monthly bag of 50 kg of rice per NRS staff member as part of their compensation package and this is generated from commercial and research plantings.) The ES is currently staffed by 78 fulltime NRS. The average age of NRS exceeds 50 years, suggesting an urgent need for a staff rejuvenation plan. These are supplemented by the *kabesilya* labour contract system that provides seasonal labour under fixed contracts, though this labour pool is largely used for unskilled low-risk activities. The ES staff carry out routine crop management tasks (land preparation; sowing or transplanting; fertilizer application, bird scaring, rodent management, crop drying and threshing) in response to requests from scientists that are entered on the IRRI intranet – a system that works well for the most part.

The operations of the Experiment Station were reviewed recently, and the CCER recommended that the ES take central control of greenhouses. This has been implemented. Records of individual field management were considered sufficiently detailed but hard to access and challenging to summarise over years. A centralized databasing system meeting these requirements has now been purchased and implemented. The use of bar-coding of plots, plant and soil samples and harvest bags should be examined as a means of reducing mix-ups and labour spent in tracking samples. Full cost recovery is practiced and discussed openly with

[12] Center Commissioned External Review on the Operations Management Unit. December 2007. 109pp.

scientific staff during the planning procedure. The Panel is concerned that IRS resources devoted to this important facility are stretched very thin, and suggests the establishment of a post doctoral position in agronomy and farm management as a means of improving on-going farm management research. In general, however, the Panel finds the ES to be a well-managed science support structure and the IRRI farm has an ISO 140001 accreditation, a qualification favoured by Internal Audit because it indicates that a certain level of quality has been attained.

Much of the ES infrastructure was established 40 years ago, but has been generally well maintained, though boreholes and irrigation infrastructure are in need of renovation. The equipment fleet is also ageing. There is apparently no adequate plan for systematic replacement of older farm machinery. One estimate puts cost of upgrading the equipment fleet at US$1.5 M, and approaches for sponsorship to a major farm machinery manufacturer have had little effect. The Panel suggests that IRRI evaluate the adequacy of the full cost recovery policy to determine if timely replacement of equipment is adequately addressed.

Despite a recent outbreak of tungro virus, the Panel applauds the outstanding record of IPM on station that has seen a 95% reduction in applied pesticides since 1992, and encourages IRRI to find environmentally compatible solutions to pest problems that serve as viable examples to its research collaborators.

5.4.2 Physical Plant Services (PPS)

The PPS is responsible for 107,000 m^2 of office, laboratory and greenhouse facilities, 23,000 m^2 of staff housing, and has a staff of 63 NRS (the number including 24 contracted janitors). PPS also fabricates small farm implements designed originally by the former agricultural mechanization section. IRRI was originally designed as a fully residential, stand alone research facility, resulting in 13 ha of building floor space. IRRI's annual budget for electricity (of which air conditioning is a substantial part) is around US$2 M. However, there are now signs in many parts of the physical plant that the basic facilities are ageing. The Phytotron, for example, although in good repair is reaching the end of its functional life, and the greenhouses have never functioned very efficiently. Refurbishing and building projects occupy most of the time of the single IRS in the Facilities Management Group. A central challenge for IRRI management is how much further investment in static facilities is justified, especially if investments in NARS facilities could meet research standards and strengthen NARS capacity at the same time. The Panel notes that the Museum needs physical upgrading, and suggests that IRRI carefully analyse ways in which energy efficiency (especially air conditioning) can be improved, including decommissioning older, less efficient structures.

5.4.3 Safety and Security Services

14 NRS are employed including an occupational health and safety (OHS) officer and a fire marshal. Core security staff work with a local security agency employing around 60 staff. This group liaises with local security groups to improve security on and off campus. Innovations include electronic door access system, a CCTV system, the creation of an Emergency Response Team, a centralized identification system based on the IRRI ID/Badge system and an IRRI-wide key database system. IRRI's safety record is enviable, with no pesticide related incidents since 2003, and the identification and packing of hazardous waste from research laboratories has been considerably improved. IRRI has three fire trucks and often assists surrounding municipalities with fire and ambulance services. The Panel endorses the community support offered in emergency services, but suggests that every attempt be made to recover costs when this is

deemed possible. Security at outreach locations, and during travel by IRRI staff, will ultimately deserve attention by this group. A close working relationship between the OHS officer and the Risk Management group will also be required.

Transport Services

IRRI maintains around 320 vehicles, has 25 full-time NRS drivers and additional drivers that are hired on contract when demand is high. Vehicles include cars allocated to staff for personal use, as well as pickups, trucks and buses. All are maintained through repair and maintenance facilities on campus. Outsourcing has been considered but rejected because of the non-uniform standard of repairs. A training agreement with Toyota Motors Corporation enables mechanics to update their working knowledge of latest technology installed on Toyota vehicles. Fleet management processes have been improved through a vehicle inventory database, driver's permit listing, Epass monitoring, vehicle rentals, accident and insurance claims history, and vehicle performance. The Panel notes with appreciation the improved safety record of IRRI's vehicles over the years, and a robust vehicle replacement policy that has resulted in a lower average age of the fleet. The 2007 CCER noted that full cost recovery for vehicle use needs to be assessed in relation to current costs.

5.4.5 Food and Housing Services (FHS)

FHS provides Guesthouse services (36 beds), visiting scientist apartments (120 units or rooms), laundry, swimming pool, staff housing (61 units), dining rooms for staff (3), and cafeterias (2). FHS oversees the operations of three food concessionaires who supply food to the dining halls. Also included in FHS is the swimming pool, the IRRI laundry, children's playground and sports areas. Communication among staff has been improved by instituting a coffee shop, with a second planned. Occupancy of the older halls of residence is low (14-40%). However, family housing is in short supply. If approximately 20 additional IRS are appointed in the next 12-18 months, housing will have to expand beyond the 61 units on campus. The panel strongly endorses the development of an off-campus housing policy for IRS, needed to give staff better options for housing, for example, near the international school. Full cost recovery has been very effective in FHS, and the section appears to be efficiently run.

5.4.6 IRRI School

A school was established about 8 years ago on campus from unused facilities to reduce excessive travel to schools in Manila or Laguna. Currently the school has 25 children enrolled from K to Grade 6. It is managed by Brent School who supply the three teachers. Older children mainly attend Brent's main campus in Mamplasan, about 25km south of Manila, and are bussed there daily. The Panel notes with appreciation the high quality school facilities that IRRI has established, and the reduction in stress for families with young children that schooling on campus provides.

5.5 The International Programs Management Office (IPMO)

IPMO was organized in 2000 and had its origins in the former Technology Transfer Division. It reports to the DDGR but also must interact with HR and Finance. It is staffed by the head, two officers, and a secretary. The mission of IPMO is: "To strengthen cooperation between IRRI and NARES", but the core business includes an exceptionally wide range of duties, including: technical and administrative support to NARES; the maintenance of national databases on statistics, research needs, etc.; support to the monitoring of IRRI country offices; support to liaison scientists in proposal writing; planning and coordination of country work plan meetings; serving as secretariat for CORRA; participation in some technology dissemination activities in Philippines and elsewhere; facilitation of some meetings and courses.

This extensive and diverse list of activities is a function of the organizational history of IPMO; the particular interests and expertise of the head (who is a technology transfer specialist) and IRRI's uncertainty about how to organize or staff outreach positions; for instance, in IRRI's annual report, IRS staff are variously described by program affiliation, by country or listed under IPMO. This would seem to be indicative of some confusion and the apparent divide between scientists in HQ and others in outreach. The current IPMO mandate mixes a number of functions that appear difficult to accommodate in a single, small office. The general administrative functions of supporting outreach offices (purchasing, ensuring uniform policies, etc) are perhaps easiest to understand, although IRRI is still developing a policy document for its outreach offices. Scientists posted in isolated locations (Laos, Mozambique) may find it difficult to access IRRI's full services, such as library resources. It may be useful for liaison scientists to have a place to turn for help in the mechanics of proposal development, but presumably those proposals receive major input from the relevant divisions as well. Issues related to setting priorities for country-level work would seem to demand major participation from relevant IRRI divisions. This is especially the case if priority setting goes beyond the mere consolidation of work plans that have already been developed through individual projects. There would appear to be opportunities in several countries for meetings or exercises that compared IRRI and national program priorities and identified mutual interests (although not necessarily formal planning exercises).

It may be argued that some of the priority setting and monitoring functions currently in IPMO's purview should be managed by designated senior scientists, but this raises the question of why the planning and management of activities in outreach should be treated differently (or managed by different people) from headquarters-based activities. Outreach positions may serve either one (or both) of the goals of (i) efficiently managing location-specific work within a project, program or consortium or (ii) building NARES capacities and strengthening their links with IRRI. The two goals assume different strategies and management methods, and a failure to articulate the difference in goals may make outreach management more difficult than it needs to be.

The future of IPMO will depend to a considerable extent on IRRI's decisions on staff deployment. The 2004 EPMR recommended the establishment of regional offices, and a CCER on Staff Placement recommended expansion of outreach positions and endorsement of the concept of country liaison scientists. As IRRI begins several large projects (such as STRASA and CSISA) which will have regional coordination positions, the importance of outreach management and reporting (and the role of IPMO) will deserve further scrutiny. The move to Africa would seem to fall outside of the traditional services provided by IPMO, as headquarters can offer little experience or expertise in supporting the establishment of operations in a completely different domain from that in which IRRI has traditionally operated.

The acting head of IPMO makes significant contributions to technology dissemination activities, but this should probably be assessed separately from IPMO and perhaps included under training.

5.6 Support for Outreach

There is considerable variation in the placement and servicing of IRRI's country offices. The Bangladesh office in Dhaka needs to move office and faces considerable transaction costs. In India, IRRI is well placed in the ICAR/CGIAR facility. In Mozambique there are difficulties in finding competent staff and the role of the national office in Mozambique versus a regional office in Tanzania needs articulation. In large part, unrestricted funds pay for country office staff and there are complaints about difficulty in hiring NRS for projects, and the difficulty in retaining them. Issues of financial management support are pressing.

Elsewhere (Chapter 4 under partnerships) the Panel has considered the function of IPMO and the most appropriate staffing level. The Panel suggests that IRRI develops a more coherent approach to out posted staff, as well as improved day to day management of these staff. This represents a particularly pressing issue as IRRI contemplates engaging in work in Africa.

5.7 Panel Assessment

IRRI was established in 1960 by the Ford and Rockefeller Foundations in cooperation with the Government of the Philippines on a property leased from the University of the Philippines. The Institute was built as a self-sufficient research community to a standard that would attract the world's best rice researchers. Today's legacy of that policy is a large and ageing research infrastructure that has served IRRI goals well, but requires selective decommissioning or capital-intensive updating if it is to meet the needs of research over the next decades. Casual estimates of this step put the cost at around US$150 M. It is a tribute to IRRI's management that through the newly-formed IRRI Foundation it is already making provisions to raise funds for such a step. Housing and accommodation facilities are also variable in quality and, on the verge of staff growth, IRRI will also have to provide and expand appropriate accommodation facilities for its staff. The Panel makes a recommendation (in Chapter 7) on means to address these issues in the light of future Center growth and programmatic expansion.

6 PANEL ASSESSMENT OF SCIENCE QUALITY

6.1 Overall quality and relevance of the research planning process at IRRI

Strategic Plan

In recognizing the limitations of the earlier Strategic Plan (*IRRI Toward 2020*), which was published in 1996 and updated in 2003, IRRI began a new round of strategic planning discussions with staff, the Board of Trustees, and with key stakeholders in 2005-2006. The process involved a significant level of discussion over the 2005-2007 period, and included brainstorming by all IRRI staff and selected NARS leaders, a conference of technical experts, and extensive external reviews of drafts. It culminated in the 2007-2015 Strategic Plan, *Bringing Hope, Improving Lives*. The Plan gives greater prominence to work on unfavorable environments relative to favorable environments than previous plans, and outlined a strategy for developing pro-poor rice research capacity in sub-Saharan Africa in collaboration with WARDA.

The Plan has five broad strategic goals:

- Reduce poverty through improved and diversified rice-based systems
- Ensure that rice production is sustainable and stable.
- Improve the nutrition and health of poor rice consumers and rice farmers.
- Provide access to knowledge on rice and train a new generation of rice scientists.
- Provide rice scientists with genetic information and improved technologies to enhance rice production.

The Plan retains a strong focus on poverty reduction and enhancing the nutritional status of rice, and is congruent with the Millennium Development Goals and Development Challenges of the CGIAR. In developing this science-based Plan, IRRI has maintained its matrix research management structure which it has had for several years, but realigned its science into new Programs. Since its adoption it has been used directly to guide the Institute in developing its Medium Term Plans and funding proposals, and in some cases rejecting requests for research outside of that focus that could be regarded as mission creep. The estimated cost of a full implementation of the Plan was US$60 M/year, a level now being approached as traditional and new donors continue their investment in IRRI. Several Frontier Projects, originally funded from IRRI reserves, received donor support once IRRI's commitment to the underlying concepts was demonstrated. The Plan envisages steady progress towards full cost recovery as unrestricted funding declines. Underfunded areas include irrigated rice breeding (including hybrids), plant protection, crop nutrition, advanced line testing, seed processing and storage, and socioeconomics.

The Panel commends IRRI staff and management for the exemplary way in which this plan was developed and in its subsequent use, and considers it a key tool in maintaining consistent science direction, quality and relevance. The proposed new position of a Strategic Planning and Impact specialist conducting ex-ante and ex-post assessment of projects will further focus the use of the Plan as a research management tool.

All Strategic Plans become dated, and the Panel urges IRRI to adopt an "evergreen" approach to this document, seeking to formally update it on a regular, planned, schedule. For example, it is now recognized that the Plan underestimates the need to boost yield potential in irrigated rice systems. Furthermore, the biofuel challenge to food production and the grain and fertilizer price spikes of 2008 were not anticipated. Growing concerns about climate change and the exponential growth in information and communication technologies, especially as they relate to genomics, must also be regularly assessed. Finally, the recent Stakeholders' Survey commissioned as part of the EPMR suggests a need for greater inclusion of national programs and donors in the process of priority setting at the Center or regional level.

Annual research planning processes

An annual program review is conducted at IRRI during one week where a critical review of all science is made. Achievements in the previous year are discussed and the goals are set in an atmosphere where different opinions can be expressed freely.

MTP development

IRRI produces a Medium Term Plan every year looking forward to the next three years (currently 2009-2011). It is updated annually, with a rigorous examination every two years. The Science Council has regularly endorsed IRRI's MTP and its science/research focus. The MTP document is a comprehensive description of Programs and Program Objectives in terms of Rationale, alignment to CGIAR priorities, details of program outputs, impact pathways, International Public Goods being produced, and an elaboration of the role of partners. This is an excellent strategic planning and information tool for IRRI, and for partners and donors needing information of IRRI's current activities both strategically and experimentally.

Development of grant proposals

All IRS are encouraged to seek external funding, provided the research area is aligned to IRRI's core objectives. Indeed, external grant funding is now key to IRRI's financial health and, therefore, an efficient and effective system of supporting the development and submission of successful grant applications is necessary to maximise income. Under the present system, proposals can be initiated by individual staff who have thought of an idea or who have seen an opportunity of securing funds in their research areas. The staff member will write and submit a concept note, and the DDG-R will determine whether it is within the core business of IRRI. If approved, a full proposal with an impact statement will be written up by the staff member. However, there is now a trend towards a more proactive approach in scoping possible future research topics suitable to seek funding for donor support. This mode is often used for proposals for large grants where the comparative advantage of IRRI is recognized and a granting body may enter into direct negotiations with IRRI. Hiring a specialist on strategic planning, *ex ante* analysis and assessment of impact will improve the efficiency of grant proposal development.

Maintaining science quality

IRRI is very conscious of the need to ensure that it produces excellent and relevant science and has several mechanisms to facilitate this process:

Recruitment process

A staff recruitment process is firmly in place, but the system for IRS recruitment has been taking rather a long time from advertisement to appointment. Prolonged delays in appointment can be a reason for losing the best candidates during the selection process, since such candidates will often take alternative offers. A quicker time scale, and the recent initiation of pre-screening to reduce number of candidates, , should speed up the process and help secure the most suitable applicant for the position.

Staff evaluation

An annual performance assessment system is in place for both IRS and NRS, and the process undergoes periodic review for fitness to purpose. There is a promotion process available for NRS; they can apply when a higher classified position becomes available or the position can be reclassified. However there needs to be clear guidelines for advancing career pathways for IRRI staff. Grades for IRS are classified as either scientist or senior scientist and an additional level or two would enable achievement to be better distinguished and rewarded.

Science communication activities

There are weekly IRRI seminars and also Divisional seminars. These are provided by IRRI staff members discussing their research and other relevant issues, but also by visitors who provide up-to-date information in their scientific fields. There are also a number of workshops held in different research areas. These are often targeted to a specific group of staff who could benefit from additional training. Examples are biometry and information management. IRRI encourages staff members to attend international conferences, professional society meetings, or take a short sabbatical leave at a University. IRRI has the largest percentage of the total budget spent for these purposes among all CGIAR Centers.

Ethical behaviour

The conduct of science requires that scientists adhere to rules with respect to ethical behaviour. This includes scientific honesty in correctly reporting the conduct and results of experiments with respect to the collection, processing and interpretation of results; respecting the work of others through proper attribution, and avoiding plagiarism, piracy and fraud; and respect for the work of others under direct supervision. IRRI adheres to these codes of conduct although there does not seem to be a written policy and a separate disciplinary policy exists.

Risk management and quality assurance

The Risk Management and Quality Assurance system implemented since the last EPMR provides another means of ensuring the quality of science. The RMQA framework requires IRRI staff to identify areas of research-related risk and put in place strategies, controls and mitigating measures.

6.2 Staff quality and staff satisfaction at IRRI

The staff quality analysis was conducted by reviewing 103 IRRI staff *curricula vitae* and up to date publication lists covering the five year period, 2003-2007[13]. The staff included 69 IRS (Internationally recruited staff and IRRI Research fellows) and a total of 34 other staff (from the categories of postdoctoral fellows, visiting scientist and liaison scientist combined). Ninety one of these staff hold a Ph.D. degree and 8 a Masters degree. Around one fifth of the staff (22/103) joined IRRI between 2000 and 2004; slightly over one half (57/103) joined IRRI more recently, between 2005 and 2008. The staff are of 24 different nationalities; the largest number coming from the USA (13) and the Philippines (13), India (10), Australia (8), France and Germany (6), and Canada, China, Nepal, Netherlands and the Republic of Korea (4).

A high percentage (82.6%) of IRRI IRS published papers in peer reviewed journals between 2003-2007, and 57.3% of the staff surveyed published more than one peer reviewed article per year (average is 2.3 per IRS; 1.9 for all staff surveyed). Considering all types of publications these averages rise to 3.2 per IRS and 2.5 for all categories surveyed. IRRI staff make substantial contributions to conference proceedings. IRRI staff published, on average, 6.2 articles over the review period (IRS average of 8.0 articles) taking into account all types of publications including conference proceedings.

Over sixty percent (63/103) of these staff supervised a total of 500 students in the period reviewed. This included 73.9% of IRS who supervised students. Just less than half of these (50/103 or 49%) are either members of editorial boards (39% of IRS) and/or regular reviewers for journals (62.3% of IRS). Forty eight of these staff received honours or prizes; 40.8% (55.1 % of IRS) have been key-note lecturers and 33% (46.4% of IRS) have been members of international panels or committees.

The average age of IRRI IRS is now 50 years, suggesting that a succession plan for key staff needs to be implemented as a matter of urgency. A similar situation exists for NRS in some units (e.g. average age of NRS on the Experiment Station, for example, is 53 yrs).

IRRI EPMR Staff Satisfaction survey

There was a 100% response to a staff satisfaction survey administered by standardised on-line survey sent to a group of 117 staff including all IRS and the most senior nationally recruited managers and researchers. The majority (108 respondents) are stationed at IRRI HQ. There were

[13] Such an analysis allows a five year comparison between CGIAR Centers. A similar review of IRRI publications covering the five and a half year period (including publications from the start of 2003 to mid 2008) was also conducted but does not alter the general significance of the results given above.

high levels of agreement by staff with the proposition that the goals, mission and direction of IRRI are clearly communicated to staff, and that at IRRI, most aspects of the living and working conditions are conducive for innovative research. However, the response to the effectiveness of staff performance evaluation elicited less than 50% agreement that it helped staff performance, with a further 43.8% undecided. But, in general, it can be concluded that IRRI remains a place with which staff identify, and which would be recommended for the standard of research done. (See Annex 7)

Job satisfaction amongst scientists is clearly generally high. However, there were three particular areas of concern identified by some staff in their comments: the current limits to career paths and problems in meeting personal staff ambitions; the relatively low salary pay scales of NRS in some professional areas causing the loss of staff to the local market; and the difficulties in identifying spousal employment, which may have effects on staff turnover and recruitment. Staff in other country offices complained of the limitations in taking time off even though it was theoretically granted, since outreach offices have small numbers of staff. Although communication between staff and management had improved, it was suggested that this is an area for continued improvement.

The Panel senses that there is a perception of a difference in terms of career progression and support between IRS who work in research at Headquarters and those at other stations. It suggests that a greater effort is needed to ensure equal treatment of the two groups. There is a need for cutting edge research activities in outreach locations, especially if outreach environments are to be more widely used in screening germplasm for specific tolerances, or if strategic agronomic research is to be conducted in east and southern Africa, or in South and South East Asia. However, it should be recognized that this is not always possible and this should be considered in the career progression process. Care must be taken to recognize and reward accomplishments in both research and development as an incentive for quality researchers to accept challenging assignments. Further motivation for excellence will follow the establishment of a well-defined means of career advancement for all staff.

6.3 Research accomplishments and achievements

The 20 key outputs.

To balance quality assessment made on publication numbers, the Panel asked IRRI to select 20 key outputs of the IRRI Programs (of all types) for evaluation. IRRI identified outputs from Program 1(5 outputs), Program 2 (5), Program 4 (1), Program 5(4), Program 6 (2) and Program 7(3). These outputs vary greatly in size and style: a single paper, several papers, varieties released, QTLs identified, and genomic technologies developed. The 20 items are representative of IRRI's typical outputs but do not cover all possible outputs during the overall review period.

These items were evaluated in terms of relevance to IRRI's objectives, quality of science or research, and impact (see Annex 9). It was not always easy to evaluate the items for all of these components. This is particularly so when impact is assessed for technologies that are only recently developed or varieties that have just been released. Some items were represented by a single paper or research proposal, while others had several papers and some others had papers as well as actual products (such as varieties). The Panel evaluated all components of each item without assigning a weight to any particular component. Impact was considered mostly in relation to clients, i.e. adoption by farmers for an individual technology, but consideration is also given to impact on other scientists.

Overall, the Panel considers most of these 20 items to be highly relevant to IRRI's objectives. The quality of science is considered to be fairly high for most items, although it would appear that the principal selection criterion was relevance, followed by impact (actual or potential), which is an understandable decision. (The limited impact in some cases is at least partly because some outputs became available only recently, e.g., IR74371-70-1-1 identified for release in India. Impact is likely to increase if the right partners are identified for technology extension to farmers.) Judging from a wider sample of IRRI publications there is no strong correlation between a paper's relevance to farmers' interests and science quality; some good journal articles (from an academic perspective) have limited relevance to IRRI's mission.

The Panel suggests that researchers should ensure that scientific excellence is maintained while Program objectives for relevance and impact are met (scientific excellence in a strategic context), and IRRI needs to ensure that the working environment is conducive to maintaining excellence in science and research.

Accomplishments and achievements

Major accomplishments and achievements during the 5 year period are listed below.

Breeding

- Accurate mapping, validation and transfer of the *SUB1* gene to several rice mega-varieties, and their testing in national program contexts.
- Identification of two regions responsible for large reproductive stage drought tolerance effects, the gene *PUP1* for increased phosphorus uptake, and a QTL for tolerance to salt conditions (*SALTOL*).
- Continued progress in Golden Rice, with a projected release date of 2012.
- Establishment of high density screening of 2000+ diverse rice lines for 400,000 SNP markers using Affymetrix ® arrays, and the development of methodologies for association mapping of key loci.
- Establishment of *Agrobacterium*-mediated transformation systems for both indica and japonica lines capable of generating 10,000 events per year.
- Upland varieties that are significantly higher yielding, developed with farmers using PVS.
- Significantly improved blast tolerance in leading varieties.

Agronomy

- Refinement and deployment of the site specific nutrient management system (SSNM) based on soil testing, crop records and relatively simple software; popularization of the leaf color chart.
- Confirmation that irrigated rice systems are sustainable over many continuous crop seasons provided crop nutrition is adequate. On the other hand, rice-maize systems result in a decline in soil organic matter.
- Identification of high night temperatures as a major driving force in yield reductions due to expected future climate change.
- Development of aerobic production systems, and crop establishment systems that involve direct drilling of both rice and wheat in the subcontinent.
- Water saving technologies, especially alternate wetting and drying (AWD), and the development of simple equipment (perforated pipe) to improve accuracy of water management.
- Identification of poor management practices, lack of appropriate field machinery, and bacterial blight susceptibility as key constraints to rice yields in eastern and southern Africa.
- Continued development of the Rice Knowledge Bank and establishment of Country Knowledge Banks for source of rice management practices.

- Research in Vietnam on pest control and fertilizer management; and its delivery in a practical extension program that reached large numbers of farmers.

Social science

- Socioeconomics research projects on livelihood diversity and drought-avoidance strategies, particularly in India, that provide valuable information for helping target rice technology for resource-poor farmers.
- Analysis of the performance of rice markets and their performance in the Philippines and Thailand and implications for policy.

Other Center outputs that have assisted farmers and other clients include grain quality kit, post harvest storage, and farm machine designs.

There are also important achievements in research support and structure that allow IRRI to excel in research and development.

- Research support, in the form of extensive special project funding, especially from BMGF. This will allow access to new genetic technologies and germplasm from China, and the development of stress-tolerant rice varieties and hybrids suited to south Asia and sub-Saharan Africa. One key accomplishment for the future is the conduct of unrestricted funds-supported research on C_4 rice that provided sufficient evidence to persuade BMGF to provide longer-term support for this exciting but high risk research.
- The continued effective functioning of key networks, IRRC and CURE, for well-watered and unfavorable environments.

Impacts of outputs

IRRI has carried out a number of impact studies in the past five years and these illustrate the institute's expertise in this area and IRRI's commitment to documenting the outcomes of research. There does not appear to be any major recent analysis that specifically examines the use of IRRI germplasm, although several studies document the spread and impacts of modern rice varieties in general. Impact studies on other technologies are largely confined to examining results in very small areas, usually associated with project activities; one exception is a large-scale adoption study of extension recommendations in Vietnam.

6.4 Effectiveness and relevance of the external review process

IRRI has used the Center Commissioned External Review process to assess the quality and relevance of seven of its research programs or its research support units from 2004-8. The CCERs have been utilized in the assessment process in different sections of this EPMR report, and the following is a brief account and assessment of each CCER.

1. *CCER on the Analytical Service Laboratory:* This review was led by two external scientists and assisted by five IRRI staff members in May 2004. The report recommended that one of the four laboratories making up ASL be transferred to the newly established Grain Quality and Nutrition Center. Other useful recommendations were made on quality assurance, methodology, budget and staff development, and they were mostly accepted by the IRRI management. The Panel supports the recommendations and the CCER report was thorough and informative.
2. *CCER on Models of Staff Placement for Optimum Impact*: This review was conducted in

September/October 2004, by three researchers familiar with IRRI's mission and with the needs of NARS. The report is comprehensive and includes four major recommendations and a number of suggestions. The CCER recommends an expansion of outreach placements, asks IRRI to consider the establishment of regional offices, endorses the strategy of hiring well-respected national scientists as IRRI liaison officers, and endorses IRRI's continued emphasis on training. We conclude that this CCER was carefully and thoroughly carried out.

3. *CCER on the Research Program of the IRRI-Korea Office*: This brief review of IRRI-Korea Office was led by two eminent rice scientists (one a former IRRI employee) over a two day period in 2004, and resulted in a seven page report. It is not clear why this was considered a CCER in an area of relatively minor concern. The Panel regards the application of the CCER process as inappropriate for this review.

4. *CCER on Social Science*: This was conducted in early 2007 by four exceptionally experienced people with intimate knowledge of IRRI social science work, at a particularly critical time of staff turnover. Although the level of knowledge of IRRI that this panel had is an overall advantage, it may be argued that a CCER must include at least one member with more of an "outsider" perspective. Nevertheless, this was a very useful review and the recommendations were largely accepted by IRRI. The institute endorses the importance of SSD, acknowledges that it is understaffed, and effectively defends the existence of a distinctive effort (Program 7) for policy analysis.

5. *CCER on Management Services*: This review took place in July 2007, by a team of three members with a mix of CGIAR and non-CGIAR experience. The review provided recommendations on Finance, Procurement and Materials Management, Human Resources, and Travel. The recommendations on Human Resources management were extremely helpful in identifying areas for significant change in policy and procedures, and are in the process of implementation. Recommendations in the other areas have been reviewed by management and followed up as appropriate. The Panel concurs with this approach.

6. *CCER on the Operations Management Unit*: This review was conducted in December 2007 by four well-qualified research support managers, and resulted in a well-written and illustrated report. The review was thorough and timely, and as a result of this CCER, IRRI has modified several operations in the Unit.

7. *CCER on the IRRI Biotechnology Program:* This was conducted recently in August 2008, by a review team that comprised an excellent balance of general plant and molecular breeding skills from the private and public sectors. It delivered an exemplary report that was easy to read and provided five clear recommendations that the Panel support. The Panel is unable to assess the degree to which IRRI has implemented recommendations because the internal consideration of the report is still ongoing, but hopes that they will provide clear direction for IRRI in this area.

Some other major commissioned external reviews were carried out during the review period as the need arose. These were not CCERs but some of them had a large impact as described briefly below:

IRRC Phase 3. The review was conducted by four experts in the field in 2007, and an excellent report was produced with 13 specific recommendations. This review of achievements in IRRC Phase 3 is one of the most positive of those conducted in the 5 year period of this EPMR, and their constructive suggestions were incorporated in IRRI's successful efforts to secure IRRC Phase 4.

Upland Rice Research This review was conducted in March 2006. It recommended IRRI to continue upland rice research, and proposed that three IRS be employed to work in upland research. IRRI has accepted and implemented the recommendations. (See Box 3.2 in Chapter 3).

Panel assessment

The timing of these CCERs has been somewhat erratic – with three conducted in 2004 and the balance in 2007-8. While it is appreciated that IRRI was busy with developing the Strategic Plan in 2005-2006, one goal of the CCER process is to reduce the demands for reviewing in great scientific or administrative detail by a subsequent EPMR, so the Panel strongly suggests that CCERs be conducted in the 3 years preceding an EPMR. A list of needed CCERs should be formulated in the near future and CCERs conducted accordingly. The Panel is generally impressed with the quality of CCER Panels, and with few exceptions, with the quality of the reports and the subsequent recommendations. The record of implementation of recommendations suggests that the CCER process has been well utilized by IRRI to improve the relevance and quality of its research. However, the budget for IRRI's activities devoted to CCERs completed in 2005-2007 (3 CCERs) was less than 30% of that allocated, and the CCER coverage was lower than the average of CGIAR Centers. Another aspect that the Panel notes is a shift in the nature of CCERs - from evaluation of in-depth scientific matters to more consideration of management issues. Management issues may require CCER evaluation, but the inclusion of more CCERs that cover key issues in scientific matters and are conducted in a timely manner will be useful. Additionally, the panel suggests that the review team members should be independent of IRRI, avoiding any conflict of interest.

6.5 IRRI EPMR Stakeholder Survey

IRRI stakeholders were asked to respond to a questionnaire of 10 questions about IRRI with options for a free text response. The questionnaire was administered as a standardised on-line survey and the results from 163 stakeholders synthesised by the SC Secretariat. The majority of respondents were representatives of NARS and consortia (31.6%), developed country universities (21.3%), developing country universities (14.8%), and government departments or institutes (11%) with other responses provided by other institutes, NGOs, the private sector or donor organisations. Greater than 95% of the respondents claimed familiarity with the work of IRRI. IRRI's performance in and reputation for development of new rice varieties, and for curation and supply of rice genetic resources, were considered excellent by more than 50% of respondents. Indeed IRRI was scored as generally good or excellent in all other categories of work listed, including quality of research, by 55.5% to 89.8% majorities of all respondents. Conversely, around 30% of respondents thought that IRRI's work on improving upland systems (32.8%) and in influencing policymakers (28.5%) was either fair or poor. The bulk of respondents perceived that IRRI's work complemented rather than competed with their own. Most felt that their institutes had had adequate opportunity to enter into IRRI priority setting (more at the program than at the Center level) although more than a quarter felt that they had had no opportunity at any level. Respondents wish IRRI to treat research activities in all relevant areas, as well as outreach and development activities, as priorities. They give (in general) medium priority to socioeconomic activities and advocating policies. A large number of respondents were knowledgeable about at least one of IRRI's consortia which were deemed to have a generally positive effect (63%) and to meet the needs of national partners (52%). However, 41% of respondents only agreed partially with the last estimation. The majority of respondents (62.9%) found IRRI's training and capacity building to be excellent, whilst 33.8% found it to be only average. IRRI's major contributions, in agreement with the above estimation of quality, were in rice breeding and genetic resources (just fewer than 60% of respondents found that IRRI's germplasm conservation effort complemented their own activities). See Annex 8.

Other comments made by stakeholders focussed on:

Programmatic focus – whilst IRRI's focus has turned from solely irrigated to considering also rain-fed systems, upland systems are a bit neglected. Some wished for more work on rice genetics and breeding whilst one respondent noted that funding shortfalls may have led to a "retreat" to a more limited program based on genetics and breeding. In this regard, several respondents noted that IRRI has moved away from natural resources management research and that natural resources packages should be researched along side new varieties, particularly R&D for small rice farmers. Plant protection activities have shrunk. There would appear to be opportunity for IRRI to contribute more to the macroeconomic picture for rice and rice trade, and to increase institute visibility in this area. Expectations for IRRI to assist the development of rice in Africa are quite high.

Delivery – High standards of research are being maintained but the focus on delivery to end users has slipped. IRRI has concentrated on the traditional public sector as partners for delivery but the institute's recent interest in expanding partnerships towards competent, development-oriented NGOs and the private sector should be vigorously pursued.

Networks - IRRI's networks and training capabilities are highly appreciated. However, IRRI needs to understand how to get beyond the network and beyond the NARES when these are in disarray. It needs to find its niche in the national context, including influencing policy makers and farmers for its research to have more impact. There should be some mechanism to move closer to farmers and targeting capacity building and extension (such as IRRC). It was suggested that there are opportunities for IRRI to have more effect on national and regional policy and provide more opportunities for training.

Many favorable comments were made on IRRI's standards of research, research collaboration and research management.

Telephone discussions (and an email questionnaire) were also held with representatives of IRRI's top 10 donors and major collaborators in CGIAR centers and Challenge Programs. Their synthesised responses are included in Chapter 7 and Chapter 4, respectively.

Panel assessment:

Quality of staff

IRRI IRS staff are at different stages of progression and seniority in their careers, and there is a reasonably good age demographic across the Divisions and Units. Nearly all are recognized internationally as experts in their field. The more senior staff are recognized as world leaders in their fields of endeavour. In general, this indicates that IRRI staff are of high caliber and this is confirmed by an above average publication record in peer-reviewed journals.

The Panel commends the high scientific standards that individual scientists maintain. The dedication of excellent scientists combined with the right directions of research has produced many outputs that will help the poor of Asia and Africa.

Quality of Science Management

The Strategic Plan was established after appropriate consultation with a range of stakeholders, and the Plan determines the goals that are appropriate to the Institute in the current environment. The Panel applauds the annual planning week where goals are set across the institute in a thorough and open manner. The MTP is a clear and comprehensive document and guide to current activities. It is developed annually and individual IRS have clear tasks that meet the overall objectives of Programs where they work.

The planning and design of project and funding proposals are also well-executed from concept note through to submission to the donor, and places relatively little burden on the scientist in the latter stages of the submission process. The Panel notes that the recruitment process for IRS was thorough but slow, although a new system adopted recently should speed up the process. Most of IRRI staff are content with the way in which research goals are set and communicated and find IRRI a good and inspiring employer. Annual evaluations of performance are apparently more problematic. Simplifying the matrix structure and strengthening the role and authority of the Program Leaders should improve decision times and reporting lines. As IRRI is in an expansion phase, maintaining a good work place atmosphere is a task for IRRI management as well as individuals.

Scientific Outputs

The Panel commends the excellent work that has been conducted in the different programs over the 5 year period. There is an institution-wide sense of achievement, and these achievements are widely recognized by IRRI's stakeholders. The Stakeholder survey and other documents indicate IRRI's quality of research to be excellent. IRRI has gradually moved from emphasis on intensive production systems to more marginal rainfed environments. The rainfed environments require well coordinated research within the research teams at IRRI and also with other groups such as NARES. It is important to recognize that IRRI has a diverse group of scientists, and that research projects need to be formulated to take advantage of this diversified skill base.

Development of consortia such as CURE and IRRC, and the expansion of activities within consortia, are applauded. One of the challenges facing IRRI is to find ways to ensure that technologies developed are adopted by resource-poor farmers in the target regions. IRRI should pursue opportunities for more effective scaling up of its technologies.

Impact

While the adoption of improved varieties and impact in rice productivity are generally known there does not appear specific major research that has documented the impact of IRRI varieties in the 5 year period. A number of new technologies have been developed during this period and some are already showing some impacts. With further inputs, they are likely to make significant impact in the near future. There has been strong impact of IRRI on human resources in rice research in Asia. Some NARS have developed their research capacities and become real partners with IRRI. Training and joint research activities through consortia and other means have contributed to the development of strong NARS research capacity.

7 INSTITUTIONAL DEVELOPMENT: GOVERNANCE, MANAGEMENT, ACCOUNTABILITY AND RELATIONSHIPS

7.1 Governance: Board of Trustees

IRRI's Board of Trustees is the body responsible for the governance, policy framework, and strategic oversight of all IRRI's operations. The Board's costs of operation have consistently remained at less than 1% of the operating budget of the Institute.

In any CGIAR Center, the Board of Trustees operates in a complex environment in which both formal and informal accountability to multiple stakeholders is required. Maintaining a clear focus on the well-being of the institute, while simultaneously responding appropriately to the concerns of donors, host country, national program partners, civil society interest groups, scientific collaborators, and the CGIAR, is a demanding task which the current board of IRRI manages well. In the five years since the last External Review of IRRI, the Board of Trustees has adapted admirably to the post-Sarbanes-Oxley context of increased concern for transparency of operations, increased scrutiny by stakeholders, and additional accountability requirements. In the same period, the Board has overseen IRRI's continuing transition from a research center primarily financed through unrestricted core contributions from CGIAR members to a center whose core mission is financed mainly through restricted grants, including grants from donors who are not CGIAR members. The percentage of IRRI's budget derived from unrestricted funding has declined as follows: 53% in 1998, 50% in 2003, 34% in 2008, 21% projected in 2009.

In earlier days, the Institute could allocate substantial unrestricted resources according to its best perception of emerging development needs and the potential contribution of rice research to meeting those needs. Thus, with large budgets consisting of unencumbered financial resources, IRRI could establish spending priorities, consultative processes and staffing plans to implement the programs it identified as primary to its core mission. In contrast, IRRI is now an institution whose core mission must be financed in large part through its restricted grants budget. IRRI advances its strategic goals through restricted grants that form the major part of its income. As a result of this change, 'business as usual', in CGIAR terms, is definitively over. The significance of the move away from unrestricted funding for the tasks of governance can hardly be overstated. In particular, this transition gives new importance to the role of the Board in providing strategic guidance on program integrity, IRRI's positioning on the research-development continuum, resource mobilization, institutional risk and institutional relationships.

As initiatives like the CGIAR Systemwide and Challenge Programs, the Rice-Wheat Consortium, and the IRRI-CIMMYT Alliance have developed, IRRI's Board has ably navigated complex questions of overlapping mandates and multi-tiered governance roles. IRRI and CIMMYT Boards have met jointly twice, and since 2007 have cross-appointed one Board member, while a number of IRRI Board members have links to CGIAR Challenge Programs. Two members of the Board of WARDA attended the IRRI Board meeting in September 2008. The Board Chair has provided leadership in alerting the Board to the governance implications of these collaborative arrangements.

The development and unfolding of the Change Management Initiative of the CGIAR, and the CGIAR Reform process have been of particular significance in the period under review. The Director General and the Chair of the Board have been active participants in these discussions through the Alliance of the CGIAR Centers. The Chair has kept Board members informed at each step of the process, as a means to ensure thorough understanding and due diligence when the decision points are reached. The Panel commends the care taken by the Chair to ensure that the Board is fully conversant with the system issues facing IRRI, at a time when maximum resilience and agility will be required.

Board of Trustees Composition

The Board of Trustees includes 12 members-at-large, of whom 3 are designated by the CGIAR. In addition, the Secretary of Agriculture of the Republic of the Philippines, the President of the University of the Philippines and the Director General of IRRI serve *ex-officio*. A list of trustee competencies based on the Strategic Plan serves as a reference point for recruitment. The membership is carefully reviewed and managed with a view to maintaining a balance against various criteria: regional representation; management, financial and scientific expertise; private, not-for-profit, and government sectors; gender; members retired from fulltime employment, and those still in the workforce. The Board is composed of distinguished scientific and institutional leaders, and includes two members with significant financial expertise (see Annex 10).

IRRI has been encouraged to consider reducing the size of the Board, in keeping with a trend in the CGIAR. The Panel notes, however that the Board functions effectively at this size, and that each member contributes uniquely to its strength. Board members also serve as key interlocutors with university, government and private sector institutions. Further, a meaningful reduction in size would necessitate additional measures to ensure continued strong regional representation at very senior level, a change which the Panel does not consider desirable at this time.

Board Operations – meetings, minutes, committee structure, self-evaluation

The Board meets twice a year, normally once at IRRI Headquarters and once at a location where IRRI is active in research. Minutes are meticulous, and reviewed with care. To improve the Board's ease of reference for past decisions, minutes are now available in searchable, digitized format, back to the mid-1980s.

The Board operates with five standing committees – Executive, Program, Finance, Audit and Nominating. Consistent efforts are undertaken by Chairs and the Board Secretary to ensure that matters dealt with at committee level are brought forward at the appropriate level of detail for further Board discussion, so as to avoid repetitive or overlapping discussions. In addition, the Board self-corrects when tempted into micro-management.

Since the last EPMR, and in keeping with recommendations of the CGIAR System Office, the Finance and Audit Committee has been re-mandated as two separate committees to differentiate more clearly between audit questions (including non-financial audit), and financial planning/budgeting matters. At present, the membership in the two new committees is the same, with the exception of the Director General, who is not a member of the Audit Committee.

The operations of the Board are detailed in the Board of Trustees Handbook, which is kept up to date, and includes provision for regular self-evaluation by the Board. The Board undertakes a review of its own performance, the performance of the Chair, the Secretary, and individual members annually. Recommendations for adjustments are based on these evaluations.

Board Program oversight

The Program Committee includes five board members, yet it functions de facto as a committee of the whole (with the exception of report-writing). This allows maximum exposure for all Board members to the core business of IRRI and appropriate interaction with scientific staff. The Panel commends this practice as pragmatic and constructive for the overall functioning of the Board. In this capacity, the Board has recently made effective use of CCERs as a mechanism to identify issues arising within the research programs of IRRI. Recommendations and follow-up commitments provide a framework for ongoing program review.

IRRI research management policies, including Intellectual Property policy and Biosafety policy, are reviewed in the Program Committee and approved by the full Board.

The Panel also notes the increasing importance of the Program Committee as a forum to consider options for the strategic positioning of IRRI in a very fluid research environment. As the trend to restricted funding increases, the Program Committee will need to attend to the alternatives available and opportunity costs of investments in IRRI's research agenda. This will imply increased attention to strategic questions in Program Committee agenda planning, and clarity about the purpose of staff presentations and discussions in the Program Committee.

Board Financial Oversight

The Board receives excellent financial reports, and appropriately engages the financial policy issues confronting IRRI. Investments, investment policy and foreign exchange policy are regularly reviewed. In the five years since the last EPMR, the Board has approved a planned reduction in reserves which is currently underway. Detailed review of financial performance and budgeting takes place in the Finance Committee, while External and Internal Audit reports are received by the Audit Committee.

The Board has shown both foresight and appropriate caution in the development of the IRRI Fund (see below).

Board Human Resources policy oversight

As noted below, the Human Resources management function is in transition at present, moving toward the provision of strategic and professionalized services to IRRI. This change has been mandated by the Board, in response to the insights and recommendations arising from a CCER on Management Services conducted in 2007. In addition, IRRI's current program and the new projects approved call for dramatic staff increases in 2009 and beyond. While the formal Human Resources policy framework including a Code of Discipline, is comprehensive and adequate for the day-to-day operations, significant policy changes are likely to be required if IRRI is to meet the challenges of recruitment, career development, and retention of high quality international staff in a programming environment where unrestricted resources are very constrained.

While Human Resources management as such falls squarely within the purview of the Director General, it would be appropriate for the Board to increase its involvement in the development of new Human Resource strategies and policies.

Board Interactions with Staff

Members of the Board interact with staff in both formal and informal ways. Staff members report that the Board seems more approachable now than in previous years. A number of Board members engage staff in discussion of scientific matters both at IRRI and through email. During

Board meetings, Board members interact with staff in Program Committee reports. Lunch meetings with national staff members and representatives of the IFEA are scheduled through the week of the Board meeting. At the conclusion of each Board meeting, the chair addresses the staff, with opportunity for questions and answers afterward.

Board Oversight of Director-General

A principal task of the Board of Trustees is to recruit and oversee the performance of the Director General, who has operational responsibility for implementing Board policy and managing the institute. The recruitment process followed in 2004 was managed internally by the Board itself in a transparent and rigorous fashion, including consultation with staff. This process provided a timely result. The performance of the Director General is formally appraised annually by the Board, through questionnaires, and discussed in closed session. The results of this appraisal are conveyed to the Director General by the Chair of the Board. The Board decides contract terms, and the level of remuneration for the DG.

Panel Assessment of Board of Trustees

The Panel considers that IRRI's Board of Trustees operates in a transparent and effective way to promote and protect the interests of IRRI. It concurs with the Board's decision not to reduce its size. It commends the efforts made by the Board to prepare for decisions which may arise from the CGIAR Change Process.

The Program Committee of the Board needs to play a critical role as IRRI seeks to identify and anticipate priorities, opportunities and opportunity costs in a challenging environment. **The Panel recommends that the Program Committee of the Board refocus its attention to strategic issues facing IRRI, and use CCER and other review processes for monitoring of IRRI research programs. It should refine its agenda-setting and ensure that program presentations are clearly linked to strategic questions which require Board deliberation.**

The Panel encourages the Board of Trustees to give high priority to its oversight of Human Resources policy and management issues as IRRI undertakes rapid growth and introduces competency-based Human Resources systems.

The Panel suggests that the performance appraisal process for the Director General include a '360^{o} review' every second year, to capture the perspective of staff (IRS and NRS), partner organizations, and donors.

The Panel also suggests that the discussion of the Director General's performance appraisal results take place with the Board Chair and one other member, in order to achieve the appropriate combination of confidentiality and transparency.

7.2 Management of the Institute

As noted in the 6th EPMR, "The Director General establishes the tone and culture that imbues an organization". Under the leadership of the incumbent Director General, appointed in 2005, the salient features of this tone and culture are clarity of purpose, vigorous pursuit of new opportunities for funding and collaboration, and a strong, pragmatic management style. IRRI has benefited greatly from all three. Through the use of the Strategic Plan as a framework for the seven programs seven programs funded through unrestricted and 152 separate restricted grants which comprise IRRI's research portfolio, and also through the coordination of external communications materials, IRRI projects a very clear and consistent image of its goals and priorities. This clarity has enhanced IRRI's capacity to approach new donors and partners successfully, with the result that in 2009, 37% of IRRI's financing will come from non-traditional donors, and 14% of IRRI's programs will be carried out jointly with other CGIAR institutions. This strong performance reflects the high caliber of the entire senior management group.

Organizational structure

The existing organizational structure of IRRI is shown in Annex 5. IRRI's upper management comprises a 5-person Management Committee consisting of the DG, the two DDGs and two Directors and it focuses, correctly, on strategy. Under the leadership of the DDG Research, the research programs are organized in a loose matrix, which has evolved at IRRI since the late 1980s. The DDG Operations and Support Services oversees IRRI's scientific regulatory functions, facilities management, public affairs program, and Board secretariat function. The Director of Management Services serves as IRRI Treasurer and oversees financial management, human resources management, procurement and material management services, travel services and the IRRI school. Communications operations, information support (library and IT), and project planning support are coordinated by the office of the Director for Program Planning and Communications. Coordination across research and service operating units means that, in practice, the entire IRRI operation functions effectively as a form of matrix.

This structure has been modified in the past five years, in part to rationalize the provision of services and in some measure to respond pragmatically to evolving personnel realities. The Panel finds that the structure functions well, and encourages IRRI to maintain this combination of concern for effectiveness with pragmatism as it evolves further. There is scope for a specific review of IRRI's matrix approach to research management, as noted below.

Human Resources Management

The human resources of a scientific research institution like IRRI are its principal asset. IRRI employs 976 staff members at the time of writing, of whom 64 staff members and 46 post-doctoral fellows were recruited internationally.

The context for recruitment, retention and career development of scientific, technical and administrative staff, recruited both nationally and internationally, has changed significantly in the five years since the last EPMR. In response to emerging needs and the recommendations of the CCER on Management Services (2007), a number of innovations are underway to modify the function of Human Resource Services at IRRI from an administrative and compliance-oriented model to a client-focused strategic role. The overall objective of these changes is to implement a human resources system which offers clearly demarcated career paths with appropriate salary scales, supports the development of professional skills and competencies through training, and transparently rewards performance for all levels of IRRI staff, including post-doctoral fellows. It is an expressed goal to harmonize internationally-recruited and nationally-recruited staff systems. This will involve changes in existing job classification, recruitment, and performance evaluation processes which are currently only partially implemented. Intranet-based information and communications on Human Resources policy and procedures will be critical in all the elements of this transition.

Competency Development

The Competency Development program, initiated by the Human Resources staff in 2007, is designed to identify a set of documented core and professional competencies which apply to all IRRI staff and which are linked to IRRI's mission, vision and values. This will support the streamlining of the job classification process, as well as the integration of post-doctoral appointments into the overall system, and the harmonization of national with international staff systems. Full implementation of the competency-based approach to recruitment and selection, career development, succession planning, performance management, and training/development is planned for the end of 2010. The job classification system has been modified to make it more transparent, fairer and more efficient. Performance appraisal based on competencies was introduced in 2008, with individualized learning plans integrated into the system. IRRI is participating through the CGIAR Gender and Diversity Program and other centers in a survey of compensation and benefits practices within and outside the system to ensure competitiveness.

As IRRI enters a period of both rapid staff growth and increased reliance on restricted funds, it will be necessary to identify new ways to recruit staff rapidly and to plan for career development and redeployment within the constraints of fixed term contracting. Concern has been raised that IRRI international recruitment is too slow to guarantee success in employing the best candidates in a timely way. Measures underway to address this challenge include the use of proactive internet-based recruiting, and the use of 'headhunting' firms. The introduction of a training component into direct cost accounting for personnel costs, and bridging funds to retain staff on fixed term contracts funded from restricted grants will make employment at IRRI more attractive. Managing in this more complex Human Resources environment will require improved Information Technology support.

Post-Doctoral Fellows

The number of post-doctoral fellows employed by IRRI is increasing sharply from 26 in 2007 to approximately 55 in 2009-10. As part of its program to modernize Human Resources management, and in order to become a preferred employer at this level, IRRI urgently needs to improve its overall approach to managing, training and mentoring this important cadre of young scientists. Improvements will include faster recruitment, and orientation of new arrivals, as well as better logistics and ongoing family support, with emphasis on housing and transport. In addition to formal scientific supervision, IRRI should offer a specific program of professional development, including skills training in grant proposal writing, making presentations, supervising students and technicians, project financial management, and career planning. It is possible that training in post-doc supervision and mentoring for senior staff will assist in creating a more constructive institutional culture for the formation of the next generation of international rice scientists.

Nationally Recruited Staff

At the time of writing, IRRI employs 908 staff members recruited nationally, of whom 837 work at IRRI Headquarters in Los Baños. The staff association in place at the time of the 6th EPMR was disbanded in 2005. After a two-year hiatus, a new national staff organization, the IRRI Filipino Employees Association (IFEA) was established in 2007 to serve as a central channel of communication with senior management on matters of salaries, benefits, career development and employee welfare and other matters. This partnership is cited by both management and employees as constructive and mutually beneficial. Efforts are underway to plan for an early retirement scheme to address the human resource challenges posed by the age and experience profile of existing IRRI staff, and in order to create recruitment opportunities in a workforce which exhibits very low turnover. IRRI has recently introduced Senior Associate Scientist (Level 7) and Senior Research Manager (Level 8) positions for nationally recruited staff in research units. This balances provisions for advancement in the non-research areas of employment, and provides a smoother interface between nationally-recruited and internationally-recruited scientific staff levels. IRRI NRS Personnel Policy was last updated in 2006, following a compensation survey by Hewitt Associates in 2005. IRRI is collaborating with Worldfish and other centers to develop a multi-location NRS compensation survey.

Support to IRS

A Family Liaison Officer (part-time) was appointed in 2008 to provide support to newly-arrived expatriate staff and families. Pre-primary and primary education is available on campus, and IRRI provides transportation to older children to schools at off-site locations. As IRRI staff expands rapidly, there will be a need for increased housing. This will entail new approaches to the housing and other support to international staff. IRRI is exploring the possibility of long-term leasing of offsite accommodation.

Gender

The Human Resources services group now serves as the focal point for Gender and Diversity efforts at IRRI. At the time of writing, 17% of IRRI internationally recruited staff and 29% of post-doctoral fellows are female. International recruitment of female scientific and senior administrative staff remains challenging, despite the practices of targeting female candidates, and offering spouse employment where possible. Formal measures to introduce a mentoring system have met with limited success, and are under review. Over 40% of nationally recruited staff (including 50% and 37% at the senior levels 7 and 8 respectively) at IRRI headquarters are women. This ratio is much lower for nationally-recruited staff outside IRRI headquarters. IRRI participates in the CGIAR Gender and Diversity program, with a consultation planned for early 2009. IRRI has an appropriate sexual harassment and discrimination policy in place and has appointed Dignity Advisors in operating units.

Whistle-blower policy

The Board of IRRI introduced a whistle-blower policy in 2007, to be administered by the Human Resources services group.

Panel assessment of Human Resources management

The Panel considers that IRRI's decisions to move Human Resources management toward a more strategic service model, and to integrated competency-based HR systems are well-founded, and will serve IRRI very well in the current circumstances.

The Panel recommends that IRRI establish and publicize a career framework for IRRI staff with clearly articulated professional levels, transparent salary scales, and performance incentives. This career structure should identify pathways from Post-Doctoral Fellow through Principal Scientist, and for NRS Grades 1 through 8. The implementation of this framework should be supported by staff development measures in performance appraisal, training and career planning, and it should recognize the special circumstances of outposted staff members.

The Panel commends staff and management on the reestablishment of the working relationship with nationally recruited staff through the IRRI Filipino Employees Association (IFEA).

Financial Management

Funding Trends and Implications

IRRI has benefited from an increase in the absolute level of funding over the review period, 2003-2008. IRRI's grant income went up by 37%, from US$27.1 M to US$37.1 M, during this 6-year period. It is forecast to rise by another 61% in 2009. A summary of IRRI's operating performance over the review and forecast period is given in Table 7.1

Table 7.1 IRRI Program and Resource Highlights, 1998-2009

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Center Revenue (millions of US Dollars)	Actual	Actual	Actual	Actual	Actual	Actual	Actual	Actual	Actual	Actual	Actual	Forecast
Unrestricted Grants	16.8	16.1	16.5	14.1	12.9	11.5	14.8	12.8	12.8	12.2	12.7	11.9
Restricted Grants(incl. attributed)	17.7	16.4	17.3	15.9	15.6	15.6	17.9	16.1	15.1	20.2	24.6	46.4
Total Grants	**34.5**	**32.5**	**33.8**	**30.0**	**28.5**	**27.1**	**32.6**	**28.9**	**27.9**	**32.4**	**37.3**	**58.3**
Center Earned Income	3.2	2.5	1.6	2.1	4.9	4.8	4.1	(0.4)	4.0	2.3	(0.7)	0.8
Total Revenue	**37.7**	**35.0**	**35.4**	**32.1**	**33.4**	**32.0**	**36.7**	**28.5**	**31.9**	**34.7**	**36.6**	**59.1**
Center expenditure (US$M)	35.0	35.1	32.6	32.6	33.6	28.7	33.2	33.9	33.6	37.6	40.2	61.5
Results from operations (US$M) Surplus/(Deficit)		(0.1)	2.8	(0.5)	(0.2)	3.3	3.5	(5.4)	(1.7)	(2.9)	(3.6)	(2.4)
Memo items:												
1. Donors grants by region (US$ M)												
Europe	11.3	9.0	10.8	10.0	12.5	13.0	14.6	9.6	7.7	10.1	7.6	7.5
Pacific Rim	10.7	11.4	10.5	8.1	4.4	5.2	5.7	4.8	4.3	5.6	7.1	10.7
North America	4.7	4.7	4.8	4.5	4.6	4.5	5.6	4.7	5.0	4.7	6.0	7.0
Developing Countries	1.6	1.2	1.1	1.1	1.1	0.5	0.6	0.6	0.9	1.2	1.3	1.5
International and regional organizations	4.8	4.9	5.4	5.2	4.6	2.8	2.9	2.9	4.0	4.0	4.5	4.7
Foundations	0.9	1.1	1.0	0.8	1.1	0.7	0.7	0.9	0.5	0.7	0.1	1.0

Challenge programs						0.3	1.9	4.9	4.7	5.4	2.8	3.1
Non-members	0.5	0.2	0.2	0.3	0.2	0.1	0.6	0.5	0.8	0.7	7.9	22.8
2. Expenditure by Object												
Personnel	17.1	16.2	14.9	15.7	16.2	12.8	12.9	13.3	14.4	15.5	17.5	23.7
Supplies/services	13.0	14.0	12.8	12.9	12.8	10.7	15.8	15.7	14.5	16.9	16.7	28.0
Travel	2.5	2.4	2.7	1.8	2.5	3.0	2.2	2.9	2.7	2.9	3.4	5.0
Depreciation	2.4	2.5	2.2	2.2	2.1	2.2	2.3	2.0	2.0	2.3	2.6	4.8
3. Staffing												
IRS-directly employed	63	65	63	66	60	61	62	58	52	56	64	82
IRS-seconded	12	10	6	6	6	6	6	3	7	7	9	6
International Research Fellow	11	11	12	9	9	11	11	11	14	11	11	9
Post Doctoral Fellow	31	36	24	18	19	13	14	22	25	26	46	42
Adjunct Scientist	1	1	1	1	1	1	1	1	1	1	1	1
Visiting Research Fellow	4	3	4	7	3	5	5	25	33	25	12	3
Liaison Scientist	4	5	5	6	5	4	4	3	3	3	4	4
Collaborating Scientist	7	9	10	1	7	4	3	10	3	1	2	2
IRS Subtotal	133	140	125	114	110	105	106	133	138	130	149	149
NRS-in Los Baños	860	887	865	870	665	717	737	732	745	738	772	903
NRS-Outreach	122	122	127	131	70	67	65	58	62	67	55	66
NRS Subtotal	982	1,009	992	1,001	735	784	802	790	807	805	827	969
Total Staff	1,115	1,149	1,117	1,115	845	889	908	923	945	935	976	1,118
4. Consultants	29	32	48	48	29	41	30	44	57	63	50	50

The major contributors to the increase in donor revenue were Australia, Canada, Japan, Bill & Melinda Gates Foundation, and USA as shown in table 7.2 below.

IRRI forecasts that donor funding will continue to increase, rising to US$58.3 M, as estimated for 2009. Much of this increase is expected to be in restricted funding and will come primarily from the Bill & Melinda Gates Foundation and other consortia projects.

Table 7.2 Trends in major donor funding to IRRI (2003-2009)

Funding trends							
Donor Funding (in US$ M)	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
(a) Australia							
Unrestricted	0.2	0.6	0.6	0.6	0.6	0.7	0.8
Restricted	0.5	0.3	0.4	0.4	0.5	0.7	0.8
	0.7	**0.9**	**1.0**	**1.0**	**1.1**	**1.4**	**1.6**
(b) Canada							
Unrestricted	0.8	1.1	0.9	1.0	1.0	1.8	1.2
Restricted	0.1	0.1	0.1	-	0.2	0.1	-
	0.9	**1.2**	**1.0**	**1.0**	**1.2**	**1.9**	**1.2**
(c) Japan							
Unrestricted	2.7	2.9	1.8	0.9	0.8	1.2	1.0
Restricted	1.4	1.3	1.2	1.5	2.7	3.6	6.9
	4.1	**4.2**	**3.0**	**2.4**	**3.5**	**4.8**	**7.9**
(d) Gates Foundation							
Unrestricted	-	-	-	-	-	-	-
Restricted	-	-	-	-	0.2	5.7	19.0
	-	**-**	**-**	**-**	**0.2**	**5.7**	**19.0**
(e) USA							
Unrestricted	3.1	3.7	3.2	3.2	2.7	3.0	3.0
Restricted	0.5	0.6	0.4	0.5	0.7	1.7	2.7
	3.6	**4.3**	**3.6**	**3.7**	**3.4**	**4.7**	**5.7**

As increased funding has become available over the past five years (2004-2008), IRRI staff levels have grown as follows:

Table 7.3 Growth in IRRI staff (2004-2008)

Staff	2003	2008	% increase
IRS	92	103	12 %
Post- Doc	14	46	329 %
NRS	784	908	22%

Unrestricted and restricted

The single most significant change in IRRI's financial position is the move by donors away from unrestricted grants toward restricted funding of the research agenda, as indicated in Table 7.4. This change has had major impacts on planning, budgeting and financial management at IRRI.

Table 7.4 Historical and projected funding from unrestricted and restricted funding at IRRI and in the CGIAR.

Donor Funding (%)	**1998**	**2003**	**2008**	**2009**
(a) IRRI				
Unrestricted	53	50	34	21
Restricted	47	50	66	79
(b) CGIAR system				
Unrestricted	61	44	n.a	n.a
Restricted	39	56	n.a	n.a

(Note: Earned income in each year is treated as unrestricted core funding) Source: IRRI 2009

Full Cost Recovery

Like other CGIAR centers, IRRI has for many years provided *de facto* subsidies from unrestricted funds to support and enhance projects financed from restricted funds. These subsidies have included indirect cost recovery at less than the audited rate, direct costs for services not charged (e.g. Experiment Station, Information Technology), personnel costs not recovered, and capital assets not funded. As the proportion of IRRI's budget financed by restricted grants has grown, this practice has become unsustainable. Therefore, as noted in the Strategic Plan, IRRI management has embarked on a strong effort to implement a system of full cost recovery on restricted grants. This will be phased in as IRRI establishes and refines its own systems for identifying direct and indirect costs, and as existing project contracts are replaced over time by project contracts which include provisions for full cost recovery.

A project template introduced in 2008 for use in all new projects assists project planners to identify the full direct cost of a project and defines indirect costs at 10% plus occupancy cost of 6%. Full charging of ES and IT elements began in 2008, and other operating units will be added. In 2009 OU financial reports will be improved to support accountability for a full operational budget, to assist managers in allocation decisions. IRRI plans to have full cost recovery mostly completed by the end of 2010.

Planning, Budgeting, and Control

Budget preparation, clearance and monitoring are computerized and reasonably efficient. Budgets deriving from unrestricted sources are allocated by OU and sub-units, with explicit expenditure authorizations. Project and unit budget reports are available online, with automatic alerts to prevent overspending. Given the changes toward full cost recovery indicated above, and the move to integrate personnel costs and depreciation into project budgets, the Panel supports IRRI's intention to invest in updated integrated financial and human resources management software, in consultation with CGIAR partners.

Capital asset replacement: The need for the replacement of the Institute's physical assets has been noted in previous chapters. The Panel recognizes that IRRI faces limitations in its attempt to build adequate capital reserves. The CGIAR historical cost accounting rules recommends that reserves be limited to approximately 180 days, and this prevents the accumulation of funds for redevelopment. Therefore, the Panel concurs with IRRI's proposed solutions aimed at using restricted grants contracts to cover more capital assets (direct purchase through grants, and cost recovery charges), the effort to secure funding through strategic resource mobilization, and strategic use of capital reserves.

Financial Stability of the Institute

Analysis of the financial indicators used by the CGIAR (short-term solvency and adequacy of reserves) showed that overall IRRI's financial health is excellent. IRRI's position, using standard comparative ratios, is shown in Table 7.5.

Table 7.5 IRRI's Financial Health Indicators

	Actuals											Plan
	1998	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
1. Short Term Liquidity												
Working capital (days)	239	170	140	237	232	553	490	422	388	309	258	146
Current ratio	1.7	1.5	1.4	1.7	1.8	4.4	4.4	3.5	3.1	2.2	1.73	1.94
(CGIAR recommended targets are 90 days and a ratio of 1.5 or better, respectively)												
2. Fixed Assets												
Capital expenditures (US$ M)	5.8	1	1.5	2.4	1.1	1.8	3	1.6	3.5	3.6	2	3.1
Cap Exp/Depreciation (%)	237	40	68	109	42	90	132	77	173	158	104	107

Reserves: IRRI's reserves, at US$26.2 M in 2008, are high by CGIAR standards. The Board has approved and regularly reviews a plan to move toward the level of US$22 M in 2010. This planned reduction will be achieved by a combination of small operating deficits and designated funds to new ventures such as the C_4 Photosynthesis Frontier Project, the strategic initiative in Africa, and the Development Office. The Board reviews the reserve target level semi-annually.

Foreign exchange risk: Like other CGIAR centers, IRRI is exposed to foreign exchange risk as it handles multiple currencies. Board policy prohibits any manner of hedging against currency fluctuations. Because a large proportion of IRRI's expenditures are in Philippine pesos, while receipts are primarily in US dollars, IRRI financial staff exercises close management on the purchase of pesos.

Cash and Funds management

IRRI's current policy is to maintain 90% of financial assets invested. The Board-approved Investment Policy (2005), which is reviewed annually and last amended in September 2008, establishes principles, guidelines and definitions. The Panel notes and concurs with IRRI's implementation of the CCER recommendations on Board investment and allocations information, and its decision not to implement the CCER recommendation to establish an Investment Committee.

IRRI's Financial Reporting - External Audit

IRRI is in full compliance with the Financial Guidelines of the CGIAR. In each year of the review period, the external auditors have expressed unqualified opinions on IRRI's financial statements. The last two IRRI external auditors were Ernst and Young for 2002 and 2003, and Price Waterhouse Coopers for 2004, 2005, 2006, and 2007. Both these external audit firms certified that the IRRI financial statements were prepared in conformity with the CGIAR guidelines.

Organization

IRRI has satisfactory financial management arrangements in place to meet donors' requirements. The overall financial management risk associated with the Institute is rated as low, while the financial management system in place provides, in an efficient and reliable fashion, timely information required to manage and monitor the implementation of its activities. Appropriate internal controls are in place and function effectively.

IRRI's financial management structure has been reorganized since the last EPMR. The new Management Services division combines the former divisions of Finance, Human Resources, Procurement and Materials Management Services, Travel Services and the IRRI School. The Panel concurs with the 2007 CCER conclusion that there is no conflict of interest resulting from the finance and procurement functions reporting to the same Director.

In the area of finance, the Management Services Director manages a sustainable financial model; provides effective and efficient support services; acts as a Treasurer for the Board, and as a Secretary for the Finance and Audit Committees. The Financial Planning & Reporting Unit (12 staff) handles financial reporting and budgeting, and assists in the preparation of plans and proposals for restricted grants. The Financial Operations Unit (21 staff) manages treasury functions and cash management, payroll functions, accounts receivable management, accounts payable, property and other asset management, and management of NRS Retirement Funds. Both units are headed by well-qualified senior managers reporting to the Director for Management Services.

NRS Retirement Fund. The Panel notes that in response to the recommendation of the CCER, IRRI has undertaken an actuarial assessment to clarify the risk exposure of IRRI in the NRS Retirement Fund, and is satisfied that this is adequate. The Panel suggests that IRRI explore the possibility of offering a choice of retirement packages.

Outsourced services. The Panel notes that IRRI has implemented the recommendation of the CCER on regular cost analysis of outsourced personnel.

Panel's Assessment

Since the last EPMR, IRRI has maintained excellent financial management competencies and integrity, and is in a healthy financial position. The Board of Trustees has responded appropriately to increased expectations for Board policies and practices for oversight of financial matters. IRRI is in full compliance with CGIAR Financial Guidelines, and has implemented improved risk management and internal controls practices.

In Summary:

i) The budgeting system of IRRI adequately controls the use of resources.
ii) The budgeting system serves well as a planning tool for allocating resources to units and projects,
iii) IRRI's management has satisfactorily controlled the level of operating expenses for the period 2002-2007; and
iv) The Financial Services-related recommendations of the 6th EPMR and the 2007 CCER have been satisfactorily implemented.

7.2.3 Research Management

Matrix management

Research management is a primary responsibility of the DDG – Research. At the operational level, IRRI's research management structure is a matrix consisting of eight Operational Units (OUs) and the seven Programs as defined in the Medium Term Plan. Operational Units are comprised of three research Divisions (PBGB, CESD and SSD), three research and support units (Genetic Resources Center, CRIL and GQNPC) and two quasi-administrative groups (Training Center and IPMO). In general terms, OUs are charged with ensuring high quality science. They recruit staff, provide a physical and social home for staff, maintain scientific standards, ensure equipment and labs operate at an appropriate level and charge Programs for these services. Programs are responsible for conducting relevant thematic research for development under a team structure composed of appropriate disciplines. Program heads coordinate this research and manage Program budgets. Individual staff performance plans and annual evaluations are conducted jointly by the OU and Program Leaders. Collectively, the heads of OUs and Programs make up the IRRI Program Committee (IPC) that meets monthly and is chaired by the DDG-R.

Matrix management was introduced at IRRI in the late 80's to promote coherence and multidisciplinarity in a complex program. The matrix structure is intended to facilitate project development, quality and relevance of science, communication, resource allocation, staff mentoring, and staff evaluation. The Panel notes a number of challenges facing IRRI's research matrix as it currently operates.

The size of the IPC: At 15 members, with the consequent challenges for regular attendance, relatively infrequent meetings, and a lack of agility in deciding research resourcing at the scientist level, the IPC appears to be a cumbersome mechanism for decision-making. Decisions on resource allocation and harmonization are sometimes reached slowly.

Unequal size and scope of the various units means that the discipline-by-program matrix is not fully achieved.

The overlay of another dimension imposed by restricted funding of projects, (and especially the projected mega-projects) increases the complexity of decision-making.

Performance evaluation: For some staff, having more than one supervisor introduces confusion, mixed messages and discontent.

While these challenges could be addressed by continuous adjustment of the matrix, the Panel encourages IRRI to open the question of the matrix, possibly with the assistance of a CCER. As a minimum adjustment, it strongly suggests that the IPC agenda be managed in such a way that it meets the above needs more effectively.

The Panel recommends that IRRI review and, if necessary, modify its research management structure to promote effective and efficient project development, quality and relevance of science, resource allocation, communication, staff mentoring and staff evaluation. The strength of IRRI's research management matrix has been in its ability to capture both the coherence of programs and the fostering of communities of practice in disciplinary divisions and operational units. If the matrix is to be modified substantially, IRRI will want to ensure that a new structure does not dilute the disciplinary critical mass which contributes to the quality of science.

Project development and monitoring

As restricted funding has increased, the need to develop and monitor individual projects funded by a variety of donors has increased. At present IRRI manages a portfolio of 152 grants, ranging in size from US$4000 to US$19.8 M. IRRI's mechanisms for project development are efficient and do not create undue demands on scientists. Ideas are usually generated by scientists through brainstorming at annual planning sessions. They then develop the idea in collaboration with a staff member from the Program Planning and Coordination Unit (PPC) under the DPPC. This unit provides comprehensive institutional support during project development, and current information on donor relations and intentions. After a nominal budget is developed by lead scientists the process is passed to PPC staff who work with Finance to ensure the budget meets donor and IRRI standards, and that the proposal is drafted in donor-approved formats. Once signed, the monitoring of progress towards goals is shared by the PPC and the executing scientists according to the donor's protocol. PPC generates automatic notices to the Project Leader and to Finance when reports from each project come due. In general, the Panel was impressed by the efficiency with which project development and management takes place, and commends the DPPC staff for their effectiveness.

7.3 Accountability

As an international institution funded by diverse donors within and outside the CGIAR system, IRRI operates in multiple reporting contexts simultaneously. This fact, in combination with the increased emphasis on accountability arising over the last decade in all public institutions, has led to the establishment of a number of interlocking accountability frameworks at IRRI.

External Reviews

Since its establishment in 1960, IRRI has been reviewed comprehensively approximately every five years through the External Program and Management Review (EPMR) process of the CGIAR. EPMRs, of which this is the seventh, are commissioned by the Science Council (or equivalent) and reviewed by the Executive Council of the CGIAR. After determining its response to the recommendations of these reviews, the Board establishes a follow-up plan for implementation by IRRI management. The status of responses from the previous review serves as a starting point for the subsequent review.

The Board of IRRI also commissions Center Commissioned External Reviews (CCER) of particular aspects of IRRI operations, with a similar follow-up system. In the period since the last EPMR IRRI has undertaken 7 CCERs (Management Services, Operations Management Unit, Social Sciences Research, Analytical Service Laboratory, IRRI Biotechnology Program, IRRI- Korea Research Program, Models of Staff Placement). As noted in Chapter 6, while there has been some unevenness in these reviews, in general they have provided useful information to Board and Management, and have served as the basis for modifications to structure and program.

Individual Project Monitoring and Evaluation Reporting

As the proportion of IRRI operations financed by restricted grants has grown, there has been increased requirement for project-specific monitoring and evaluation. The Program Planning and Coordination Unit supports the research units in meeting reporting deadlines and fulfilling evaluation requirements with a very wide range of reporting specifications. Donors have expressed satisfaction with the quality and timeliness of project reports.

CGIAR Performance Measurement Indicators

Since 2004, the CGIAR has required annual reporting on a comprehensive set of performance measurement indicators. The Institute's report on these indicators is in turn verified by the CGIAR Office and in some instances the Science Council. In some cases a number of iterations have been required to reach an agreed assessment. This process is very time-consuming.

External Audit

IRRI's financial statements are audited annually by an external audit firm of international standing, reporting to the Board through its Audit Committee. The audit contract is tendered every five years, and confirmed annually by the Board, based on performance and fees. Price Waterhouse Coopers expressed unqualified opinions on IRRI financial statements in 2005, 2006, and 2007.

Internal Audit

IRRI participates with other CGIAR centers in financing the Internal Auditing Unit (IAU) of the CGIAR System Office, which provides ongoing internal audit services. The unit staff is hosted at IRRI. Audits are planned and implemented on a three year planning cycle. In addition to carrying out approximately 12 internal audits per year, the unit also tracks the status of implementation of audit recommendations. The Board receives reports on the status of implementation every six months. In March 2008, a comprehensive report on implementation of 759 recommendations from 89 audits undertaken from 2000-2007 concluded that overall "*IRRI management and staff have been responsive to the audit recommendations. The Institute has been proactive in seeking continuous improvement to the way they do things through participation in the system-wide initiatives such as gene bank risk management, compliance with system-wide financial guides and adoption of IAU's good practice notes.*"

Risk Management and Quality Assurance (RMQA)

It is the responsibility of the Board to ensure that an appropriate risk management policy framework is implemented at IRRI. Since 2004, IRRI has undertaken a thorough process to introduce a system of risk management and quality assurance (RMQA) based on the Australia-New Zealand Risk Management Standards (AS/NZ 4360:2004), the CGIAR Internal Auditing Unit's Good Practice Note on Enterprise Risk Management, and other relevant standards. The purpose of the IRRI RMQA system is to identify and manage risks to IRRI operations. The Risk Management policy formally adopted in September 2008 provides an excellent framework through which to accomplish this goal.

IRRI RMQA policy development and implementation processes are overseen by an RMQA Steering committee comprised of IRRI senior staff and supported by the RMQA Senior Manager, who reports to the Director General. One staff member in each operating unit is identified as a Risk Assessment officer. The RMQA manager guides the implementation of a two-part iterative process: a risk analysis compiled across all units and levels of the institute, and a risk management strategy for mitigation and monitoring. In collaboration with the team of RMQA officers, the RMQA Senior Manager develops risk management awareness, training, and monitoring procedures for the institute. The RMQA process has led to the adoption of new initiatives in Environmental Management System planning, and business continuity planning, and fostered a risk assessment mindset more generally at IRRI. Quality Assurance initiatives and processes include training in data management, calibration of balances, temperature verification of ovens, use of standardized research notebooks, and monitoring of soil and water in the IRRI farm. The Board receives an annual status report on RMQA implementation, and issues a

Statement on Risk Management and Internal Controls to donors. As the implementation of the RMQA framework moves beyond the start-up phase it will be important to maintain momentum. Implementation is to be reviewed on a regular basis by the Internal Auditing Unit.

Panel assessment of IRRI accountability framework

The Panel considers that IRRI has adapted well to the sharply increased external accountability requirements of the last five years, and manages its internal audit system very well. The accountability framework in place is exemplary.

The Panel encourages IRRI to ensure that, to the extent possible, the various accountability measures are dovetailed and linked, to ensure that scientists and administrators are not required to duplicate efforts in meeting accountability standards.

7.4 Managing Future Growth

Infrastructure

Short term needs: In the next few years housing for an additional (20 nearly) IRS will be required, though IRRI is encouraged to look at housing alternatives off campus rather than adding additional staff housing. The most pressing needs in research relate to phenotyping facilities, and these may be an appropriate mix of modern screen houses, controlled environment facilities and appropriate field facilities at Los Baños. These should include facilities that permit managed stress treatments in the field at Los Baños and selected hot spots in Asia and ESA. Laboratory facilities are generally in good working condition and the GAMMA laboratory and transgenic facilities have recently been refurbished. For large capital items of equipment IRRI is encouraged to consider outsourcing or leasing rather than outright purchase. The Experiment Station at HQ will need significant upgrading of basic field equipment to bring it to a level where full cost recovery can sustain an up-to-date equipment fleet.

Longer term needs: As IRRI plans its research program over the next decade and beyond, it must deal with a large and ageing infrastructure in a climate that accelerates maintenance needs. IRRI will have to choose carefully among the acquisition of new capital assets needed to meet its contractual obligations, targeted refurbishing of existing facilities, and selective decommissioning of older unneeded facilities. Depreciation charges paid to reserves as per CGIAR financial policies have proven totally inadequate for this process. IRRI management have developed a tentative list of the cost of modernizing the current research facilities that totals US$150 M, and the Panel believes this to be a realistic estimate of the needs over the next 10-20 years. This requirement has been a driving force behind the establishment of the IRRI Fund. If this proves inadequate for the task, then IRRI will have to depend wholly on full cost accounting under the proposed megaprojects to provide for capital replacement. If IRRI is to remain a center that conducts scientific research of the highest standards, and attracts and retains high quality young research staff in areas such as genomic sciences, constant upgrading of facilities is a necessity. **The Panel recommends that IRRI prepare a comprehensive plan for the refurbishment and redevelopment of its Los Baños and other sites, and embark on a resource mobilization strategy which includes the judicious use of the reserves, as well as a fundraising campaign to provide the additional capital investment required.**

Staff

As noted above, in response to significant expansion in restricted project funding, IRRI is facing very rapid growth in numbers of international staff, the majority of whose contracts will be financed by restricted grants. IRRI has begun to use proactive internet-based recruitment approaches, and 'headhunters' in order to meet the demand. A corollary of this growth will be the need to offer career incentives to high quality staff through training and retention between contracts. In addition, site planning will need to review the housing stock against future needs.

IRRI Fund

As part of its effort to explore alternative resource mobilization approaches, IRRI management commissioned a study in 2006 by the fund-raising consultant, Brakeley Ltd. The study assessed the potential levels of new support in Asia for rice research and related issues of climate change, poverty alleviation, food security and capacity building. It also examined the feasibility of IRRI mounting a campaign to develop such new sources.

The consultants' final report, presented to the Board in April 2007, indicated that significant potential exists for fund-raising from private sector philanthropic sources and that IRRI has the capacity to undertake such a campaign. In response, the Board approved the creation of the IRRI Development Office, which has taken the lead in establishing a free-standing foundation, the International Rice Research Institute Fund.

Legally incorporated as a registered charity in Singapore in January 2009 (and, it is anticipated, in Hong Kong), the Fund will serve as a vehicle to support IRRI fundraising campaigns. Oversight of the Fund policy and operations falls under the responsibility of an independent Board of Trustees, of which the majority is formed by the Executive Committee of the IRRI Board. The start-up costs and initial operating costs of the Fund have been met by designated reserves and support from the Government of Singapore.

7.5 Managing Relationships

Host Country

IRRI's relationship with the host country, the Philippines, is strong. This relationship is reinforced by the appointment of two ex-officio members on IRRI's Board of Trustees (the Secretary of Agriculture of the Republic of the Philippines, and the President of the University of the Philippines), and by an ongoing partnership with the Philippines Rice Research Institute (PhilRice). In 2008, after many years' negotiation, the host country agreement has been finalized and ratified by the Senate. The Panel notes that changes in the structure and responsibilities of the Board implied by the CGIAR Change Process may have an impact on both the charter agreement and the host country agreement. IRRI's relations with government offices and agencies are coordinated by the Community and Host Country Relations Office in the office of the DDG-Operations Services.

Community Relations

The Community and Host Country Relations Office also takes responsibility for IRRI's activities in support of local development. IRRI is proactive in seeking to relate constructively to the community surrounding the headquarters site at Los Baños, and supports such activities as medical missions, equipping public schools through computer donations, training in emergency response for fire and natural disasters, and various livelihood projects. IRRI also supports the rural development initiatives of the Los Baños Science Community Foundation. As many IRRI employees are affected by these community endeavors, the Community and Host Country Relations Office has recently been merged with the Employee Relations Office of Human Resources Services.

Visitors

IRRI welcomes over 40,000 visitors every year, and hosts a large number of meetings, seminars and workshops. IRRI operates the Rice World Museum, which receives many schoolchildren and tourists as well as official visitors. IRRI has recently integrated the events planning and visitors' service into the Events and Visitors' Office, and in a separate office, combined responsibility for organizing exhibits with the management of the Rice World Museum.

Donors

IRRI's work is financed by 63 donor organizations, including multilateral agencies, the cooperation programs of member countries, and private foundations. Financial support to IRRI in 2008 totaled over US$ 37 M, of which 34% was provided for unrestricted use, and the remainder restricted to particular programs and projects. Significant contributions are made by developing country collaborators of IRRI. In telephone interviews with a number of donor representatives, and through the Stakeholder Survey, the Panel found a high rate of satisfaction with IRRI's work. IRRI is perceived as focused and competent. In particular, donors expressed appreciation for the strong leadership offered by IRRI's senior management, for the clarity of IRRI's current Strategic Plan, and for the initiatives taken in partnership with WARDA to support rice research in Africa. As noted elsewhere, donors appreciate the timeliness and precision of IRRI project reporting.

The Panel notes significant differences in perspective among donors - while some donors are clearly committed to the long term well-being of IRRI as a development research institution, other donors are focused primarily on IRRI as a capable supplier for particular pieces of work. This has implications for IRRI's approach to different donors, and it underlines the overriding importance of clarity in priority-setting and program planning. This will also be important as IRRI continues to engage and develop the support of large developing country donors such as China, India, and Brazil. Donor representatives noted that the CGIAR Reform process is likely to have a significant impact on the organization of IRRI's work, and expressed the view that IRRI's participation and leadership will be a critical element of success.

8 THE FUTURE OF IRRI

The year 2009 is being celebrated as the two hundredth anniversary of Darwin's birth. The significant attention this attracts around the world is evidence of humanity's debt to dedicated and courageous scientific research. Equally important, Darwin's work reminds us all of our common heritage and our shared future. The world faces daunting challenges in feeding itself and preserving the environment for future generations, and agricultural research of the highest quality will be required in response. The science may often be conducted in seemingly isolated laboratories and fields, but it will only make an impact on our increasingly interdependent world if it is directed toward a common purpose.

There is no better example of the value of comprehensive, pragmatic, well-organized research than the history of the international agricultural research centers, a history whose first page was written by IRRI 50 years ago and whose narrative continues to feature IRRI and its accomplishments. This document summarizes a review of the past five years of IRRI's activities. In many ways, this was a relatively easy task. IRRI has made many important contributions during that period, and these are readily accessible to any observer. Similarly, the quality of IRRI's work and the openness of its staff make it fairly straightforward to suggest ways in which an excellent institution can be made even better in the next five years.

But the ease with which one may predict a future full of promise for IRRI must be tempered by the recognition that the future is also full of uncertainties. Neither the Panel nor the Institute can predict with certainty what will transpire in the coming decade; several of the major events affecting IRRI in the past five years were not predicted by the previous EPMR. It is better to focus advice on evaluating and responding to trends rather than being doctrinaire. Thus this final chapter attempts to suggest some of the major factors in IRRI's external and internal environments that must be addressed and to identify the qualities of IRRI that will help it achieve the flexibility, agility and resilience to meet these challenges.

8.1 The external environment

There are a number of external factors that contribute to the uncertainty that IRRI must face in the next decade and beyond. Many of these are reviewed in Chapter 2.

Resource degradation and scarcity are among the most serious challenges. This review has particularly emphasized the importance of water, as competing demands will decrease its availability and increase its price, and climate change will bring significant changes in water availability. Rice is a major consumer of water resources and even a small reduction in water use will have a large impact on resource conservation. The challenge is so serious that this review suggests that water should be an organizing principle for a range of research and development activities.

Climate change is an acknowledged reality. Temperatures will rise significantly, increasing the risk of drought and heat stress while the increase in night-time temperature will reduce rice yield in the tropics. Extreme weather events will likely become more frequent and unpredictable. Rainfall will become more variable, requiring more resilient rice varieties and cropping practices. Increased flooding will call for access to better salinity and submergence tolerance. Climate change will bring a host of other changes to rice fields, such as shifts in the balance and incidence of pests, their predators, and diseases.

On the positive side, we can expect significant advances in agricultural science, in areas such as genetics and genomics, physiology and bioinformatics, leading to predictive modeling of rice performance in different environments and enabling the phenotype-genotype relationship to move from a description of genotype x environment interaction to gene x environment interaction.

The nature of agricultural research and the delivery of technology will also continue to change. One of the most significant factors will be the role of the private sector. This includes the increasing dominance of private technology development, especially in fields such as gene discovery and transgenics; and the expanding role of the private sector in technology delivery, particularly in the seed sector. IRRI has already had to accommodate to these trends, in the way that it acquires advanced technology and the way that it organizes the provision of its rice hybrids. The private sector brings welcome resources to agricultural technology development, but its incentives are not always congruent with those of an institution like IRRI, which must be vigilant that it is developing and providing IPGs that ensure that smaller NARS have access to the resources they need and that small and medium enterprises are not overwhelmed by global corporations.

Economic changes will also affect the nature of rice research. The recent price shock in grain markets that particularly affected rice is a good example. IRRI's capacity to offer a cogent analysis and to explain how this calamity illustrated the need for strong support for rice research earned IRRI high marks. IRRI is further developing its capacity to anticipate further shifts in rice price. It is unlikely that rice prices will return to the low levels of the early years of this millennium, but rice price may or may not be the most salient justification for investment in rice research in the next decade. IRRI needs to be sure that it can articulate a comprehensive agenda for poverty-focused rice research that contemplates, but is not limited to, the vagaries of rice market behavior.

IRRI was established fifty years ago to address an apparently overwhelming burden of poverty and malnutrition. There have been significant gains since that time, but unacceptable levels of poverty and hunger are still with us. However, rural economies and the role of agriculture have shifted in the intervening years, so that although agricultural technology is still an essential ingredient, some of the old formulas are no longer relevant. Thus IRRI must continually assess changing rural livelihoods and the realities of the urban poor in order to ensure that technology development addresses today's needs. In addition, patterns of change in Asia and Africa are significantly different, placing IRRI on a steep learning curve as it embarks on African partnerships.

8.2 The internal environment: the organization of agricultural science

Just as IRRI must be prepared for changes in the external environment, it will also have to adapt to some factors that are closer to home and that determine how it organizes its research programs. These include changes in the type and character of its funding, the need to maintain its infrastructure and invest in the future, continuing growth and evolution of its NARS partners, and increasing attention to the governance and accountability of international agricultural research.

IRRI has had to adjust to the continuing decline in the availability of unrestricted funding. The appearance of several new donors and more imaginative projects, in both upstream areas of fundamental rice biology and downstream challenges of adapting rice technology to the needs of farmers in difficult environments, goes some way to alleviate this constraint. But it is difficult for an institute like IRRI to manage an agile and coherent research strategy without a significant unrestricted budget. The CGIAR Change Process is meant to address this problem but it will be several years until any new pattern of funding emerges. IRRI's engagement will be an important element of the success of the change process.

The conduct of world class research requires excellent infrastructure, not only to meet the needs of ever more sophisticated methods and techniques but also to provide a stimulating and secure environment for the scientists who do the work. The intellectual challenges and working and living conditions must be sufficient to attract the best quality scientists, from post-docs at the beginning of their careers to distinguished scientists later in their careers. This means that IRRI must invest in maintaining the present infrastructure but also plan ahead to accommodate the demands of the next decade's science.

The availability of funding and the ability to access the best science will also determine the future of IRRI's partners, the NARS. Inevitable evolution on both sides of the relationship means that IRRI will have to continually review and renew its partnerships if they are to be productive and equitable.

The governance of international agricultural research will remain an important task. In a world where the majority of the potential beneficiaries of the research have little voice in its conduct, significant responsibilities fall on the shoulders of research governance. It is a challenge to strike a balance between encouraging the creativity and energy of cutting-edge science, on the one hand, and ensuring that its products are effectively marshaled to meet the pressing needs of the world's poor, on the other. IRRI's capacity to produce IPGs that have the widest possible access and application must be one of the key tasks of research managers and governors.

Finally, and perhaps most importantly, the management of agricultural research over the next decade will need to pay careful attention to accountability. The commitment of fifty years ago to support international agricultural research yielded impressive rewards in improving the availability of food for the world's poor. But significant change and growth in developing countries has increased the complexity of agricultural technology's role in poverty reduction. The unequivocal gains of the Green Revolution do not vouchsafe the contributions of today's, and tomorrow's, research. Thus there is a continuing need to ensure that the innovations emerging from IRRI's efforts continue to be delivered to farmers in a way that promotes equitable rural development and that continues to have an impact on the world's poor. Continual monitoring of progress and demonstration of impact is essential.

8.3 IRRI's strengths

IRRI has a series of strengths that will permit it to be resilient and creative in an uncertain environment. IRRI's strengths reside in at least five major areas: its germplasm resources, the human element of its partnerships, its ability to anticipate strategic opportunities in cropping systems and crop management research, its knowledge and information management, and its capacity to exert leadership in rice research.

Germplasm forms the first pillar of IRRI's comparative advantage. It must ensure that the way it tests and develops new varieties addresses the variable and changing conditions and needs of the farmers who depend upon the delivery of new rice varieties. Because of its considerable knowledge of the genetic variation present in the largest collection of rice germplasm in the world, and its location where most accessions can be successfully grown, IRRI is well positioned to pursue evaluation of accessions and allele mining and phenotyping for specific traits. IRRI's comparative advantage is using the genomic information from its own programs and those of others and translating it into tools that NARS and others can use to identify novel genes and gene pools and translate these into breeding practices. The basic genomic information will be shared with IRRI by its partners, and IRRI's primary role will be to establish gene-phenotype associations for traits that are critical to maintaining resilience in the face of future environmental challenges. This review does not attempt to identify what the precise priorities might be, but the recent CCER in Biotechnology suggests that these will be firstly related to water (drought; salinity; submergence) and high yield potential. Other important factors include resistance to pests and diseases (particularly as climate change occasions major changes in pest complexes of rice), as well as grain quality and human nutritional factors.

Partnerships based on personal relationships and common goals are the second pillar of IRRI's strength. The consortium model provides equal status for all partners, and is a suitable vehicle of enhancing future collaboration. IRRI's comparative advantage lies in facilitating the consortia, in organizing meetings and negotiating and managing donor support. Partnerships with northern and southern ARIs are a critically important resource so that IRRI can access new technology, especially in genomics. Traditional links with ARIs in US and European institutions must be maintained, but mutual sharing of genomics information with ARIs in China and India is fast becoming essential for success. Indeed these countries are also now major research providers for rice, and IRRI needs to be aware of them as complementary suppliers of germplasm and technology to IRRI's traditional partners.

Partnerships also entail the training of the next generation of rice scientists for Asia and SSA. While distance learning and the Rice Knowledge Bank will undoubtedly become more important, one of the real strengths of training has been the personal links between IRRI scientists and trainees. While there are declining possibilities for having trainees on campus in courses of reasonable length, innovations in communication technology coupled with a mentoring program of trainees and NARS scientists will help establish and maintain these personal links. Decentralized research programs will also assist in establishing relationships with scientists in the host country and region. If IRRI is to be flexible and responsive in an uncertain future, it is these personal relations that will allow appropriate decisions to be taken and commitments to be made that address emerging needs.

The third pillar of IRRI's strength lies in its crop management research skills and the anticipation of new cropping systems. The changing natural environment described earlier points towards a warmer, drier and more variable crop environment in the next few decades and the changing economic environment will demand increasingly complex crop production regimes. The rice-wheat consortium provides a useful model of how strategic crop management research can be carried out on systems that are in a rapid state of change in response to the need for intensification, cost savings and sustainable productivity. Techniques such as alternate wetting and drying are proving attractive to farmers who pay the full cost of irrigation water. Rice-based cropping systems research for SSA starts at a different level, perhaps focusing initially on appropriate equipment, good water control, and determining the right balance of applied nutrients. A significant proportion of IRRI's technologies in crop management will be transferable to SSA over the next decade, provided IRRI staff modify these appropriately to suit the low input availability, high levels of risk, and lack of awareness of technological options that characterise this region. The capacity to innovate, test, and adapt crop management technology to the changing needs of farmers and the evolving demands of the environment will be an important mark of IRRI's ability to cope with the uncertainty of the coming decade.

The fourth strength of IRRI is its role in information and knowledge management. Technological advance has provided an exponential increase in the amount of information available to researchers and farmers. New research methods, the imaginative use of media, and training activities in the classroom and the field have meant that the information that is harvested can be converted to useful knowledge. IRRI has been a leader in this process. Its role in the Crop Research Informatics Laboratory (CRIL) and the Crop Science Information Resource are excellent illustrations and point the way to further collaborative activities among crop scientists in order to make optimum use of the research information that is being generated. The available information overwhelms even the most sophisticated techniques for synthesis, so the further development of resources such as these requires communication among researchers and a continual revision of priorities. The same may be said of efforts to strengthen farmer knowledge. IRRI's Rice Knowledge Bank has been very successful in assembling a range of information and presenting it in a platform that can be used by extension agents and farmers. Again, flexibility and adaptation are the keys, and the resource requires the commitment of local users to convert it into a carefully focused resource for improving farming practices.

A fifth, less tangible but equally important strength of IRRI is its leadership in rice research. This leadership may sometimes derive from the superiority of its resources and skills, but even when others bring more advanced inputs to the table, IRRI's leadership is evident in its role as an honest broker and as an institution with a capacity to learn and adapt. It may represent the aspirations of a struggling NARS in a small, poor country; organize a network of players who might not otherwise even communicate with each other; stimulate CGIAR partners to more global approaches to rice research; or help encourage access to some of the world's most advanced proprietary technology for the benefit of rice research globally. It is these roles, as friend, facilitator, colleague and advocate, which distinguish IRRI from others. And it is this leadership that IRRI must strive to maintain if it is to help the world respond to the challenges facing rice growers and consumers in the next decade.

ANNEX 1

TERMS OF REFERENCE FOR EPMRs

Objectives and Scope

EPMRs seek to inform CGIAR members that their investment is sound, or recommend measures to make it so. Members of the CGIAR and other stakeholders can be informed whether the Institute is doing its work effectively and efficiently. EPMRs are both retrospective and prospective and help ensure the Institutes' excellence, relevance and continued viability, and the CGIAR System's coherence. Each review is expected to be strategic in orientation and as comprehensive as the situation warrants.

The broad objectives of EPMRs are to: a) provide CGIAR members with an independent and rigorous assessment of the institutional health and contribution of a Center they are supporting; and b) to provide the Center and its collaborators with assessment information that complements or validates their own evaluation efforts, including the CCERs.

The EPMR Panel is specifically charged to assess the following topics:

Mission, Strategy and Priorities

- The continuing appropriateness of the Institute's mission in light of important changes in the Institute and its external environment since the previous external review.
- The policies, strategies, and priorities of the Institute, their coherence with the CGIAR'sgoals (of poverty alleviation, natural resources management, and sustainable food security), and relevance to beneficiaries, especially rural women.
- The appropriateness of the roles of relevant partners in the formulation and implementation of the Institute's strategy and priorities, considering alternative sources of supply and the benefits of partnerships with others.

Quality and Relevance

- The quality and relevance of the science practised at the Institute.
- The effectiveness of the Institute's processes for planning, priority setting, quality management (e.g., CCERs, peer reviews and other quality and relevance assurance mechanisms), and impact assessment.

Effectiveness and Efficiency of Management

- The performance of the Institute's Board in governing the Institute, the effectiveness of leadership throughout the Institute, and the suitability of the organization's culture to its mission.
- The adequacy of the Institute's organizational structure and the mechanisms in place to manage, coordinate and ensure the excellence of the research programs and related activities.
- The adequacy of resources (financial, human, physical and information) available and the effectiveness and efficiency of their management.
- The effectiveness of the Institute's relationships with relevant research partners and other stakeholders of the CGIAR System.

Accomplishments and Impact

- Recent achievements of the Institute in research and other areas.
- The effectiveness of the Institute's programs in terms of their impact and contribution to the achievement of the mission and goals of the CGIAR.

ANNEX 2

THE 7TH IRRI EPMR PANEL (WITH OUTLINE BIOGRAPHIES)

The Panel was:

Greg EDMEADES, Chair of the Panel (New Zealand)

Shu FUKAI (Japan/Australia)

Martha TER KUILE (Canada)

John SNAPE (UK)

Robert TRIPP (USA)

Nicolas DROSSOS, Finance consultant (Greece)

Summary biographical information of Panel members:

Name: EDMEADES GREG

Nationality: New Zealand

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Position: Consultant based in New Zealand

Experience: 2005-present:Consultant, based in New Zealand; 2001-2004: Research Fellow, Pioneer Hi-Bred International, Waimea, Kauai, Hawaii, responsible for abiotic stress tolerance/trait development in Woodland CA, and Viluco, Chile; 1999-2000: Senior Scientist, Pioneer Hi-Bred International, Waimea, Kauai, Hawaii, responsible for Genetics Winter Nursery; 1998: Maize Physiologist, Maize Program, CIMMYT; 1997:Interim Director, Maize Program, CIMMYT; 1989-1996: Maize physiologist/agronomist and Coordinator, Maize Agronomy and Physiology Subprogram, CIMMYT, Mexico. Served as one of three subprogram leaders. 1991-1992: Visiting Research Fellow, Plant Environment Laboratory, University of Reading,England, while on Study Leave from CIMMYT;1985 - 1988: Maize physiologist/agronomist, Leader of the Maize Physiology Program, CIMMYT, Mexico; 1978 - 1985: Maize Agronomist and Joint Coordinator, Ghana Grains Development Project, Kumasi, Ghana, employed by CIMMYT (from 1979-84 located in Ghana; 1984-5 on study leave in New Zealand at the Plant Physiology Division, DSIR, Palmerston North); 1976-1978: Post Doctoral Fellow in Crop Physiology and Breeding, Maize Program, CIMMYT; 1972 - 1976: Graduate Research Assistant, Crop Science Department, University of Guelph, Canada;1970 - 1972: Lecturer, Agronomy Department, Massey University, New Zealand. Member of professional societies. Winner of the award Fellow, Crop Science Society of America (CSSA) in 2004. Author of 50+ peer-reveiwed publications related to improving the resource use efficiency of agricultural systems at the farm level and developing genetic solutions to environmental constraints such as drought. Member, 6th IITA EPMR 2007.

Name: FUKAI SHU

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Position: 2002-Present, Professor in Crop Physiology, The University of Queensland, Brisbane, Australia.

Expertise: Natural Resources Management, Crop physiology particularly tolerance to water an low temperature stresses including drought resistance in rainfed lowland rice.

Education: PhD in Agronomy, The University of Adelaide, 1975. BAgrSc, The University of Tokio, 1969.

Experience: 1992-2001: Associate Professor in Crop Physiology. 1986-1991: Senior Lecturer in Crop Science. 1978-1985: Lecturer in Crop Agronomy. 1976-1978: Tutor in the School of Biological Science, Macquarie University, Sydney. 1975: CSIRO, Postdoctoral fellow at the University of California, Davis, USA.

External Review of CIMMYT (5TH EPMR) and External Review of IRRI project funded by the Japanese Government, 2005. He has led several research projects and published over 100 journal papers in applied crop physiology and breeding

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Name: TER KUILE MARTHA

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Position: Minister, Bloor Street United Church, Bloor Street, Toronto, Ontario.

Expertise: Agricultural economics

Education: Currently, at dissertation stage of Ph.D.program in Ethics, Faculty of Theology, Saint Paul University, University of Ottawa; M.A. Saint Paul University, University of Ottawa, Ethics (Thesis: Thinking about Poverty: an enquiry into ideas), 2000; M.Div.Queen's Theological College, Queen's University, 1998; M.Sc. University of Guelph, Agricultural Economics (Thesis: Determinants of Maize Sales by Smallholders in Kenya), 1984; B.A. History, University of Toronto, 1973.

Experience: 2002-2007: Minister, Bells Corners United Church, Nepean, Ontario.1998- 2001: Minister, Zion United Church, Apple Hill, Ontario. 2000, 2002: Sessional lecturer, Saint Paul University. "Flourishing: an introduction to Virtue Ethics".1996-1997: Intern Minister, Kanata United Church, Kanata, Ontario. 1993-1995: Head of Aid, Guatemala and El Salvador Program, Canadian Embassy, Guatemala (CIDA position). 1991-92: Director, Programming and Systems, Multilateral Branch, Canadian International Development Agency (CIDA). 1990-91: Section Head, Commonwealth/Francophonie/Agricultural Research, Multilateral Branch, CIDA. 1987-90: Senior Program Officer, Consultative Group on International Agricultural Research, CIDA. 1986-87: Senior Program Officer, United Nations Programs, Multilateral Branch, CIDA. 1975-1977: Junior Professional Officer, United Nations Development Program, Nairobi, Kenya. 1973-1975: Program Officer, Nigeria and Sierra Leone Program, Commonwealth Africa Division, CIDA.

Name: SNAPE JOHN WILLIAM

Nationality: United Kingdom

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Position: Head of Crop Genetics, Department of Crop Genetics, John Innes Center

Expertise: agronomy, cereal development and biotechnology (wheat), quantitative and applied genetics, plant breeding

Education: 1967-1970, Birmingham University, England, School of Biological Sciences, BSc 1st Class Honours, Biological Sciences 1970-1973, Birmingham University, England, Genetics Department PhD Genetics. Thesis Title: Population and Biometrical Genetics of *Arabidopsis thaliana.*

Experience: 1973: Appointed Higher Scientific Officer, Band 6 (Plant Geneticist), Cytogenetics Department, Plant Breeding Institute, Cambridge, UK. 1985-86: Sears Monsanto Visiting Professor, Dept of Agronomy, University of Missouri, USA. 1990-: Plant Breeding Institute Research Departments transformed into the Cambridge Laboratory, Institute of Plant Science Research and relocated to the JI Center, Norwich. 1992-: Head, Cereals Research Department, John Innes Center. 2001-: Head, Department of Crop Genetics, John Innes Center. Over 160 publications in the fields of quantitative genetics, plant breeding methodology, cereal genetics and cereal biotechnology. Managing Editor of Euphytica. He served as a member of review panel, Plant Breeding International, Biotechnology programme (1995); External Reviewer, Wheat molecular Marker Program, Grain Research & Development Corporation, Australia (1999).

Name: TRIPP ROBERT

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Position: Latest position since 1994: Research Fellow, Overseas Development Institute, (ODI) London.

Expertise: Social anthropology, applied agricultural economics, economics, economic analysis of agricultural research, human nutrition, farming systems, on-farm research, NRM, Seed regulations, seed systems, agricultural research and extension

Education: Ph.D. in Social Anthropology, Columbia University (1978); M.S. in Human Nutrition, Columbia University (1972); B.S. with High Honours in Chemistry, University of Michigan (1966).

Experience: Latest position since 1994: Research Fellow, Overseas Development Institute, (ODI) London. 1982-89: International Staff, Economics Program, CIMMYT. Coordination of CIMMYT Economics training activities, including teaching, course design and training materials development. Responsible for Ecuador, Ghana, and Turkey; 1981-82: Associate Scientist, Economics Program, CIMMYT. Assigned to Andean Regional Program, Ecuador. Development of an on farm research program. Responsible for surveys, experimental design and management, dietary studies; 1978-81: Postdoctoral Fellow, Economics Program, CIMMYT. Assigned to Andean Regional Program, Ecuador. Development of an on farm research program. Responsible for surveys, experimental design and management, dietary studies; 1978: Consultant, Study of private voluntary organizations in Kenya, Development Alternatives Inc., Washington, D.C.; Field experience in adaptive agricultural research, farm survey design and analysis and in research institutional issues. Author/co-author of about 20 journal articles, book chapters, and books related to anthropology, agricultural development, and agricultural research. Also, author/co-author of abut 10 reports and working papers related to agricultural development. Member, 6th IITA EPMR, 2007

Name: DROSSOS NICOLAS

Nationality: Greece

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Email: nicolas.drossos@verizon.net

Position: ND Finance, (Investment Advice), November 1994 to March 1997, Financial Management Specialist Paris, France. The Advisor's Group (Stock Broker, Ameritas-Acacia Group), April 2000 to November 2002, Financial Analyst, Bethesda, Maryland-USA

Expertise: Financial and Investment Analyst with strong financial management skills, extensive international background and strong research experience, specialized in fundamental, sell-side and buy-side analysis for institutional customers, with a particular interest in the building materials, construction, utilities, and telecommunication sectors, having achieved over 60 comprehensive professional and academic papers on specific markets, industries and companies.

Carried out project and sector related tasks including: Project design concept; Costing and Financing Arrangements; Key Monitoring Indicators, Institutional Arrangements and Set-Up, Operational Manual and Flow of Funds, involving professional and academic skills related to: value-based, financial and strategic management, project and cost management, and micro-finance.

Education: University of Maryland, Master of Science in Management, Dec. 2002(Financial Management Specialization). University of Maryland, Graduate Certificate in Financial Management, May 2002. Arts et Métiers, Paris, France, Financial Analysis Certificate,1990-1991. Didacta Institute, Athens, Greece, Accounting Training, 1982-1983. University of Athens, Greece. Bachelor's Degree in Political Science, 1978-1982. University of Maryland: MBA Program.

Experience: Chartered Financial Analyst (CFA), Program Assessment, World Bank, Brazil.

ANNEX 3

STRATEGIC QUESTIONS FOR THE 7TH EPMR OF PANEL AND AN IDENTIFICATION OF WHERE THEY ARE ADDRESSED IN THE REPORT.

Several of the Strategic questions posed have more than one part and readers are directed to the relevant section of the report to find a discussion of these different parts:

1. A recent (late 2007/2008) surge in cereal and rice prices globally and in IRRI's target countries presents quite a different scenario for rice farming from that considered at the time of the 6th EPMR. ***Addressed in sections:*** *1.3, 2.2, discussion of Program 7 in Chapter 3, discussion of social sciences in Chapter 3.*

What will IRRI change in response to this changed external environment? **Addressed in section:** Recommendation on social sciences, Chapter 3; Chapter 8 on the external environment.

What expanded roles does IRRI see for the private sector in Asia and what research could IRRI devolve to that sector? ***Addressed in section:*** *"the private sector" in Chapter 2, section 4.5 and box 4.1 on Hybrid seed in Chapter 4.*

2. Is IRRI correctly positioned within the overall CGIAR effort in rice research? **Addressed in section:** 1.2 and 1.4, section 2.4 and Chapter 4 especially sections 4.3.1 and 4.3.2.

Are the relationships with CIAT and WARDA appropriate and effectively handled and what is IRRI's niche in Africa? **Addressed in sections:** 4.3.1 and 4.3.2, and the Panel recommendation on Africa in relation to Program 3 in Chapter 3.

3. What aspects of IRRI research have been devolved to the stronger NARES in the Asian region? What more devolution is planned within the next 5 years? ***Addressed in section:*** *see Achievements section of Chapter 6 and section 4.1 (through to 4.1.5).*

How has this changed the staffing profile of IRRI? **Addressed in section:** section 4.2, and the recommendation on country office management and the IPMO relate.

4. What gains have been achieved in the rice - based uplands attributed to IRRI research on rice? What are the anticipated gains over the next 5 years and how will IRRI measure the achievement within the next 5 years? What is the global allocation of CGIAR research to upland rice systems (as distinct from rainfed rice systems) in Latin America, Africa and Asia and what opportunities exist for greater spill over among the regions in terms of improving the processes of adaptation to upland (rainfed) systems? Which regional program—IRRI, CIAT or WARDA – has the greater capacity to undertake the strategic research for the upland systems? ***Addressed in section:*** *Program 1 section of Chapter 3, the specific box 3.2 on the "Challenge of upland rice" in Chapter 3 and section 4.3.5.*

5. What have been the gains in the rainfed rice systems of Asia linked to rice research by IRRI? What are the expected gains over the next 5 years and how will they be measured? To what extent are the yields of the rainfed rice systems limited by factors other than water and is the research of IRRI and its CURE partners targeted to understanding the limiting processes? ***Addressed in section:*** *Section 2.3.6, Discussion of Program 1 in Chapter 3 in which there is a section on CURE, section*

4.1.3, Center accomplishments in section 6.3.

6. IRRI has a leading role in three continuing Challenge Programs. The 6th EPMR made recommendations encouraging IRRI to intensify its research approach to functional genomics and to productivity in the face of diminishing water supplies. What has been the role of Challenge Programs in meeting these two recommendations and are the two areas being adequately addressed by IRRI's total research portfolio and partnerships? ***Addressed in section:*** *4.3.3. Water is addressed in the box 3.5 "Rice and water" in Chapter 3 and the related Panel recommendation. Functional genomics is considered in relation to Program 5 and the Genetic Resources Center in Chapter 3 and the response to the Biotechnology CCER, section 6.4.*

7. Does the new platform for dissemination of hybrid rice meet the IPG requirements for CGIAR product dissemination? **Addressed in section:** section 4.5 and the specific box "Hybrid seed – issues in managing the HRDC" and the associated Panel recommendation on an approach to pursuing the HRDC .

What is the future of the INGER as a means of safe sharing of rice germplasm among collaborators in light of the changes in IP policies of some of the major national rice research providers such as India, Thailand and China? Has the movement of germplasm been restricted (over the last 10 years) and what might be the consequences for IPG research? ***Addressed in section:*** *Discussion of Program 2 in Chapter 3 and Section 4.1.1.*

8. IRRI has been actively engaged in collaborative research in the rice - wheat consortium and conducts work increasingly on rice systems rather than just rice farming per se.

Are the strategic underpinnings for the various research approaches to agricultural system improvement adequately identified and followed through? ***Addressed in section:*** *Discussions of programs 1 and 2 in Chapter 3, and in Box 3.4 on "Precision phenotyping" and associated panel recommendation on multilocation testing and phenotyping. The evolution of the RWC is noted in section 4.1.4.*

9. Are the arrangement, scope and depth of IRRI's social science expertise adequate for the Institute's role currently and in the future? ***Addressed in section:*** *Discussions of Program 7 and the Social science division in Chapter 3 and the associated Panel recommendation on social sciences at IRRI.*

10. IRRI has more recently integrated its disciplinary research on pest science (including ecological management and biological control) into a broader genetic resources program. How has that move strengthened IPM outcomes? Has a broad disciplinary approach to pest management been maintained? ***Addressed in section:*** *See the discussion on the Plant Breeding, Genetics and Biotechnology Division in Chapter 3 and the associated Panel recommendation on IPM.*

11. There has been a turn over in senior management since the last EPMR. Does the Panel consider this an appropriate time to consider alternative organizational arrangements for Center and research management, and indeed are such changes warranted to meet IRRI's needs and aspirations? ***Addressed in section:*** *See introduction to Chapter 3 and section 7.2.3 and the associated Panel recommendation.*

12. Has the IRRI Board dealt adequately with issues of risk, liability and quality assurance of staff performance raised in the 6th EPMR? ***Addressed in section:*** *6.1.6 and 7.3.*

13. Following the formation of the IRRI - CIMMYT Crop Research Informatics Laboratory how does IRRI (and its Center partners) intend to fulfill the vision of having the three mandated crops – rice, maize and wheat – in a common International Crop Information System (ICIS) structure as rapidly as possible, and to maximize its impact with NARES? ***Addressed in section:*** *See discussion of Program 6 and the CRIL under Research and Support units in Chapter 3, Chapter 8 under strengths.*

14. How does IRRI expect to contribute to the climate change agenda and to provide assistance to NARES? **Addressed in section:** section 2.3.7, sections on Program 2 (relating to the Rice Climate Change Consortium) and Program 5 (drought etc) in Chapter 3; and CURE and RWC in chapter 4 relate.

ANNEX 4

CONDUCT OF THE EPMR INCLUDING COUNTRY AND IRRI'S COUNTRY PROGRAM SITE VISITS CONDUCTED BY SELECTED PANEL MEMBERS DURING THE COURSE OF THE REVIEW.

The Review was conducted according to the following schedule:

- Monitoring of IRRI's BoT meeting on 16-19 September 2008,
- The initial phase: 27-31 October 2008,
- The main phase: 2-13 February 2009,

all at IRRI Headquarters, Los Baños, The Philippines

Panel members individually or in small groups also visited IRRI's country programs and collaborators through a series of visits held before or between the major phases of the review. These are listed in the chronological sequence they were conducted (Sub-Saharan Africa and then Asia) with indications of persons met by Panel members.

A: Sub-Saharan Africa

Nigeria - visit on 18th June, 2008 to IITA (included IRRI and WARDA staff),

Dr. Glenn Gregorio, Rice Breeder (70%) and WARDA liaison (30%), IRRI (housed in WARDA offices in IITA)

Dr. Hiroshi Tsunematsu, Rice Geneticist, WARDA/JIRCAS, Ibadan, Nigeria (based at IITA)

Dr. Olupomi Ajayi, WARDA Coordinator, Ibadan,Nigeria (based at IITA);

Dr. Francis Nwilene, Liaison Scientist/WARDA Entomologist, Ibadan, Nigeria (based at IITA).

Tanzania - visit on 24th June, 2008 to Kilimanjaro Agricultural Training Center (KATC), Moshi.

Mr. Adam G. Pyuza, Deputy Principal, Kilimanjaro Agricultural Training Center, Moshi, Tanzania

Mozambique - visit between November 2-6, 2008

Mr. Joe Rickman, Coordinator, East and Southern Africa Rice Program, IRRI, Maputo (November 2-6, 2008)

Dr. Calisto Bias, Director General of Instituto de Investigação de Agrária de Moçambique (IIAM), Maputo (November 3, 2008)

Carlos B. Zandamela, Agronomist, Project Coordinator, Sasakawa-Global 2000 (SG2000), Maputo (November 3, 2008)

B: Asia

Lao PDR: visit on 7th November 2008 Vientiane, Laos

Dr Monthathip Chanphengxay, Director General, National Agricultural and Forestry Research Institute, Vientiane.

Dr Ben Samson, IRRI agronomist, Luang Prabang.

Cambodia: visit on 8th November 2008 Phnom Penh, Cambodia

Dr Men Sarom, Director, Cambodia Agricultural Research and Development Institute (CARDI), Phnom Penh.

Dr Ouk Makara, Deputy Director, Cambodia Agricultural Research and Development Institute (CARDI), Phnom Penh.

Thailand: visit on 13th November 2008 to Bangkok, Thailand

Dr Nongrat Nilpanit, Assistant Director and Mr Suniyom Taprab, Rice breeder, Bureau of Rice Research and Development, Rice Department, Ministry of Agriculture and Cooperatives.

Bangladesh : visit between November 23-28th, 2008 to Dhaka, Bangladesh

IRRI staff (based in Dhaka)

Dr Zainul Abedin, Agronomist, Leader, FoSHoL

Dr M.A. Hamid Miah, Liaison Scientist

Dr. Muhammed Alam, Coordinator of ADB & USAID Projects

Tahmina Banu, Officer-Administrative Coordination

Md Abdul Mannan, Information Technology Officer

Dr. Abutaher Ziauddin, Monitoring and Evaluation (M&E) Specialist

Seed company representatives

Md. Farukh Hossain, Business Manager, Syngenta Bangladesh Ltd.

Mohammed Musum, Chairman, Supreme Seeds

Ashim Kumar Saha, Seed Dev Production Officer, Petrochem (Bangladesh) Ltd

Siraj A. Chowdhury, Vice President, McDonald Bangladesh (Pvt) Ltd

M.R. Khan, Manager (QC & Prod. Devel.), Malik Group of Companies

F.R. Malik, Manager, Mollika Seed Company

K.M. Nazrul Islam, Project Director, Seeds, Bangladesh Agric Devel. Corp (BADC)

Md Sohiful Islam Shahim, Supply Chain Manager, Syngenta Bangladesh Ltd

A.T.M. Ziauddin, M & E Specialist, FoSHoL – IRRI

Sudair Chanda Nath, Program Manager (Agromarketing), Bangladesh Rural Advancement Ctte (BRAC)

Md Shafique Aktaz, DGM & Head of Production, Lal Teer Seed Ltd

Others

Dr. Md. Nur-E-Elahi, Director-General, BRRI, Gazipur, and a number of his staff

Dr. Md. Abdul Mazid, Chief Agronomist (CSO) and head, Agronomy Division, BRRI, Gazipur

M. Abdul Aziz, NDC Secretary, Ministry of Agriculture, Government of Bangladesh, Dhaka

Md. Shahidul Alam, Manager (Seed Stock), Lal Teer Seed Ltd., Gazipur

Md. Nasim Akbar (Manager PPQC), Lal Teer Seed Ltd., Gazipur

G.M. Mohsin, Senior Plant Breeder, Lal Teer Seed Ltd., Gazipur

Dr. Mahabub Hossain, Executive Director, Bangladesh Rural Advancement Committee (BRAC), Dhaka

Dr. Syed Samsuzzaman, Director (Livelihoods), RDRS Bangladesh, Rangpur

Mr M.G. Neogi, Agriculture Coordinator, RDRS Bangladesh, Rangpur

Mr Md. Abdul Mannan, Director general, Rural Development Academy (RDA), Bogra

Mr. M.A. Matin, Director, Center for Irrigation and Water management (CIWM), Rural Development Academy (RDA), Bogra

Dr. A.K.M. Zakaria, Agronomist, RDA, Bogra

Mr. Md. Mozifur Rahman, Associate Coordinator-Agriculture, FoSHoL Project, Dhaka

India: visit between November 28-December 3, 2008

IRRI India Office, New Delhi

Dr. J.K. Ladha, Country Representative and Rice-Wheat Coordinator, Agronomist

Dr. U.S. Singh, South Asia Regional Coordinator, STRASA, Breeder

Dr. Mahesh Gathala, NRS, agronomist

Dr. Parvesh Chandna NRS, GIS specialist

Dr. Virender Kumar, NRS, Weed scientist

Dr. Sheetal Sharma, NRS, Soil scientist

Mr. M. Vijaya Kumar, Asst. Manager

Ms. Savita Sharma, Admin. Associate

Mr. Gopal Agarwal, Admin. Officer, Finance and Accounts

Central Rice Research Institute, Cuttack

Dr. T. K. Adhya, Director

Dr. D.P. Sinhababu, Agronomist

Dr. M. Variar, Rice Breeder, Upland Systems

Dr. P. Swain , Physiologist, Drought Tolerance

Dr. J.N. Reddy, Rice Breeder, Submergence Tolerance

Dr. D.P. Singh, Rice Breeder, Salt Tolerance

Dr. O.N. Singh, Rice Breeder, Aerobic Rice

Others

Dr. P.L. Gautam, Deputy Director General, Crop Sciences, ICAR

Dr. T.P. Rajendran, Assistant Director General, Plant protection, ICAR

Dr. B.C. Viraktamath, Project Director, Directorate of Rice Research

Dr. Basant Ram, Vice Chancellor, Narendra Deva University of Agriculture and Technology

Dr. M.P. Yadav, Vice Chancellor, Sardar Vallabh Bhai Patel University of Agriculture and Technology

Dr. Paresh Verma, Director (Research), Bioseed Research India Private Limited

Dr. Olaf Erenstein, Agro-economist, CIMMYT

China: visit between 18-22nd December 2006, Hangzhou, China.

Meeting with the Green Super Rice consortium

Consortium members:

Zhikang Li (Chair, Chinese Academy of Agricultural Sciences (CAAS), Beijing) – rice breeder, co-appointment with IRRI

Qifa Zhang (Co-Chair, Huazhong Agricultural University, Wuhan) – rice genetics, genomics

Xing-Wang Deng (Peking University, Beijing) – rice genomics

Yongming Gao (Project Secretary, CAAS, Beijing) – rice breeding

Lijun Luo (Shanghai Agoecological Gene Center (SAGC), Shanghai) - -rice drought research

Others:

Jianlong Xu (CAAS, Beijing) – rice breeder

Dongxin Feng (Division Chief, Department of International Cooperation, CAAS, Beijing)

Hanwei Mei (SAGC, Shanghai) – rice genetics/physiology

Philippines: visit between January 29-31st, 2009

Philippine Rice Research Institute (PhilRice), Central Experiment Station, Maligaya, Science City of Muñoz, 3119 Nueva Ecija, Philippines

Atty. Ronilo A. Beronio, Executive Director, PhilRice

Dr. Gabriel O. Romero, Germplasm Curator, Rice Genetic Resources and Molecular Genetics, PhilRice

Engr. Evangeline Sibayan, Rice Engineering and Mechanization Division, PhilRice

Ms. Thelma Padolina, Rice Breeder, PhilRice

Dr. Ronaldo Cruz, Nutrient and Water Management Physiologist, PhilRice

Dr. Antonio Alfonso, Biotechnologist, Rice Genetic Resources and Molecular Genetics, PhilRice

Mr. Nelson Garcia, Biotechnologist, Rice Genetic Resources and Molecular Genetics, PhilRice

Western Visayas State University

Eleodoro Alicante, Dean, College of Agriculture and Forestry

Gerardo Penecilla, Director of Research

Bobby Gerardo, Director, University Planning and Development Office

Maria Lula Loyola, Vice President for Research, Extension and Training

Greta Gabinete, Asst. Professor, Soil Science

Provincial Department of Agriculture, Iloilo

Reynaldo M. Osano, Division Chief, Crops Division

Carmelo D. Oren, Rice Program Coordinator

Regional Department of Agriculture, Iloilo

Manuel Olanday, Senior Agricultural Development Specialist

Hector Peñaranda, Senior Agriculturalist

Larry Nacionales, Regional Executive Director

Municipal Extension

Romeo Librando, Municipal Agriculturalist, Dingle

W.W. J. Terania, Acting Municipal Agriculturalist, Sta. Barbara

Farmers at Camambugan barangay (Dingle)

Farmers at Lanag barangay (Sta. Barbara)

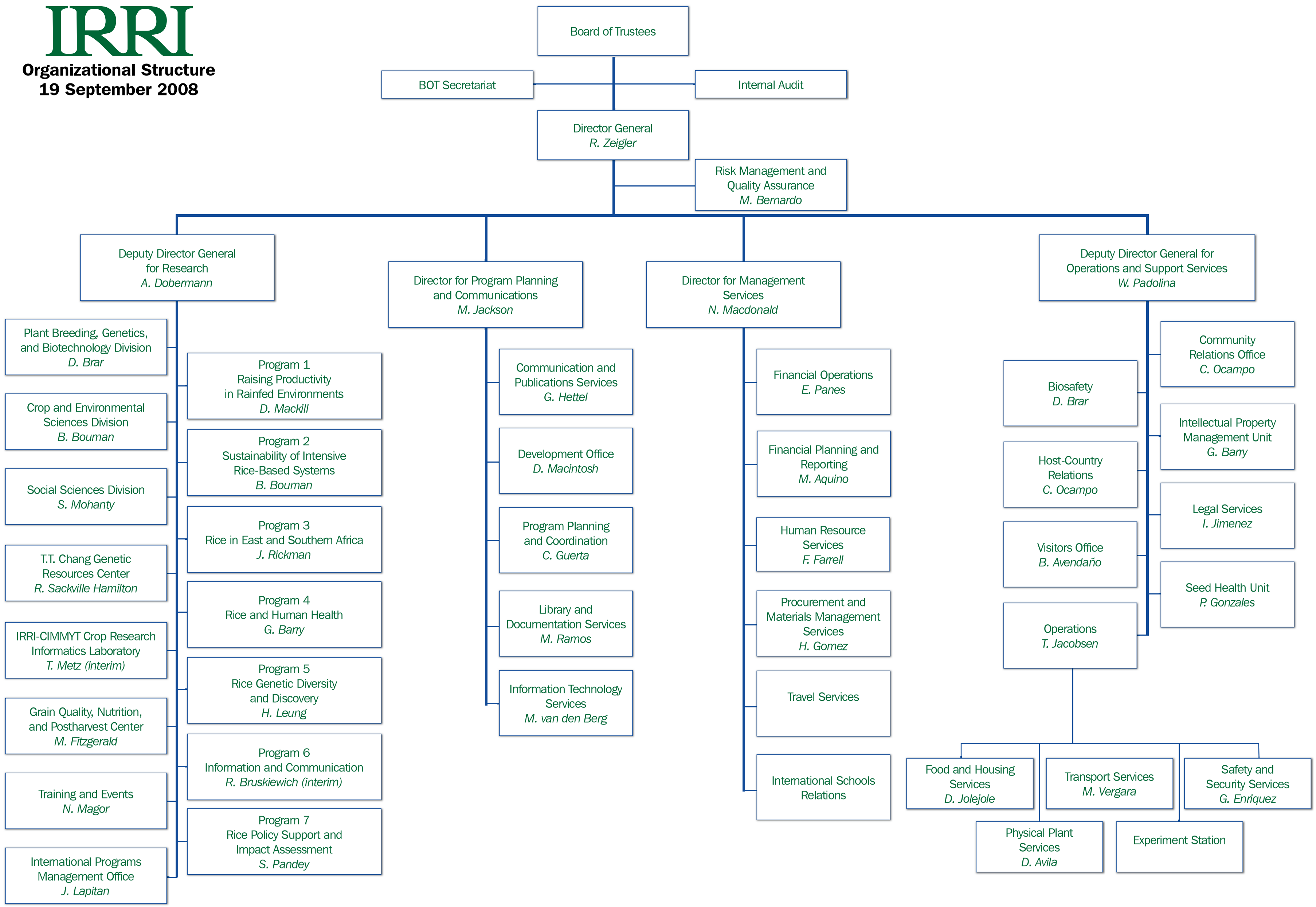
PhilRice (Negros Research station)

Edgar Libertario, Head, Negros Research Station

ANNEX 5

IRRI'S ORGANIZATIONAL CHART

IRRI
Organizational Structure
19 September 2008



ANNEX 6

IRRI'S MAJOR CONSORTIA AND NETWORKS

1. Irrigated Rice Research Consortium (IRRC) – provides an international platform for development and dissemination of production technologies for lowland irrigated rice among 11 countries in Asia.

2. Consortium for Unfavourable Rice Environments (CURE) – aspires to be a NARES-led consortium drawing on local scientific expertise across the diverse ecosystems and addressing the challenges of unfavourable rice environments. CURE now comprises 26 institutions from 10 countries. [CURE is discussed in more detail under Program 1 in Chapter 3].

3. International Network for Genetic Evaluation of Rice (INGER) – is a 31-year old partnership amongst rice improvement programs for rice germplasm exchange and utilization, and, historically, INGER has a fine record of achievement. [Current developments are considered in Section 4.1].

4. Council for Partnership on Rice Research in Asia (CORRA) – the Council promotes more effective partnership on rice in the Asian region and guides formulation and sharing of responsibility in its implementation. It serves as the Steering Committee of INGER.

5. Temperate Rice Research Consortium (TRRC) - develops and shares improved temperate rice germplasm among 12 country members.

6. The C_4 Rice Consortium - was formed under IRRI leadership to contribute to the development of C4 rice. The research function has been subsumed under the C_4 Rice Project, funded by BMGF.

7. Rice and Climate Change Consortium (RCCC) - nine collaborating institutions are conducting research on mitigation of climate change effects and adaptation strategies by rice to rising temperatures. Funding remains a constraint.

8. International Rice Functional Genomics Consortium (IRFGC) - provides for informal sharing of functional genomics information related to rice.

9. The International Network for Quality Rice (INQR) - improves grain quality attributes of rice and improves laboratory assays for key traits in collaborating laboratories.

10. Rice-Wheat Consortium for Indo-Gangetic Plains – includes as its principal members the national agricultural research systems of Bangladesh, India, Nepal and Pakistan and several IARCs (principally CIMMYT and IRRI with smaller contributions from ICRISAT, ILRI, CIP and IWMI) several ARIs and the private sector. Its main goal is to develop and deploy more productive and sustainable technologies for areas dominated by the rice-wheat crop rotation using research partnerships amongst members. Much of the research of the RWC will subsumed under the new CSISA project.

11. The Hybrid Rice Research and Development Consortium – has been designed to support research on developing parental lines and hybrids, improving hybrid rice grain quality and

supporting information sharing, public awareness and capacity building amongst members. [The HRDC is discussed in Section 4.5].

ANNEX 7

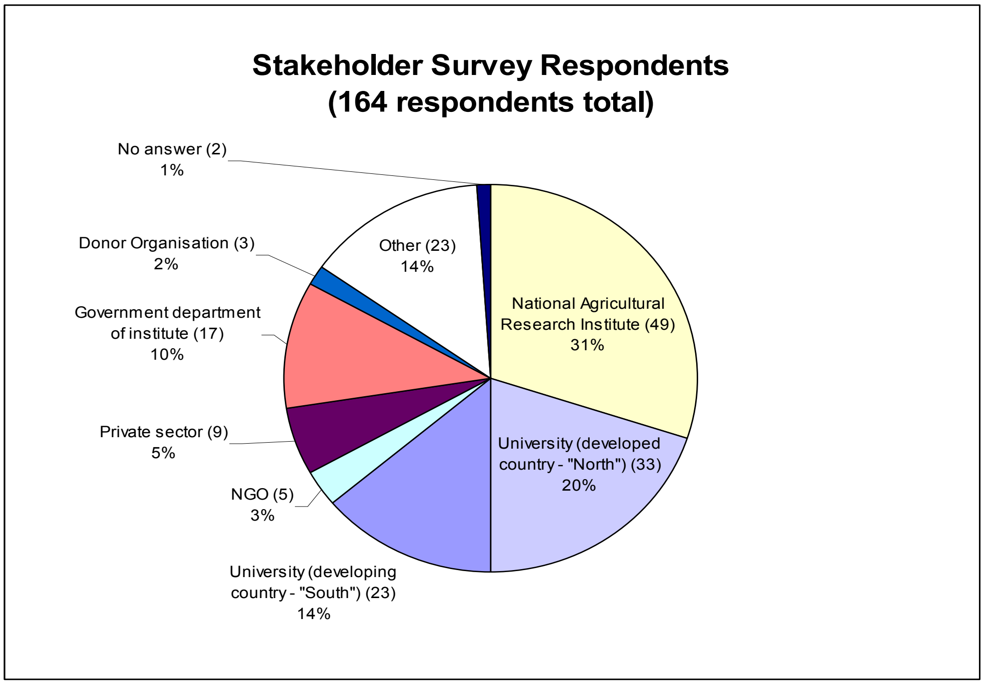
IRRI'S STAFF SATISFACTION SURVEY (total number of respondents: 117)

	Agree	Hard to decide	Disagree	Total count
IRRI GOALS, MISSION & DIRECTION: The goals, mission and direction of IRRI are clearly communicated to staff.	87.2% (102)	6.0% (7)	6.8% (8)	117
IRRI WORK PLACE: IRRI provides an environment conducive for innovative research.	82.9% (97)	9.4% (11)	7.7% (9)	117
POLICIES AND PROCEDURES: The manner in which new and revised procedures and policies are communicated to staff is satisfactory.	60.7% (71)	26.5% (31)	12.8% (15)	117
INTERNAL COMMUNICATION: PROCESSES. Generally, I am provided the information I need to do my job in the best possible way.	70.7% (82)	19.0% (22)	10.3% (12)	116
INTERNAL COMMUNICATION PROCESSES: The written communications I receive at IRRI are clear and understandable.	77.6% (90)	16.4% (19)	6.0% (7)	116
WORKING CONDITIONS: IRRI is willing to invest in equipment and provide facilities needed to ensure high quality results.	66.4% (77)	25.9% (30)	7.8% (9)	116
JOB DEFINITION: My skills, abilities and professional experience fully match with the requirements of my position.	83.8% (98)	11.1% (13)	5.1% (6)	117
JOB SATISFACTION: My position gives me the opportunity to develop my individual talents.	80.2% (93)	12.9% (15)	6.9% (8)	116
LEADERSHIP: My immediate supervisor communicates specific work goals to me clearly.	74.1% (86)	18.1% (21)	7.8% (9)	116
CO-WORKER RELATIONS: The people I work with daily have a high level of trust and confidence in each other.	71.6% (83)	21.6% (25)	6.9% (8)	116
STAFF EMPOWERMENT: The recognition I receive from IRRI when I solve a work-related problem motivates me to work harder.	56.5% (65)	31.3% (36)	12.2% (14)	115
STAFF EMPOWERMENT: I can express my opinion in issues that affect my work.	75.0% (87)	19.8% (23)	5.2% (6)	116
STAFF PERFORMANCE: EVALUATION. The last staff evaluation has helped me to improve my job performance.	40.2% (45)	43.8% (49)	16.1% (18)	112
IDENTITY WITH IRRI: The morale of staff at IRRI is high.	58.1% (68)	32.5% (38)	9.4% (11)	117
IDENTITY WITH IRRI: I would recommend IRRI to my friends as a good place to work.	78.6% (92)	15.4% (18)	6.0% (7)	117

ANNEX 8

SELECTED RESPONSES FROM THE IRRI STAKEHOLDER SURVEY

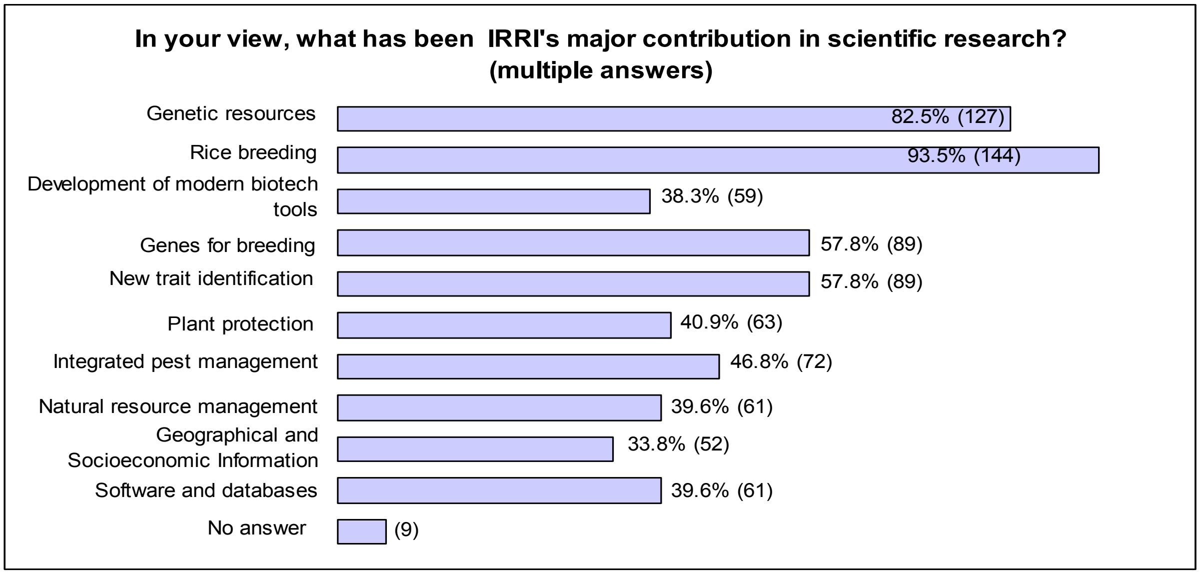
a) Breakdown of responding stakeholders



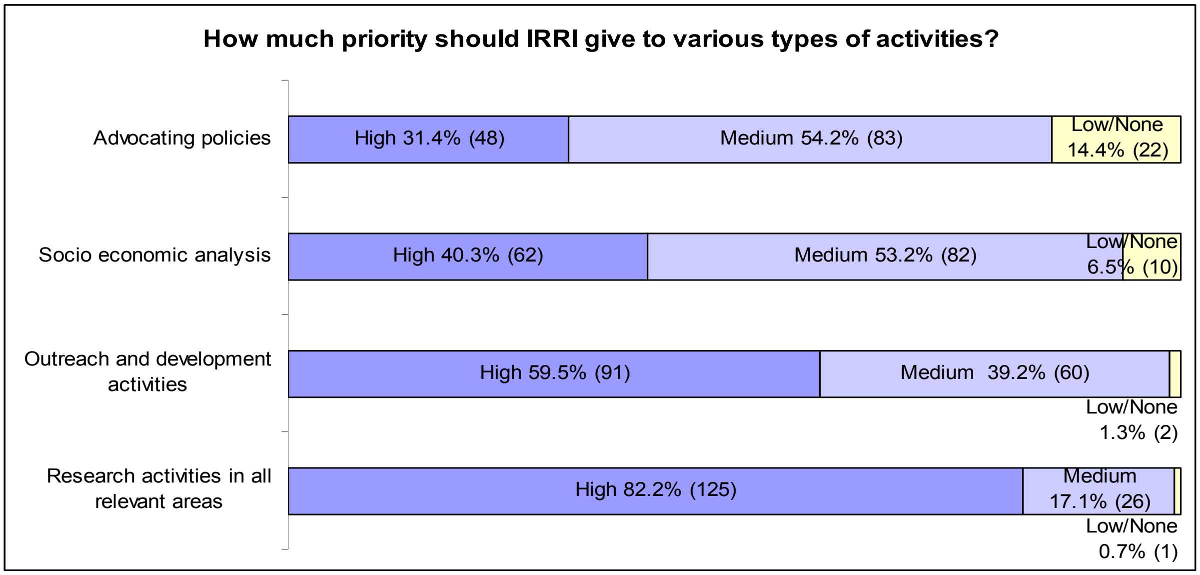
b) Stakeholder assessment of IRRI's performance and reputation in different areas

	excellent	good	fair	poor	no opinion	total count
Development of new rice varieties	50.3% (78)	36.1% (56)	5.2% (8)	0.0% (0)	8.4% (13)	155
Source of published information (including software and web-based data modules) on rice and rice research	43.6% (68)	42.9% (67)	9.0% (14)	0.0% (0)	4.5% (7)	156
Improving lowland irrigated rice systems	34.4% (53)	42.2% (65)	4.5% (7)	1.9% (3)	16.9% (26)	154
Improving lowland rainfed rice systems	18.8% (29)	50.6% (78)	10.4% (16)	1.3% (2)	18.8% (29)	154
Improving upland rice systems	9.7% (15)	39.0% (60)	27.3% (42)	4.5% (7)	19.5% (30)	154
Natural resources management	12.4% (19)	47.7% (73)	19.6% (30)	4.6% (7)	15.7% (24)	153
Curation and source of rice genetic resources	51.9% (80)	31.2% (48)	4.5% (7)	0.0% (0)	12.3% (19)	154
Poverty and livelihood analysis and impact assessment	11.0% (17)	44.5% (69)	22.6% (35)	3.9% (6)	18.1% (28)	155
Influence on policy makers	13.0% (20)	44.2% (68)	22.7% (35)	5.8% (9)	14.3% (22)	154
Quality of research	46.2% (72)	43.6% (68)	8.3% (13)	0.0% (0)	1.9% (3)	156

c) Stakeholders' assessment of IRRI's major contributions to research



d) Stakeholder assessment of areas on which IRRI should focus preferentially



ANNEX 9

LIST OF IRRI ACHIEVEMENTS EVALUATED BY PANEL AS PART OF SCIENCE QUALITY ASSESSMENT

Program 1

1. Identification of the submergence tolerance gene *SUB1* and subsequent development of *SUB1* varieties by marker assisted backcrossing for evaluation and dissemination in flood-prone areas.

2. Major QTLs for grain yield under upland (DTY12.1, DTY4.1) and lowland (DTY2.1, DTY3.1) drought stress identified.

3. Drought tolerant breeding line IR74371-70-1-1 identified for release in Orissa and Tamil Nadu. Sister line IR74371-54-1-1 identified for release in Philippines.

4. Major QTL for salinity tolerance at the seedling stage (*SALTOL)* identified and salt tolerant cultivars developed that are being taken up by farmers.

5. Conceptual model of the main factors affecting nutrient response in rainfed lowland rice as the basis for developing improved fertilizer management strategies.

Program 2

6. Released the first 2nd generation New Plant Type line (IR77186-122-2-2-3; 36 landraces) and the first aromatic semi-dwarf line (IR71137-243-3-3-2-2).

7. Obtained direct evidence of decreased rice yields from increased night time temperature associated with global warming. Discovered 10% rice yield reduction for every 1 degree increase in seasonal average night temperature.

8. Developed and successfully evaluated in farmers' fields across Asia a new crop-based approach for site-specific nutrient management (SSNM) in rice-based systems.

9. Two systems developed to grow rice under water scarcity: safe Alternate Wetting and Drying (AWD) irrigation, which can save 15 – 20% of applied water without compromising the rice yield, and Aerobic Rice which allows farmers to grow rice under non-flooded conditions like an upland cereal, using around 50% of the water used in flooded rice with yields that are 20 ‐ 30% lower.

10. Quantified the effects of N enrichment in crops on insect pest fitness and designed a multi media campaign and a radio soap opera) to motivate farmers to adopt IPM and improved crop management practices. The soap opera was awarded the 2007 COM+ Communications Award for communicating science to people and a special commendation award for outstanding and unique contribution to communication of sustainable development by ONEWORLD Broadcasting Trust.

Program 4

11. Advanced lines of important Asian rice varieties introgressed with Golden Rice 1 (GR1) and Golden Rice 2 (GR2) traits; IR 64 introgression lines with golden rice traits developed through marker assisted selection (MAS)) evaluated for the first time in Asia in the field trial during 2008

at IRRI

Program 5

12. C4 rice: New Frontier Project and C4 Consortium with international partners from leading ARIs; Designed protocols and constructed infrastructure to start C4 research.

13. Large collection of IR64 mutants developed and disseminated for use in forward and reverse genetic screens.

14. Novel blast resistance gene *PI40* was identified and validated by MAS in the progenies from 5 Japonica cultivars with *PI40*.

15. OryzaSNP project discovered 160,000 SNPs in 20 diverse rice varieties, providing abundant SNP markers for major parental lines, mega varieties.

Program 6

16. Global leadership within international collaborations to provide bioinformatics analysis to, and develop information management systems for, germplasm, genotype and genomics data: at IRRI for rice (see http://seeds.irri.org); at CIMMYT for wheat and maize (IRRI - CIMMYT CRIL alliance); and within the Generation Challenge Programme and the global ICIS community, for other crops: IRRI - CIMMYT Alliance "Crop Research Informatics Laboratory" (CRIL) established (January 2006) to provide a critical mass of capacity for germplasm, genotype and genomics information analysis and management (along with other benefits).

ICIS adopted as a single system at IRRI and CIMMYT for rice, maize and wheat. Integration of INGER and IRGCIS into IRIS.

Global leadership in the development of web-based Standard Materials Transfer Agreements (SMTA) information management systems and seed ordering systems (INGER prototype) as required by the new ITPGRFA guidelines.

Global leadership in Generation Challenge Programme crop information systems platform and network development.

Analysis support provided, and database developed, for the OryzaSNP high throughput rice germplasm single nucleotide polymorphism discovery project (www.orzyasnp.org).

Contributions to the Rice Annotation Project and International Rice Genome Sequencing Consortium genome annotation activities.

17. Rice Knowledge Bank (www.knowledgebank.irri.org) for up to date source on rice management practices in format for extension (several revisions and under Rice Management Committee at IRRI); Established country knowledge banks under local authority (Thailand, Cambodia, Vietnam, Bangladesh, Indonesia, Sri Lanka, Myanmar, China and Nepal); Cereal Knowledge Bank developed on principles of RKB under CIMMYT alliance;

E learning materials for post harvest.

Program 7

18. Study of the rice economy and policies in the Philippines.

19. Institutionalized participatory varietal selection (PVS) and socio-economic (gender analysis) in rice varietal development for stress prone environments.

20. Cross-country comparative study of drought-coping mechanisms of rice farmers in eastern India, northeastern Thailand and southwestern China.

ANNEX 10

LIST OF IRRI BOARD MEMBERS, NATIONALITIES AND COMPETENCIES

PROFILE OF THE IRRI BOARD OF TRUSTEES, 2003-2008

NAME	TERM	GENDER	COUNTRY	EXPERTISE	BOARD ROLES
Angeline S. Kamba	1998-2003	F	Zimbabwe	Public service and human resources management	M-FAC; C-BOT; C-NC; C-EC
Jian Song	1998-2003	M	China	Engineering and education	M- PC; M-NC
Ronald P. Cantrell***	1998-2004	M	USA	Plant breeding and genetics, research management	M-EC; M-NC; M-PC; M-FC
Emanuel Adilson Serrao	1999-2004	M	Brazil	Agronomy research	C-NC; M-PC; M-EC
Calvin O. Qualset	1999-2004	M	USA	Genetics and genetic resources	C-PC; M-NC; VC-EC; M-FAC
Francisco Nemenzo**	1999-2005	M	Philippines	Political science and education	M- PC
E. A. Siddiq	2000-2005	M	India	Genetics and plant breeding	M-PC
Shigemi Akita	2000-2005	M	Japan	Plant physiology	M-PC; VC-NC
Michael D. Gale	2001-2003	M	UK	Cytogenetics, genomics, plant breeding	VC-PC; VC-FAC
Fazle Hasan Abed	2001-2006	M	Bangladesh	Rural development	C-FAC; M-EC
Kay Beese	2002-2005	M	Germany	Biology and ecology	M-PC
Achmad M. Fagi	2002-2007	M	Indonesia	Agriculture, farming systems	M-PC; M-NC; C-NC
Eun-Jong Lee	2002-2007	M	Korea	Plant pathology	M-PC; M-NC
Keijiro Otsuka	2002-2007	M	Japan	Agricultural economics	C-BOT; C-EC; M-PC
Luis P. Lorenzo, Jr.*	2003-2004	M	Philippines	Government, agribusiness, agricultural development	M-PC
Domingo F. Panganiban*	2005-2006	M	Philippines	Agricultural development	M-PC
CURRENT BOARD OF TRUSTEES MEMBERS					
Baowen Zhang	2004-2009	M	China	Agricultural education and management	M-PC; M-FAC
Ruth K. Oniango	2004-2009	F	Kenya	Food science and nutrition	M-PC; VC-NC
Ronald L. Phillips	2004-2009	M	USA	Plant breeding and genetics	C-PC; M-NC; M-EC; M-FAC
Arthur C. Yap*	2004-2005 2006- to date	M	Philippines	Government, law, agricultural and rural development	M-PC
Elizabeth J. Woods	2005-2010	F	Australia	Agribusiness	C-BOT; C-EC; M-FAC
Ralph Anthony Fischer	2005-2010	M	Australia	Plant and crop physiology, land and water resources and sustainable agriculture, agricultural development	C-NC; VC-PC
Emerlinda R. Roman**	2005-2011	F	Philippines	Business administration	M-PC; C-FAC
Robert S. Zeigler***	2005-2010	M	USA	Plant pathology, research management	M-EC; M-NC; M-PC; M-FC
Mangala Rai	2006-2010	M	India	Plant breeding	M-PC
Jillian Lenné	2007-2009	F	UK	Plant pathology	M-PC; M-FAC
Mohammed Syeduzzaman	2007-2009	M	Bangladesh	Financial management	M-PC; VC-FAC
Usha Barwale Zehr	2007-2009	F	India	Genetics and plant breeding	M-PC; M-NC
Mutsuo Iwamoto	2008-2010	M	Japan	Food engineering, research management	M-PC; M-FAC
Seong-Hee Lee	2008-2010	M	Korea	Plant physiology	M-NC; M-PC
Achmad Suryana	2008-2010	M	Indonesia	Agricultural economics	M-PC; M-FAC

*Ex-officio, DA Secretary
** Ex-officio, UP President
*** Ex-Officio, IRRI DG

C - Chair
VC - Vice Chair
M - Member

BOT - Board of Trustees
EC - Executive Committee
PC - Program Committee
FAC - Finance and Audit Committee
NC - Nominating Committee

NOTE: The FAC will be re-organized into a separate Finance Committee and Audit Committee in September 2008.

ANNEX 11

LIST OF ACRONYMS

ARI	Advanced Research Institute
AWD	Alternate Wetting and Drying
BAC	Bacterial artificial chromosome
BMGF	Bill & Melinda Gates Foundation
CAAS	Chinese Academy of Agricultural Sciences
CCCP	Climate Change Challenge Program
CCER	Center Commissioned External Review
cDNA	complementary DNA
CESD	Crop and Environment Sciences Division
CGIAR	Consultative Group on International Agricultural Research
CIAT	International Center for Tropical Agriculture
CIMMYT	Centro Internacional de Mejoramiento de Maiz y Trigo
CIP	International Potato Center
CPWF	Challenge Program for Water and Food
CRIL	Crop Research Information Laboratory
CSISA	Crop System Intensification for South Asia
CURE	Consortium for Unfavorable Rice Environments
DDG	Deputy Director General
DDG-R	Deputy Director General of Research
EPMR	External Program and Management Review
ES	Experiment Station
ESA	East and South Africa
ESARP	East and Southern African Rice Program
FHS	Food and Housing Services
FLAR	Latin American Fund for Irrigated Rice
FMG	Facilities Management Group
GCP	Generation Challenge Program
GMS	Greater Mekong subregion
GQNPC	Grain Quality, Nutrition and Post-Harvest Center
GR	Golden Rice
GRC	Genetic Resources Center
GSR	Green Super Rice
HPCP	Harvest Plus Challenge Program
HRDC	Hybrid Rice Research and Development Consortium
IARC	International Agricultural Research Center
ICA	IRRI-CIMMYT Alliance
ICIS	International Crop Information System
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
IGP	Indo-Gangetic Plain
IIAM	Instituto de Investigação Agrária de Moçambique

IITA	International Institute of Tropical Agriculture
ILRI	International Livestock Research Institute
INGER	International Network for the Genetic Evaluation of Rice
INQR	International Network on Quality in Rice
IPG	International Public Good
IPM	Integrated Pest Management
IPMU	Intellectual Property Management Unit
IPR	Intellectual Property Rights
IPMO	International Programs Management Office
IRF	International Research Fellow
IRFGC	International Rice Functional Genomics Consortium
IRGSP	The International Rice Genome Sequencing Project
IRRC	Irrigated Rice Research Consortium
IRRI	International Rice Research Institute
IRS	Internationally Recruited Staff
ITPGRFA	International Treaty on Plant Genetic Resources for Food and Agriculture
IWMI	International Water Management Institute
KATC	Kilimanjaro Agricultural Training Center
MARS	Marker-Assisted Recurrent Selection
MAS	Marker-Assisted Selection
miRNA	micro-RNAs (regulators of gene expression)
MNC	Multinational Corporation
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
MTP	Medium-Term Plan
NARES	National Agricultural Research and Extention Systems
NARS	National Agricultural Research Systems
Nerica	New Rice for Africa
NIL	Near Isogenic Line
NPT	New Plant Types
NRS	Nationally Recruited Staff
OMAP	Oryza Map Alignment Project
OU	Operational Units
PBGBD	Plant Breeding, Genetics and Biotechnology Division
PPS	Physical Plant Services
PVP	Plant Variety Protection
PVS	Participatory Variety Selection
QTL	Quantitative Trait Locus
RCCC	Rice Climate Change Consortium
RIL	Recombinant Inbred Line
RWC	Rice Wheat Consortium
SHU	Seed Health Unit
siRNAs	Short interfering (or silencing) RNA
SKEPs	Scientific Know-how and Exchange Programs
SMTA	Standard Material Transfer Agreement
SNP	Single Nucleotide Polymorphisms
SSA	Sub-Saharan Africa

SSD	Social Sciences Division
SSNM	Site-Specific Nutrient Management
STRASA	Stress-Tolerant Rice for Africa and South Asia
USAID	United States Agency for International Development
VRF	Visiting Research Fellow
WARDA	West African Rice Development Association (also known as Africa Rice Center)

Science Council Commentary on the Seventh External Program and Management Review (EPMR) of the International Rice Research Institute (IRRI)

SCIENCE COUNCIL OF THE CGIAR

Science Council Commentary on the Seventh External Program and Management Review (EPMR) of the International Rice Research Institute (IRRI)

24 April 2009

The Science Council considered the Report of the 7th External Program and Management Review (EPMR) of the International Rice Research Institute (IRRI) at its eleventh meeting (SC11) that was held at CIP, Lima, Peru in March 2009. The review had been conducted between September 2008 and the 13th of February 2009. During the Meeting, *Dr. Greg Edmeades*, EPMR Panel Chair, provided a summary of the written EPMR Report and its recommendations. *Dr Robert Zeigler*, Director General IRRI, provided the Institute's response to the Report and *Dr Beth Woods*, IRRI Board Chair (present by telephone) provided additional comments including responding to the Report's recommendations on governance. The SC expressed its satisfaction with the Report as it provided a thorough and readable review and analysis. The SC welcomes the constructive response of the Institute to the Review process and its outcomes. Implementation of the good set of recommendations is expected to help guide a successful Institute undergoing unprecedented rapid expansion.

Summary of the report

The Report considers that IRRI is a strong, even flagship, Center of the CGIAR. The Panel had been aware of the CGIAR change process as an important context variable but had approached the review focused on what the Institute needed to do in rice research. The Panel found the Institute to be well led and managed and that it had developed a good Strategic Plan with good buy-in from staff and stakeholders. The Panel Chair noted therefore that the Panel's eleven recommendations were designed to make a good Institute even better. Five of the recommendations relate to scientific approaches and capacity, and one each to the expansion to Africa, management of country partnerships, the Program Committee of the Board, research management, career paths and the renewal of infrastructure. The Report highlights management issues which will be important as the Institute faces a period of substantial growth having secured a number of new major grants and as it starts to implement a new approach towards Africa.

IRRI had demonstrated several major scientific achievements - including the identification and use of the submergence tolerance gene *sub1;* it had developed improved linkages with CIMMYT and produced very valuable insights into long term rice-wheat rotation systems; made important strides in developing an entry program for work in Africa in conjunction with WARDA (the Africa Rice Center); and was developing innovative approaches to engage with the private sector in hybrid rice.

The Report noted that IRRI had a long history of working through networks. These networks and consortia had been established originally to help transfer rice germplasm but there were additional ways in which consortium arrangements between IRRI and its partners could be used to advance the cause of rice research and development. One of the major scientific recommendations in the Report described how IRRI, in partnership, might exploit GxE interactions through multi-location testing and an improved database to guide the rice breeding program. This was suggested to enhance efficacy, the current high levels of satisfaction expressed by IRRI stakeholders with networks and the overall performance of the Institute notwithstanding. However, formal impact assessment studies in the period of the review were considered less strong and, more generally, social science research needed to be strengthened to meet the overall needs of the Institute. The anticipated rapid growth in budget (and new project staff), the change to increased proportions of large restricted project fund management, and the formation of the appropriate relations with the strong emerging NARS like China and India were all major challenges for the future. Similarly, the Report notes that IRRI is a mature Institute and that some of the facilities require renewal. The Panel Chair noted that current CGIAR rules on asset depreciation and reserves were inadequate to provide infrastructural renewal programs for older Centers but the Panel is pleased to see that IRRI was also addressing this challenge.

Center response

IRRI thanked the EPMR Panel for a valuable report and expressed satisfaction with the process by which it had been conducted, noting that the Institute had committed substantial time and resources to the EPMR. A carefully reasoned response of the Institute's Board and management had been provided to the Report in which IRRI stated its agreement with the majority of the recommendations. The major recommendation for more work on GxE interactions would be important, especially in rainfed rice, and the Institute was working out how to approach this, particularly with respect to determining the scale, intensity and costs. Similarly, and in response to individual recommendations, the Director-General gave assurances that IRRI would increase research on hybrid rice, evaluate steps to be taken in integrated pest management (IPM) – by investing in a CCER in late 2009/early 2010 - and in reviewing requirements in social science (the latter areas having suffered during an earlier era when IRRI was faced with budget cuts). However, it was noted that each of these recommendations also requires the Institute to raise additional resources. The anticipated growth discussed for 2009 resulting from the capture of large project funds meant that, proportionately, IRRI's unrestricted funding would reduce to 21% of the total.

Similarly, the Institute agreed with the basis of the recommendation to make water an organizing principle for its work. To an extent, IRRI believed it was doing this already, but the institute agreed that it could do more in aligning the breeding work around this principle, a point also identified by the CCER on biotechnology held just prior to the EPMR. IRRI acknowledged the recommendation of the EPMR to enhance its strategy for managing country partnerships, and the precise means by which IRRI would address this was already being considered by the institute. In response to the Report's recommendation on the structure of research management, the Institute agreed that matrix management had been useful for IRRI in the past but, with growth, revised forms of research management should be considered. In relation to the recommendation on the development of more transparent career paths at IRRI, the Director-General acknowledged that, to date, IRRI had had a rather "clerical" approach to human resources management. However, the institute has recently sought substantial external input in this area, had employed new key staff and was currently completely revising and modernizing HR management.

IRRI concurred with the recommendations on the Board Program Committee. On the question of Board size, the IRRI Board Chair noted that IRRI valued and benefited from a Board Membership that was required to deal with rice science, administration and financial matters provide regional coverage and had common members with CIMMYT and to link with the Board of WARDA.

Assessment

The SC was pleased with the Report in all respects as it provided a thorough and readable review and analysis. The good recommendations can help guide a successful Institute undergoing unprecedented rapid expansion from total revenues of around $37m in 2008 to an anticipated $61m in 2009. The SC noted that the Report had elicited a very thoughtful Institute response to the main recommendations and also to the many suggestions in the body of the text. The SC welcomes the constructive response of the Institute and looks forward to the active implementation of the agreed recommendations. The SC is particularly pleased with the establishment of an excellent working relationship with the African Rice Center and a shared programmatic approach to rice in Africa in which IRRI will establish new initiatives in east and southern Africa. However, it was noted that this progress is a function of personal relationships at higher management levels and that, for sustainability, the SC recommends that these interactions should be fostered at all staff levels. IRRI is to be commended in leading in several different areas e.g. extending the responsibility of the Genetic Resources Center to include genetic stocks, as otherwise these extremely valuable materials are very easily lost with staff turnover.

Even in a strong Institute there are always areas where added strength is required. The Panel noted IPM as one of these and the SC agrees that an early CCER in this area would be valuable. The CCER must address the issue of weeds, as weeds increase in importance as a constraint to production as less water is used in rice production systems. Similarly, the SC concurs with the Panel that IRRI's social science work should provide more strategic value to the Institute from an increased focus on high priority issues in rice. The SC would particularly like to see more attention given to impact assessment of IRRI's overall efforts in rice research and not just at the level of technology adoption projects.

The SC agrees with the recommendation to undertake multi-location yield testing as a means for making greater progress in yield (irrigated environments) and in yield stability (rainfed environments). This shift from past practice for irrigated environments will also take account of the changes that will occur in water supply, since these irrigated environments can no longer be seen as being uniform in water supply. The SC understands IRRI's reluctance to commit unreservedly to the expense of increasing to 30-40 trials sites. However, the SC believes that the issue is vital and necessary to confirm that IRRI's breeding approaches and strategy are optimal and encourages IRRI to take this forward.

The SC is supportive, as was the Panel, of the hybrid rice program and the hybrid rice development consortium (HRDC). The role for the CGIAR in these circumstances is to enhance the broad genetic base on which production of hybrids is based and to maintain the widespread availability of hybrid lines. Neither individual national programs nor the private sector will necessarily respond to these public sector roles for hybrid development. The SC noted that the initiative may catalyse the private sector in new areas. However, as there is already considerable activity by the multinational corporations, IRRI should continuously monitor developments to ensure that their program continues to reach farmers who would not otherwise have access to hybrid rice.

The rapid growth that will accompany the large increase in funding is likely to involve recruitment of an additional 20 IRS. The SC concurs with the Panel that this brings great challenges for appropriate assimilation, mentoring and research management. There will be a growing influence of project-based funding on the shape of the IRRI staff contingent. The SC notes that a review of the matrix structure is already in progress. Whatever structure is adopted in the future needs to provide agility in decision making. The SC would encourage the System Office to move ahead with their intention to review best practices and structures for research management across the CGIAR.

CGIAR Performance Management System 2008

IRRI performance assessment: OUTSTANDING

CGIAR

Performance Measurement System Summary Report 2008

Results

Outputs

Definition

Outputs are the products of research with a defined time line, contributing to reaching the Center goals by offering solutions to problems identified during the planning process.

Starting this year, the PM System will measure outputs in terms of publications, capacity strengthening activities and data management strategies. The latter two indicators will be piloted outside the PM System.

The PM System will not have an overall measure of percentage of output targets achieved, but through linking the PM System with the newly established CGMap it will continue to allow interested CGIAR Members and Partners to track the results (i.e. outputs) for individual projects.
During a transition period the data continues to be collected through the PM interface until a CGMap interface has been developed.

INDICATOR 1:
Composite measure of Center research publications
This composite indicator consists of three measures:

- 1A: Number of externally peer-reviewed publications per scientist in 2008 that are published in journals listed in Thomson Scientific/ISI
- 1B: Number of externally peer-reviewed publications per scientist in 2008 (excluding articles published in journals listed in the Thomson Scientific/ ISI)
- 1C: Relative rating of Center's best publications regarding journal impact factor

Rationales for sub-measures 1A-1C along with instructions are given below. Calculation of the overall score for indicator 1 is presented in Table 1.

Measure 1A:
Number of externally peer-reviewed publications per scientist in 2008 that are published in journals listed in Thomson Scientific/ISI

Rationale:
This measure reflects the contribution of knowledge by the Center to a wide international audience and the quality and usefulness of that information as determined by peers from an internationally recognized journal database.
Please report the number of peer-reviewed publications per scientist in 2008 that are published in journals listed in the Thomson Scientific/ISI Master Journal List (database of over 15500 peerreviewed journals). The list can be found at
http://www.thomsonscientific.com/cgi-bin/jrnlst/jloptions.cgi?PC=master

Requested Evidence Material:

- List of publications (with full citation and consecutive numbering), including (i) name of Center scientist(s) who authored or co-authored, (ii) year of publication, (iii) title of publication, (iv) volume number, (v) journal name, (vi) page numbers, (vii) ISSN, and (viii) indication of which author is a developing country partner if applicable.
- List of scientists included in the denominator FTE. This list must include: (i) Name and position or title, (ii) date of hire and departure, and (iii) status (e.g. IRS, RRS NRS). Please also include a description of your indicator computation and the FTE for each scientist in the list.

Consultative Group on International Agricultural Research
Performance Measurement System

Guidelines for measuring the number of peer-reviewed publications

- This should include publications strictly published in 2008. Publications from the previous year (2007), whether online or hard copy, will be accepted only if they were not included in the list of publications from the previous year. Publications can only be counted once, either online or in hard copy. Please ensure that publications from the previous year that were not counted in that PM verification are listed separately
- The journals or book series should have an editorial board and clear review procedures (feedback from technical editors).
- Peer-reviewed publications other than journals should include i) books either written or edited by IARC staff[1] ii) chapters in books and conference compilation documents where these have been formally published and externally refereed; iii) monographs only when they are formally published and externally refereed. No other publications should be included in this category such as abstracts, working papers, internal series, newsletters, reprints etc.
- Only ONE entry of each paper per Center is permitted. Where there are multiple authors including ones from different Centers then both Centers may count the paper in their submissions.
- When staff joins an institute during the year in question, publications from their previous employment may be counted as long as they are relevant to the work of the CGIAR. Likewise for staff leaving an institute in 2008 all appropriate 2008 publications may be counted. If the scientist has left in years prior to 2008 and the publication is published in 2008, then both the publication and scientist must be counted only if the publication was prepared during the scientist's tenure at the center. Please refer to "Annex 1. Summary of definitions" for the calculation of FTE in these cases.
- Publications resulting from work fully funded by the Center, but written by a non- Center staff can be included, but then the person must be also included in the scientist count.

[1] In the case of IARC staff acting as both editors and authors of chapters in an edited book, the book itself would count as one publication (if it had been externally peer reviewed) and each chapter with an IARC author would count separately.

Follow the guidelines for measuring the number of externally peer-reviewed publications given above when applicable. For calculating the number of scientists and its FTE please use the definition in Annex 1.

Measure 1B:
Number of externally peer-reviewed publications per scientist in 2008 (excluding articles published in journals listed in the Thomson Scientific/ ISI).

Rationale:
This measure reflects the contribution of peer reviewed knowledge and information by the Center for targeted stakeholder audiences (not including major international journals) Please report the externally peer-reviewed publications per scientist in 2008. Please report separately– if pertinent:

- number of externally peer-reviewed publications per scientist in externally published journals and books.
- number of externally peer-reviewed publications per scientist in Center-produced book/research report series or journals.

Externally peer reviewed means that the publications have been reviewed by experts that are not Centers' staff or work as consultants with the Centers.

Requested Evidence Material:

- List of publications (with full citation and consecutive numbering), including (i) name of Center scientist(s) who authored or co-authored, (ii) year of publication, (iii) title of publication, (iv) volume number, (v) name of journal, (vi) book or other, (vii) page numbers (range), (viii) indication of whether it is a Center owned series/journal or an externally published journal or book, (ix) indication of which author is a developing country partner if applicable, and (x) editors.

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Performance Measurement System

Measure 1C:
Relative rating of Center's best publications

Rationale:
The CGIAR Centers aim to be Centers of excellence in agricultural science to address complex issues of relevance to the poor. As a system of excellence the CGIAR is more likely to attract new research partners. This measure reflects the quality and originality of the Center's research shown by ability to reach top quality journals with a proportion of all publications.
This measure compares the journals in which a sample of the Centers articles (defined on basis of FTE) was published to the top journals in a subject category using a "normalized impact factor (IF)"[1] **This measure is generated based on a sample of articles submitted for 1A. Centers do not have to provide additional information.**

[1] Normalised IF = journal impact factor divided by the average of the IFs of the three top journals in the subject category

Table 1: Calculation of the composite publication indicator value

Measure	Weight	Performance Target and Scoring [2]
1A Number of peer-reviewed publications per scientist in 2008 that are published in journals listed in Thomson Scientific/ISI	50 %	• 2 journal articles per scientist. • Scoring = 0-5 points with 0.5 articles/scientist being the lower threshold.
1B Number of externally peerreviewed publications per scientist in 2008 (excluding articles published in journals listed in the Thomson Scientific/ ISI)	20%	• 1 publication per scientist. • Scoring = 0-2 points with 0.5 publications/scientist being the lower threshold.
1C Relative rating of Center's best publications regarding journal impact factor	30%	• relative to highest score among Centers. • Scoring = relative to highest score that gets 3 points.
Total indicator 1 score is the sum of the three sub-measure scores.		

INDICATOR 2:
Percentage of scientific papers that are published with developing country partners in refereed journals, conference and workshop proceedings in 2008

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Performance Measurement System

NOTE: Development of a capacity building indicator is on-going and this measure will be part of the more comprehensive component indicator.
For calculating indicator 2, use those publications listed in measures 1A and 1B and add those published in international newsletters and other scientific series, and papers presented at formal conferences and workshops with external attendance. Do not include internal presentations. The publications considered co-authored must clearly articulate the formal authorship including the authors who are NARS based. Indicate the percentage of publications which has NARS based coauthors within the total list.

Requested Evidence Material
List of all publications (with full citation and consecutive numbering) included under this category, indicating the developing country partner(s) among the authors of the publication.
Please also include a description of your indicator computation.

[2] Examples of calculation
1A-1: Publishing rate = 1.90; Score = (1.9-0.5)*[5/(2-0.5)] = 4.66
1A-2: Publishing rate = 1.25; Score = (1.25-0.5)*[2/(2-0.5)] = 1.00.

Monitoring of achievement of MTP output targets in 2008

Definition: Output and Output Target

- Outputs are the products of research with a defined time line, contributing to reaching the MTP project (and thus the Center's and CGIAR goals) by offering solutions to problems identified during the MTP planning process.
- Output Targets are the annual deliverables, defined by quantity and type, expected in a specific year and contributing to achieving the MTP Project Outputs. Output targets are deliverables in the following categories: materials, policy strategies, practices, capacity, and other kinds of knowledge.

One of the results of the CGIAR Performance Measurement workshop was to recommend that "Achievement of output targets will be monitored by Centers and will be made publicly available through linking CGMap with the PM System …The PM System will not have an overall measure of percentage of output targets achieved, but through linking the PM System with the newly established CGMap it will continue to allow interested CGIAR Members and Partners to track the results (i.e. outputs) for individual projects." This recommendation was endorsed by ExCo during its meeting in October 2008.

NOTE: During a transition period the data continues to be collected through the PM interface until a CGMap interface has been developed.

Centers are requested to report on achievements in 2008 of the annual output targets set in MTP 2008-2010. The PM report is to cover all MTP projects and outputs listed in MTP 2008-2010. For each MTP project please list the outputs and output targets and select the status of the output target. The following status options will be available:

- Fully Achieved – all aspect of the target have been achieved/completed
- >75% Achieved (with comments on what has been achieved and why it is less than 100%);
- >50% Achieved (with comments on what has been achieved and why it is less than 100%);
- < 50% Achieved (with an explanation);
- Cancelled (with an explanation);
- Deferred (with an explanation and new target year)

Deferred output targets (including those that have been partially achieved) should be resubmitted in the MTP for a later year; in MTP 2010-2012 for 2009 or 2010. If output targets are deferred by more than 2 years, they should be marked cancelled. If the outputs and output targets have significantly changed from those planned, provide an explanation for the new output targets reported.

The online system will have an interface for inputting explanations related to the reported targets.

Note:

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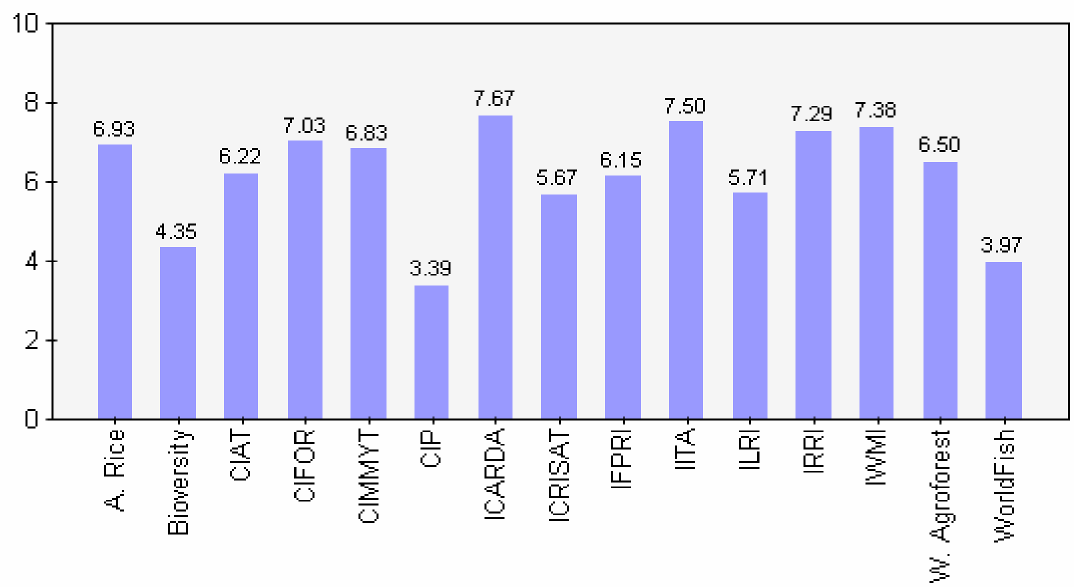
For a clearer definition of each of the output categories: Materials refer to all biological materials and knowledge that adds value to them; not to documents. Policy strategies refer to analysis and information that is aimed to be used for policy decision making. Practices include tools, methods and processes that intended for use in research, breeding, policy work, extension, demonstration, and evaluation in the field. Capacity strengthening includes training and other instruction aimed at enhancing individual capacity, training materials and resources, and interventions that are aimed at enhancing institutional capacity. Other kinds of knowledge include knowledge and data that are the deliverable research achievements and do not belong to any of the other categories.
Completed ex post impact studies should be reported under the Impacts measure 3A: ex post impact assessment
studies.

INDICATOR 1: Composite measure of Center research publications - 2008



Note that there are different conventions regarding reviewed publications in the various disciplines represented in the CGIAR; comparison across natural science, social science and economics is not recommended

Center	Score
A. Rice	6.93
Bioversity	4.35
CIAT	6.22
CIFOR	7.03
CIMMYT	6.83
CIP	3.39
ICARDA	7.67
ICRISAT	5.67
IFPRI	6.15
IITA	7.5
ILRI	5.71
IRRI	7.29
IWMI	7.38

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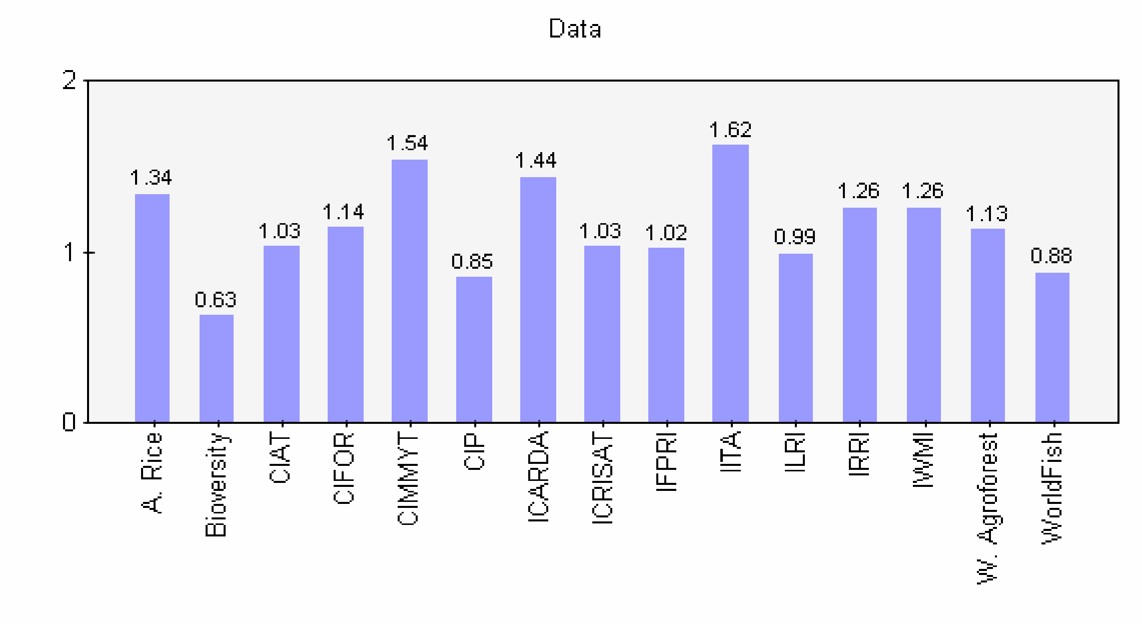
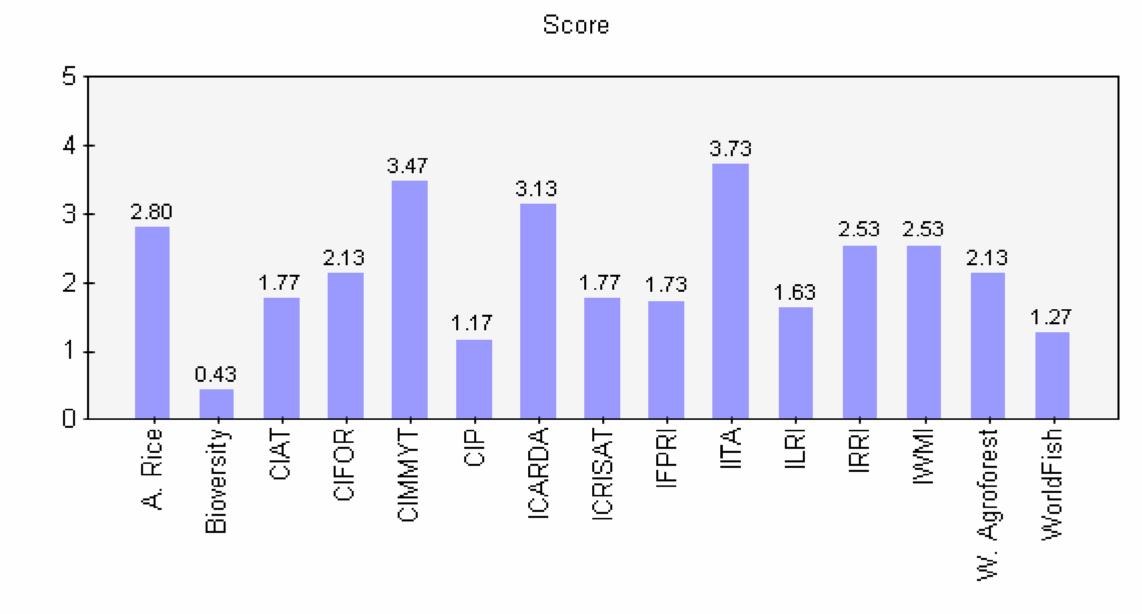
W. Agroforest	6.5
WorldFish	3.97

1A: Number of externally peer-reviewed publications per scientist in 2008 that are published in journals listed in Thomson Scientific/ISI - 2008





Note that there are different conventions regarding reviewed publications in the various disciplines represented in the CGIAR; comparison across natural science, social science and economics is not recommended

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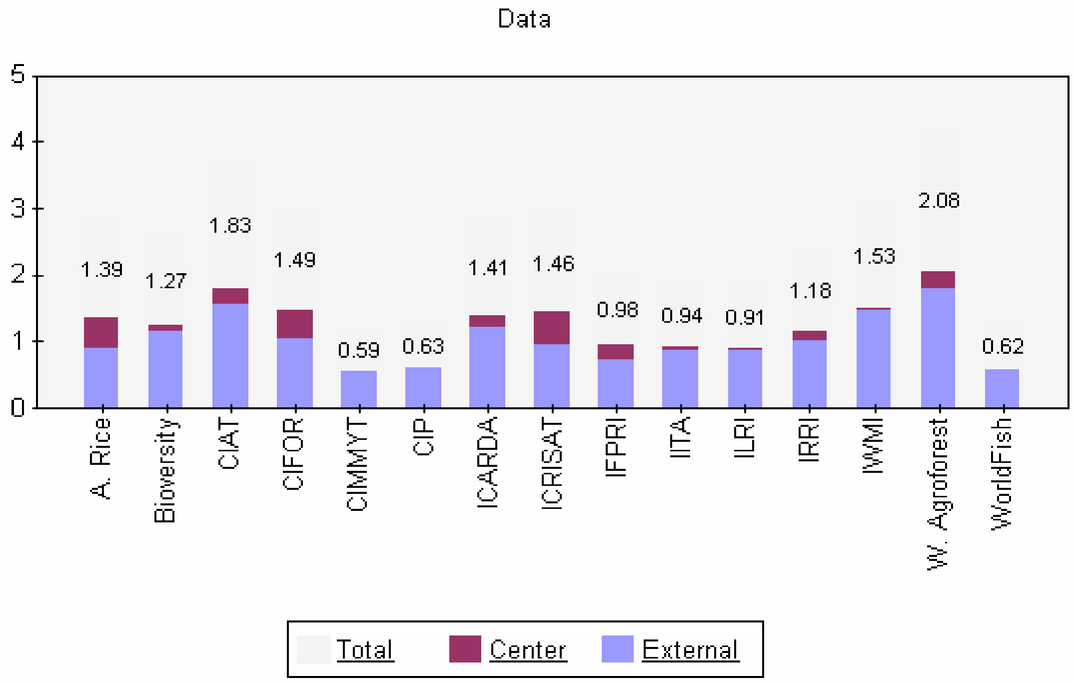
Center	Data	Score
A. Rice	1.34	2.8
Bioversity	0.63	0.43
CIAT	1.03	1.77
CIFOR	1.14	2.13
CIMMYT	1.54	3.47
CIP	0.85	1.17
ICARDA	1.44	3.13
ICRISAT	1.03	1.77
IFPRI	1.02	1.73
IITA	1.62	3.73
ILRI	0.99	1.63
IRRI	1.26	2.53
IWMI	1.26	2.53
W. Agroforest	1.13	2.13
WorldFish	0.88	1.27

1B: Number of externally peer-reviewed publications per scientist in 2008 (excluding articles published in journals listed in the Thomson Scientific/ ISI) – 2008



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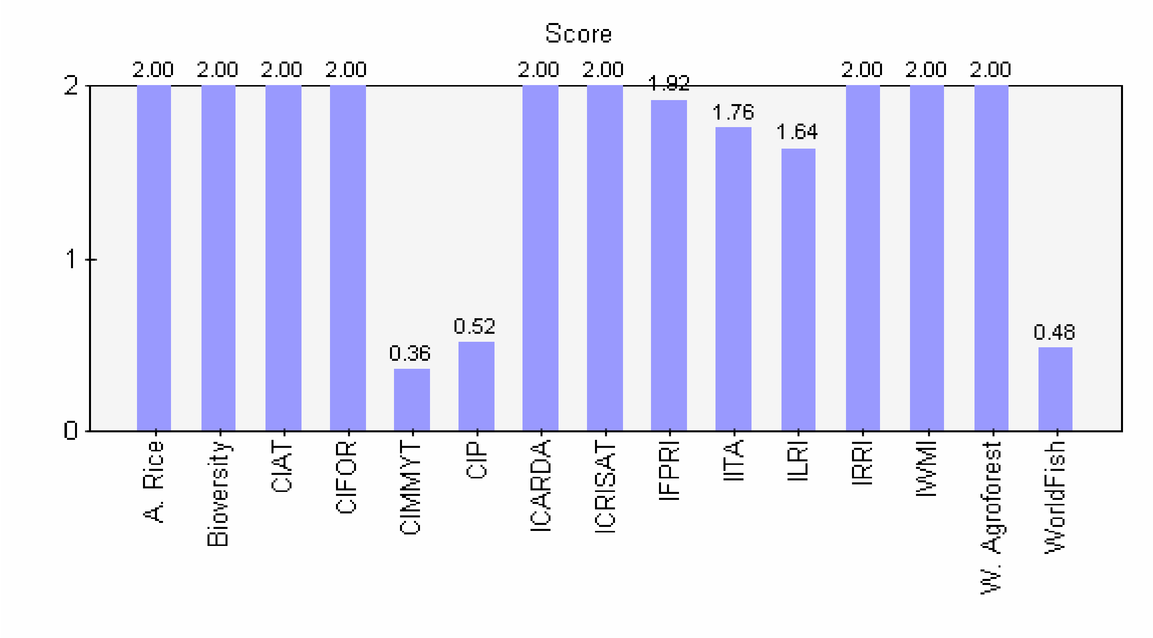

Note that there are different conventions regarding reviewed publications in the various disciplines represented in the CGIAR; comparison across natural science, social science and economics is not recommended

Center	External	Center	Total	Score
A. Rice	0.9	0.49	1.39	2
Bioversity	1.15	0.12	1.27	2
CIAT	1.56	0.27	1.83	2
CIFOR	1.05	0.44	1.49	2
CIMMYT	0.59	0	0.59	0.36
CIP	0.63	0	0.63	0.52
ICARDA	1.22	0.19	1.41	2
ICRISAT	0.95	0.51	1.46	2
IFPRI	0.72	0.26	0.98	1.92
IITA	0.87	0.07	0.94	1.76
ILRI	0.87	0.04	0.91	1.64
IRRI	1.02	0.16	1.18	2
IWMI	1.47	0.06	1.53	2
W. Agroforest	1.79	0.29	2.08	2
WorldFish	0.62	0	0.62	0.48

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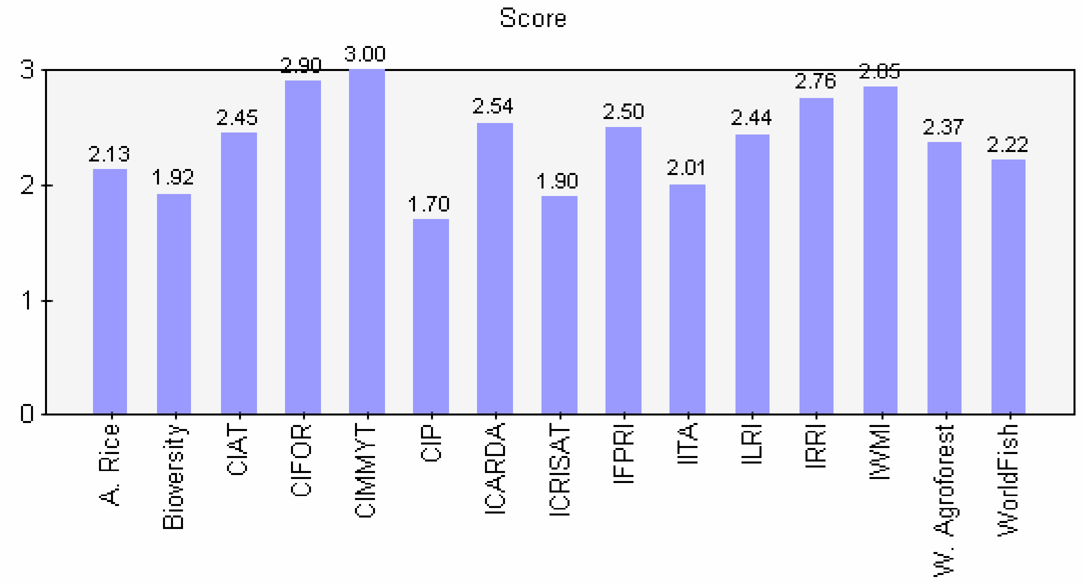
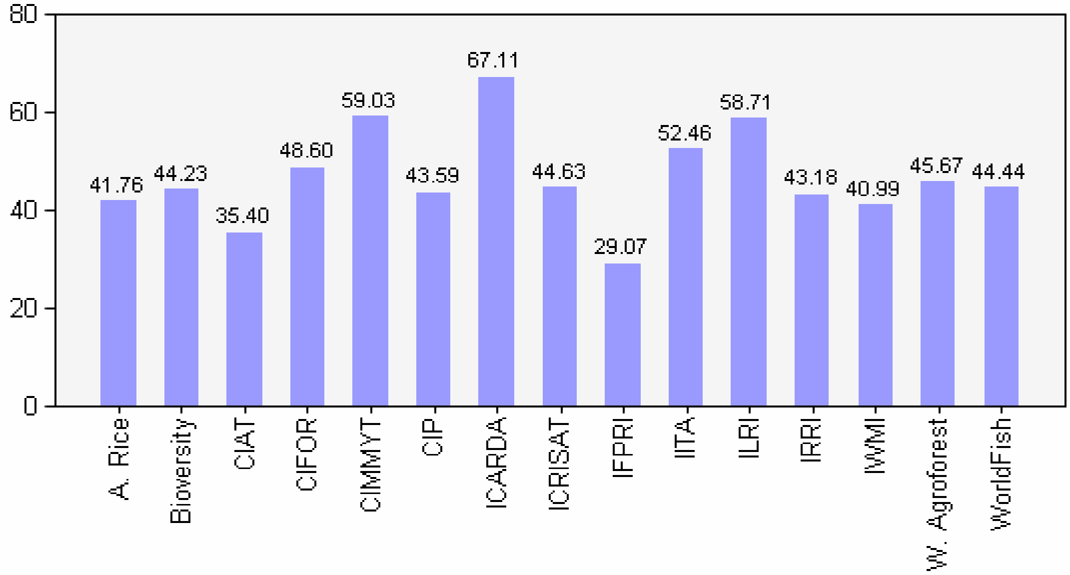
1C: Relative rating of Center's best publications – 2008



Center	Score
A. Rice	2.13
Bioversity	1.92
CIAT	2.45
CIFOR	2.9
CIMMYT	3
CIP	1.7
ICARDA	2.54
ICRISAT	1.9
IFPRI	2.5
IITA	2.01
ILRI	2.44
IRRI	2.76
IWMI	2.85
W. Agroforest	2.37
WorldFish	2.22

INDICATOR 2: Percentage of scientific papers that are published with developing country partners in refereed journals, conference and workshop proceedings in 2008

Consultative Group on International Agricultural Research
Performance Measurement System



Center	Data
A. Rice	41.76
Bioversity	44.23
CIAT	35.4
CIFOR	48.6
CIMMYT	59.03
CIP	43.59
ICARDA	67.11
ICRISAT	44.63
IFPRI	29.07
IITA	52.46
ILRI	58.71
IRRI	43.18
IWMI	40.99
W. Agroforest	45.67
WorldFish	44.44

Outcomes

Definition

Outcome
Outcome is the external use, adoption, or influence of a Center output(s) (e.g. by partners, stakeholders, clients).
Rationale:
This indicator measures the uptake and use of the research results by the immediate clients. It is a measure of the relevance of the research by the Center and its ability to monitor and document outcomes from the

diffusion of research outputs as the first step toward demonstrating impact. It also reflects the effectiveness of auxiliary activities by the Center to stimulate outcome, such as capacity building and establishment of partnerships.

INDICATOR 3: SC **assessment of Center Outcome reports**
Centers are requested to report on the most significant outcomes documented in 2008 resulting from outputs that the Center produced. The number of cases to be submitted depends on the Center's actual expenditure for 2007 and is shown in the table below.

Center	Actual Expenditure 2007 (US$ million)	# of outcome cases requested
Africa Rice Center	10.3	3
CIFOR	16.9	4
WorldFish Center	17.3	4
IWMI	23.9	4
CIP	24.1	5
ICARDA	27.0	5
World Agroforestry Center	30.4	5
Bioversity International	37.6	6
IRRI	37.7	6
ICRISAT	37.8	6
ILRI	40.6	6
CIMMYT	43.9	7
IITA	44.7	7
IFPRI	45.7	7
CIAT	48.9	7

The outcomes need to be linked to an achieved output target identifiable in an MTP (also called research milestone in MTPs prior to MTP 2006-2008) or to an overall achieved output specified in any MTP not earlier than in MTP 2004-2006.

Please provide a description (in 750 words maximum) for each of the outcomes, including the following:

- An clear outcome statement of the outcome achieved (the statement must explicitly describe the achieved outcome rather than cite the planned outcome as written in the MTP)
- What output/output target resulted in the outcome?
- In which MTP was the output/output target identified as planned before its achievement?
- Where was the achievement of the output/output target documented?
- Who used/adopted or was influenced by the output? Identify the kinds of people or entities affected and their location by country.
- How was the output used or adopted? What was the nature of the influence of the output?
- What is the magnitude and significance of the outcome relative to the intended recommendation domain? (in terms of, for example, the extent of use/adoption by the intended users and geographic coverage or reach of intended user groups, IPG nature of research, likelihood of impact on CGIAR goals, novelty and innovativeness of research or capacity building that led to the outcome, success in more intractable targets).
- What is the evidence for the outcome? Specifically, what kind of data were collected or study was conducted? Who collected the data and/or conducted the study? If not included in the outcome

evidence, what is the evidence that shows that the outcome is derived from the output/output target?

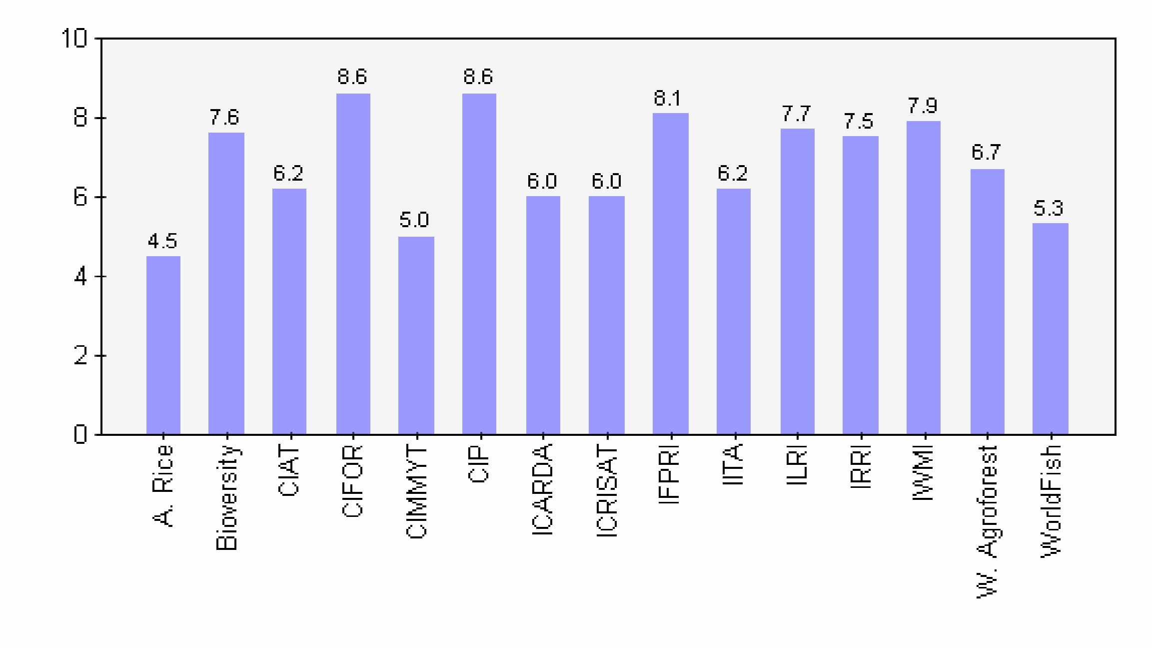
Requested Evidence Material

- Please make all evidence documents available in the PM database as attachments (files or zipped files).
- Keep the documentation to the minimum and include only direct evidence explicitly documenting the outcome and showing the link from the output to the outcome, not anecdotal evidence. Direct evidence means that a study has been conducted or set of observations are collected showing explicitly that the outcome has occurred or the outcome is explicitly reported in document other than an outcome assessment, for example in a newspaper article. Anecdotal evidence refers to material, including for example books, photographs, newspaper articles and bills that have limited relevance to the outcome reported or make an unsubstantiated reference to the outcome or outcomes of similar nature in general.
- The study documenting the outcome must have been completed in 2008 and the output/output target from where the outcome derived should have been presented as planned not earlier than in MTP 2004-2006.
- The number of evidence documents should not exceed three.
- Relevant sections from large reports should be extracted into a single document. In such case full references need to be given.
- If the evidence for the achievement of the output is not in the outcome study, it needs to be included separately.
- The most appropriate evidence documents are studies that have been specifically conducted to monitor outcomes and therefore clearly establish the link from Center output to the outcome. Testimony from a stakeholder is not sufficient evidence.
- The evidence material needs to be made available in English, French or Spanish.

The value of the overall evidence depends on the strength of the evidence about the outcome having occurred and attribution of the outcome to a specific Center output/output target.

The scoring table used by the SC for assessing the outcome cases is given in Annex 2.

INDICATOR 3: SC assessment of Center Outcome reports (1-10) - 2008



CGIAR

Consultative Group on International Agricultural Research
Performance Measurement System

Center	SC Rating
A. Rice	4.5
Bioversity	7.6
CIAT	6.2
CIFOR	8.6
CIMMYT	5
CIP	8.6
ICARDA	6
ICRISAT	6
IFPRI	8.1
IITA	6.2
ILRI	7.7
IRRI	7.5
IWMI	7.9
W. Agroforest	6.7
WorldFish	5.3

Impact Culture

Definition

Impact
Impacts are the longer range social, environmental and economic benefits that contribute to CGIAR goals and the center's mission and objectives that derive at least in part from a Center's research related outputs.

Definition: Ex post Impact Assessment (epIA)
EpIA is a specialized area of evaluation that is designed to identify and measure consequences resulting from earlier interventions of a program or project. Its timing is epIA's defining characteristic: epIA takes place after the program's or project's investment has generated the intervention, and sufficient time has elapsed and experience has accumulated to assess the intervention's performance in terms of longer term economic, social, and environmental consequences. EpIA contributes mainly to accountability and secondarily to learning in the evaluation of agricultural research. Impacts of an intervention may be positive or negative, direct or indirect, and
intended or unintended.

Rationale:
This indicator measures Centers' efforts to document impact from their past research (hence, ex post impact assessment) to fulfill their accountability imperative towards CGIAR stakeholders. It also measures their efforts to institutionalize impact culture among their own researchers and partners.

INDICATOR 4:
Composite Indicator on Center Impact Assessment Culture
The indicator is the SC/SPIA rating of commitment to documenting impacts from past research in a credible way and building an impact assessment culture. Centers are requested to report information related to its commitment to documenting impacts and building an impact assessment culture in three main areas that the SC will use as the criteria for scoring the reports:
(1) Ex-post Impact Assessment (epIA) studies / advancement of epIA methods (45%);
(2) Building an impact assessment culture at the Center, including communication / dissemination and capacity enhancement (20%); and,
(3) Quality of submission of one published epIA study during the past three years that effectively demonstrates the impact of the Center's research on the poor or food insecure people and to the environment, as judged by peer reviewers appointed by SPIA (35%).

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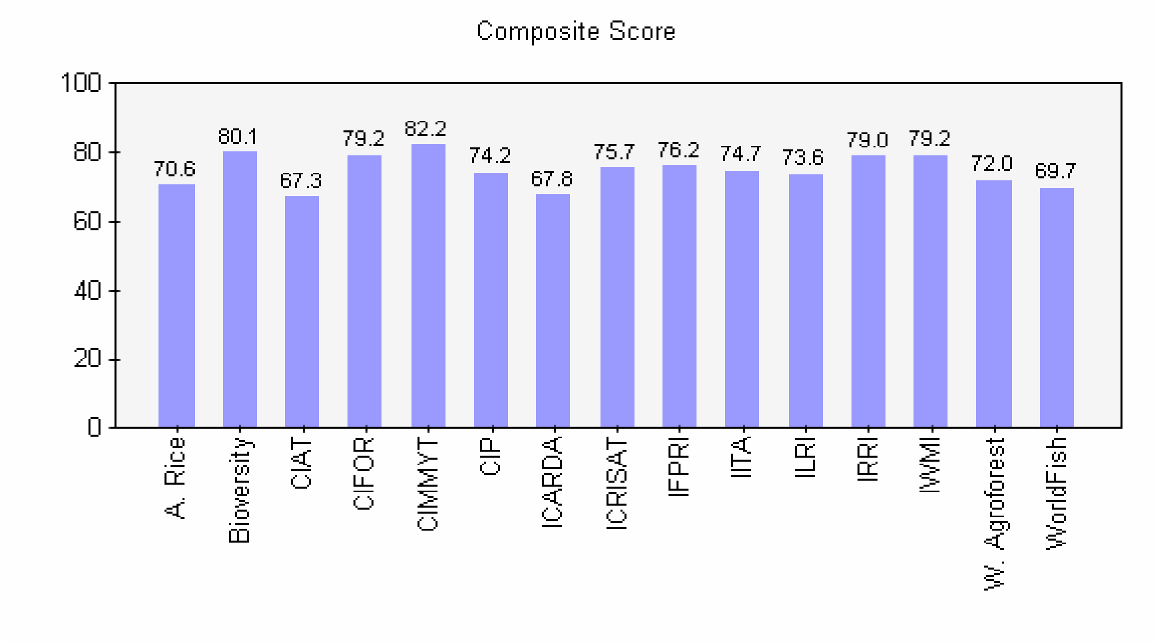
Please complete the checklist in Annex 3 for components (1) and (2) and submit one epIA for component (3). The criteria used for assessing component (3) can be found in Annex 3

For the purposes of this exercise, an epIA refers to a published journal article, conference paper, book chapter (but not entire edited book), report or any other publication that has entered the public domain, which is not a revised version of an earlier submission, that documents empirically the impact of a center's research or research-related output in terms of CGIAR goals.
The impacts measured may be short-term, medium- term or long-term but must be linked to a clearly discernible intervention derived from research. The epIAs must include some measurement of adoption beyond the household or village level and some measure of ex-post impact as a result of that adoption. Adoption constraints analyses, pilot technology evaluations, farmer preference and demand type studies and ex-ante impact assessments are not, for this exercise, regarded as epIAs[3] . While there may well be an element of ex-ante in many epIAs, there must be some measurement of adoption and ex-post impact to qualify.

[3] While those studies are useful in their own right, and may well be counted as outputs or outcomes, none of these qualify as ex post impact assessments (epIAs) for purposes of this exercise.

INDIACTOR 4: Composite Indicator on Center Impact Assessment Culture – 2008



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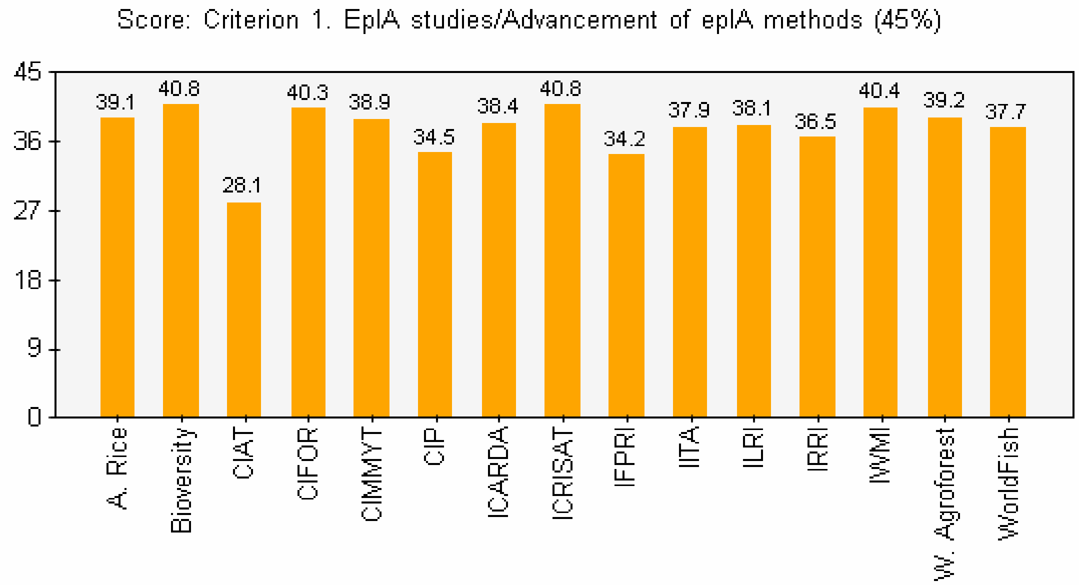

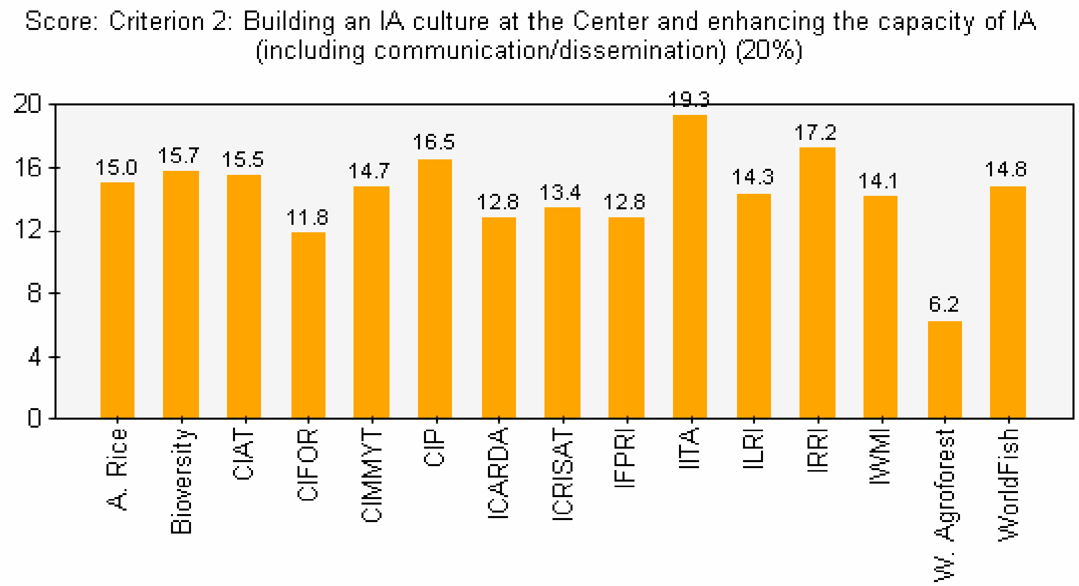

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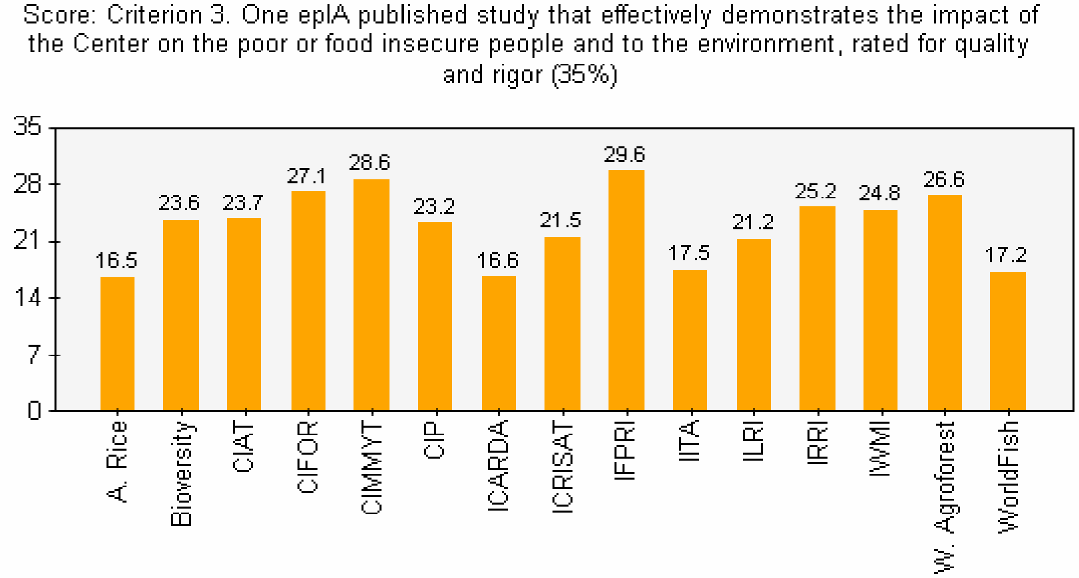

Center	Composite Score	Score 1	Score 2	Score 3
A. Rice	70.6	39.1	15	16.5
Bioversity	80.1	40.8	15.7	23.6
CIAT	67.3	28.1	15.5	23.7
CIFOR	79.2	40.3	11.8	27.1
CIMMYT	82.2	38.9	14.7	28.6
CIP	74.2	34.5	16.5	23.2
ICARDA	67.8	38.4	12.8	16.6
ICRISAT	75.7	40.8	13.4	21.5
IFPRI	76.2	34.2	12.8	29.6
IITA	74.7	37.9	19.3	17.5
ILRI	73.6	38.1	14.3	21.2
IRRI	79	36.5	17.2	25.2
IWMI	79.2	40.4	14.1	24.8
W. Agroforest	72	39.2	6.2	26.6
WorldFish	69.7	37.7	14.8	17.2

Potential to Perform

Institutional Health

Definition

GOVERNANCE

INDICATOR 5A:
Summary Score on Governance Checklist

Rationale: The governance indicators reflect the range of policies and practices that the CGIAR determined were instrumental to good governance based on best practices in the corporate and nongovernmental sectors. The specific measures follow closely the recommendations identified in the 2006 Stripe Review on Corporate Governance, and the roles and responsibilities of Center boards outlined in the CGIAR Guidelines on Center Governance.
Please complete the checklist in Annex 4 for your Center. Also keep available for verification purposes supporting documents such as Board profile, policy documents, excerpts of Board minutes and resolutions.

INDICATOR 5B:
Assessment of Board statements

Please submit a short statement (maximum 500 words) describing **one important action** taken by the board in 2008 to improve the board's performance and the expected impact from this action.
Examples of such actions include board restructuring, re-organization of board and committee agendas improvements to evaluation processes, etc.
A peer-reviewed panel composed of three external members will assess the submissions in terms of standards and practices in governance, relevance, and the expected impact of the actions taken. In particular, the panel will consider:

- If the action is important for improving board performance
- If, in the context of the board's performance, the action will have a substantial impact
- If the action and its impact are clearly and specifically described
- If there is as verifiable source for the action

Supporting Evidence Material:
Please also attach a verifiable source for the actions described.
Documentation should be verifiable, clear and brief. Relevant extracts from documents (minutes, board-endorsed reports) can be submitted, or if supporting documentation cannot easily be extracted from longer texts, it should be clearly marked within the text.
Center review of panel assessments: Before the score for the board statement are made final, Centers will have an opportunity to review the panel's assessments and to improve or clarify the supporting evidence if the panel has considered it deficient to form an assessment. Centers are not permitted to submit a different action or to appeal the panel's scores once all improved supporting evidence has been re -submitted and reviewed.

CULTURE OF LEARNING AND CHANGE

INDICATOR 5C:
Summary Score on Culture of Learning and Change Checklist

Rationale: A vibrant culture of learning and change is critical for a Center's long-term success. Sustaining the quality and relevance of research is related to a Center's regular investment into development of its staff, staff satisfaction, the evaluation of its own effectiveness and the renewal of its human and intellectual capital by seeking greater diversity.
Please complete the checklist in Annex 5 for your Center.

DIVERSITY

INDICATOR 5D:
Percentage of women in management
(Percent of management positions, either research or nonresearch, occupied by women as of 31. December 2008).

Requested Evidence Material:

- List of all staff members in management positions, including names, titles and gender.

Definition: "Management position" includes Director General, Deputy Directors General, Directors of major programs/divisions and senior heads of administration if they report directly to the DG.

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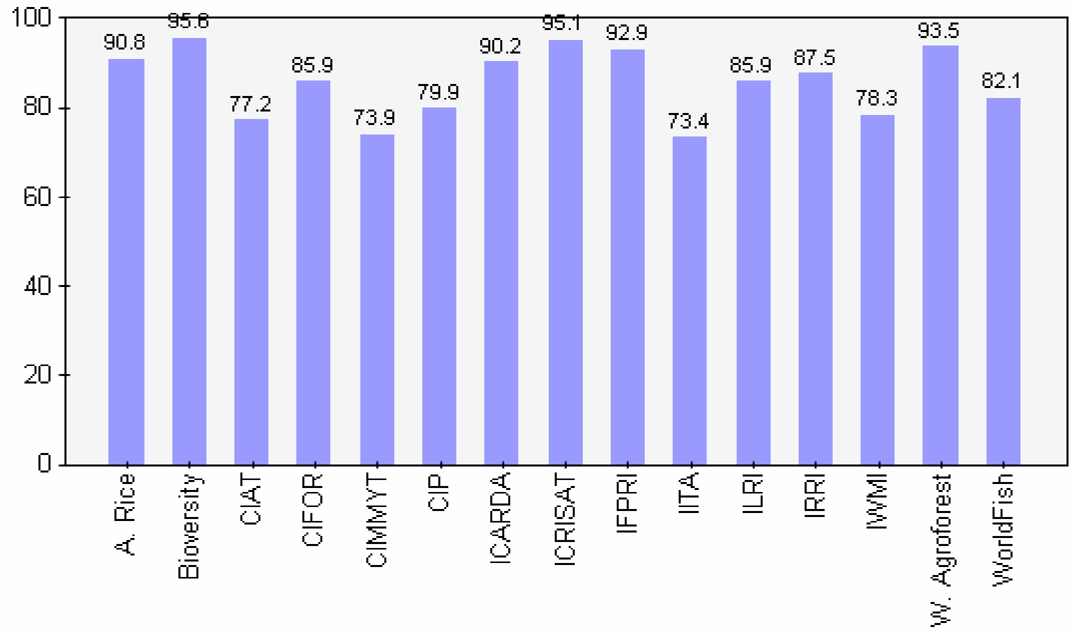
INDICATOR 5E:
IRS Nationality concentration: Percentage of internationally-recruited staff that comes from the top two countries represented in the IRS staff nationality list for the Center (as of December 31, 2008).
Please also indicate the Nationality.

Requested Evidence Material:
List of IRS staff names and country of nationality

Governance

INDICATOR 5A: Composite Score on Governance Checklist

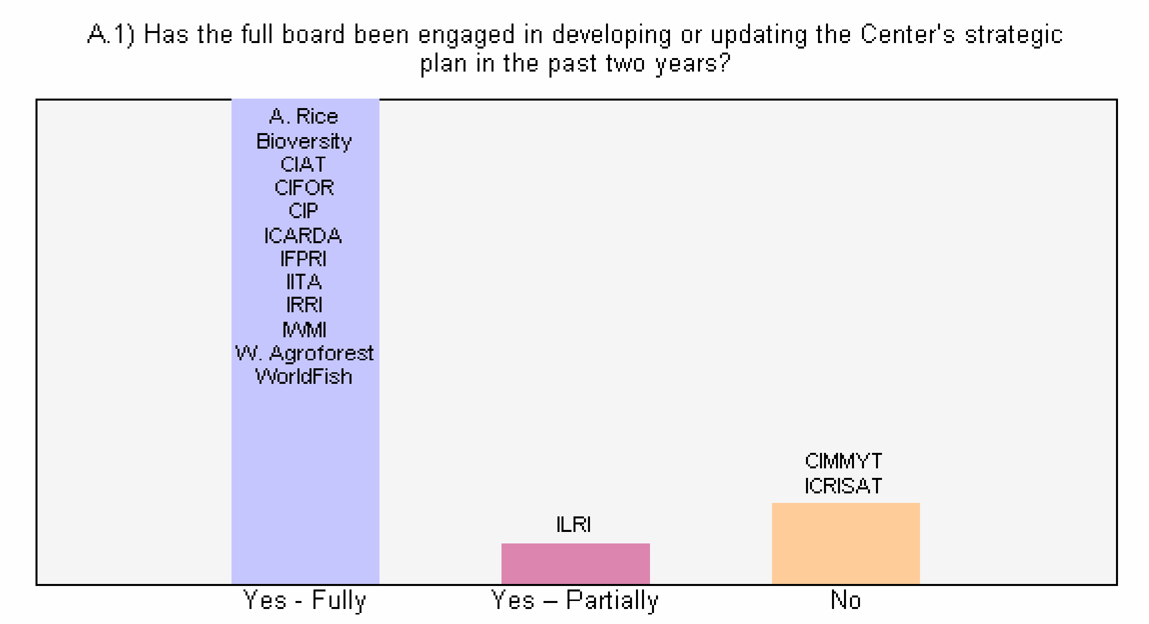
INDICATOR 5A: Overall Score on Governance Checklist - 2008

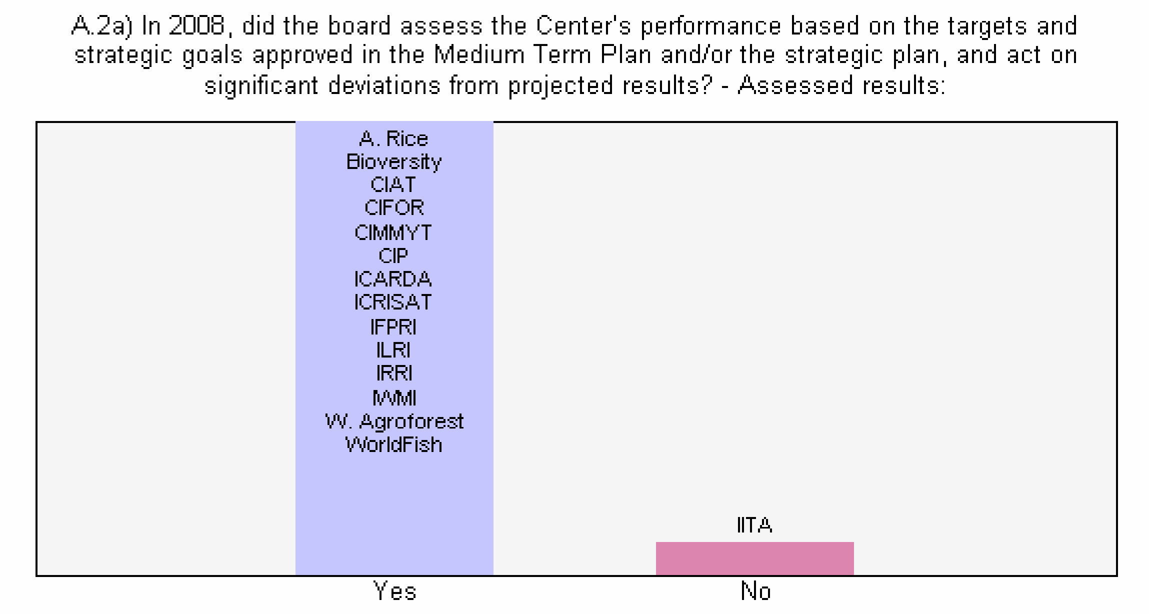


Center	Score
A. Rice	90.8
Bioversity	95.6
CIAT	77.2
CIFOR	85.9
CIMMYT	73.9
CIP	79.9
ICARDA	90.2
ICRISAT	95.1
IFPRI	92.9
IITA	73.4
ILRI	85.9
IRRI	87.5
IWMI	78.3

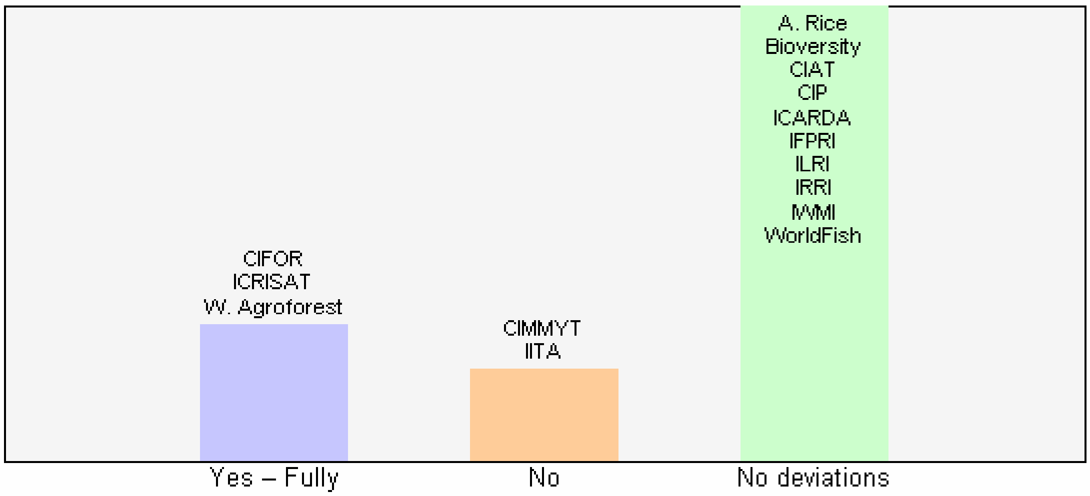
W. Agroforest	93.5
WorldFish	82.1

Checklist on Center Governance – 2008

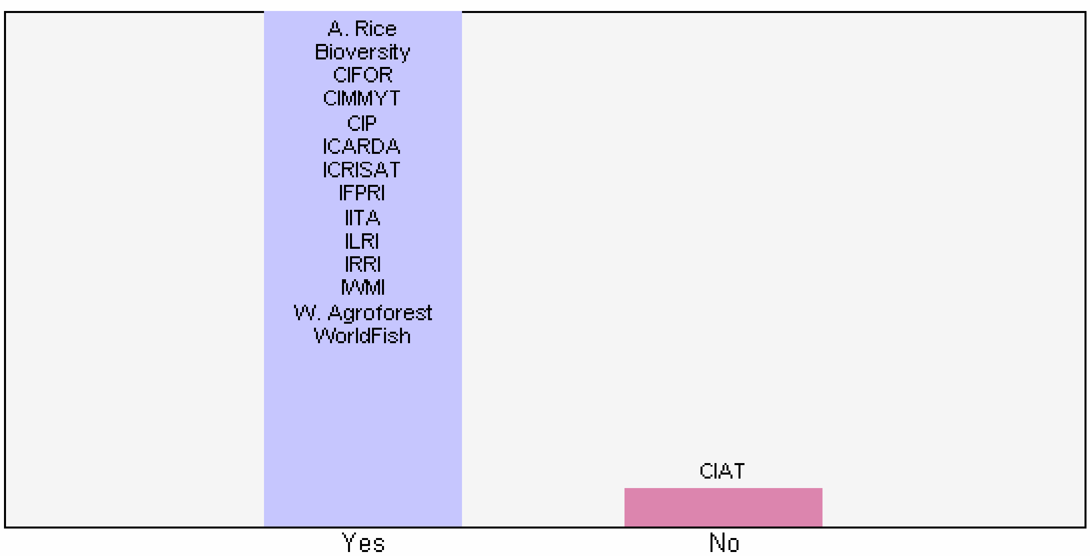




A.2b) In 2008, did the board assess the Center's performance based on the targets and strategic goals approved in the Medium Term Plan and/or the strategic plan, and act on significant deviations from projected results? - Acted on significant deviations:



A.3) Does the board have an approved schedule for CCERs on program matters?



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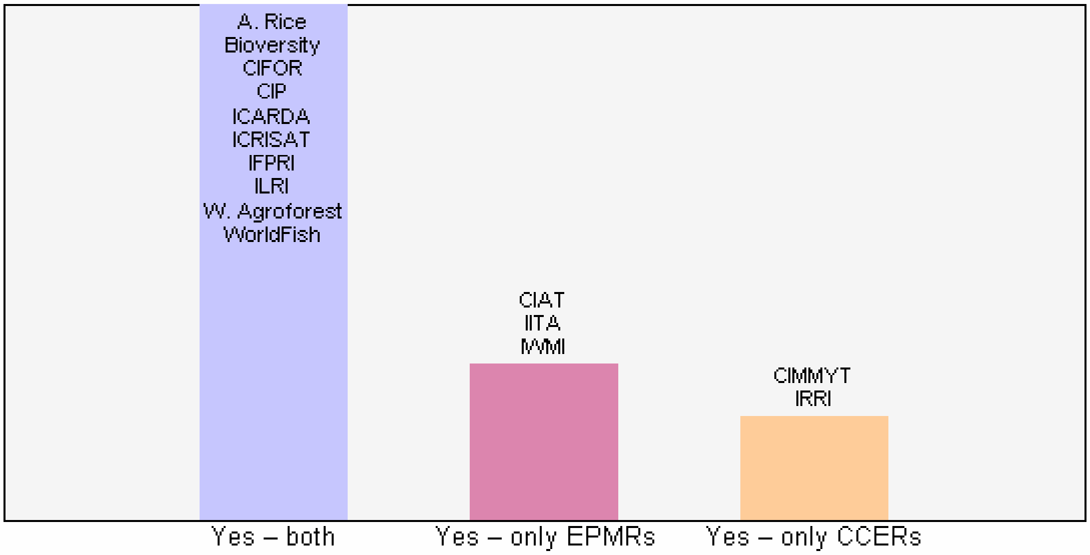
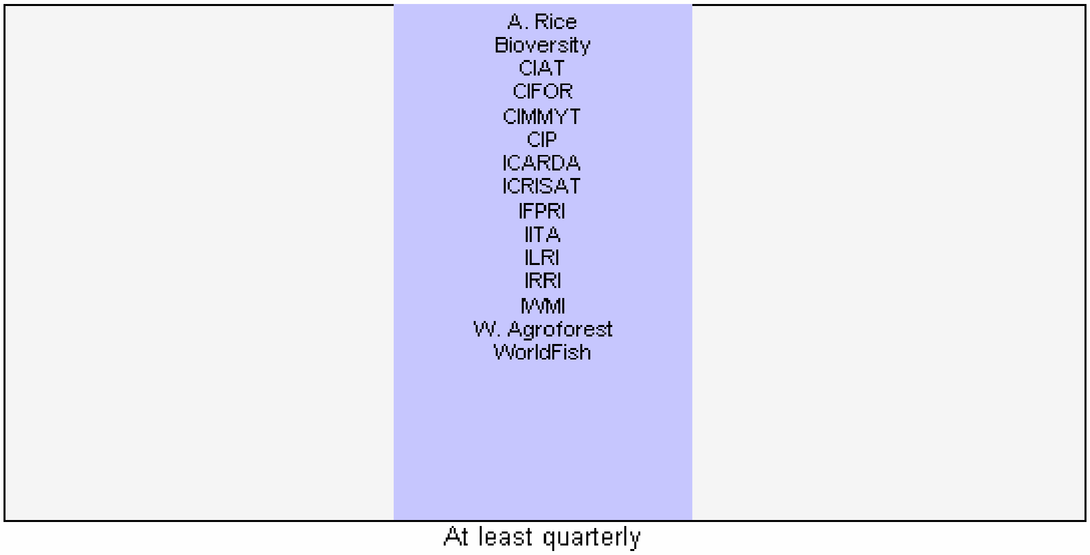
A.4) In 2008, did the board monitor actions taken in response to CCERs and EPMRs?



A.5) How often does the full board receive information on key financial indicators?



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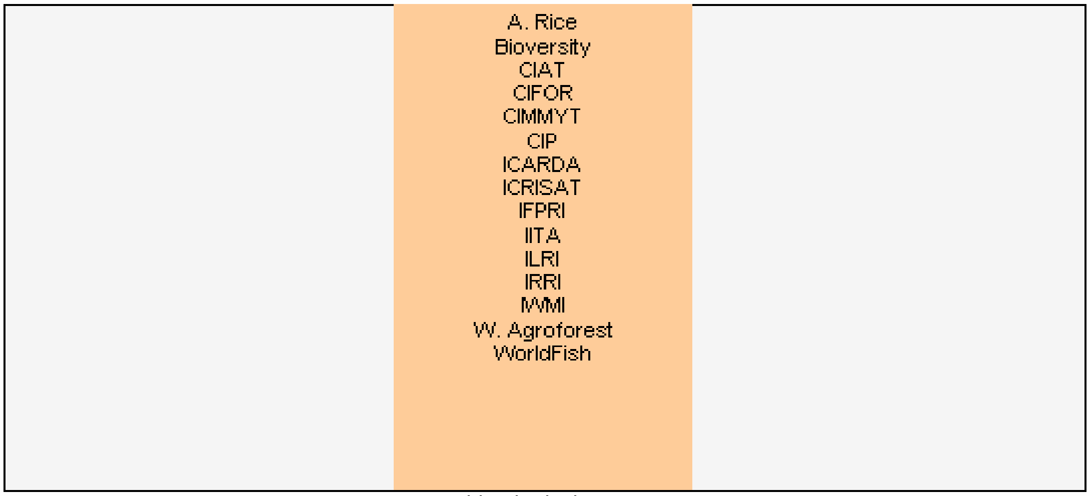
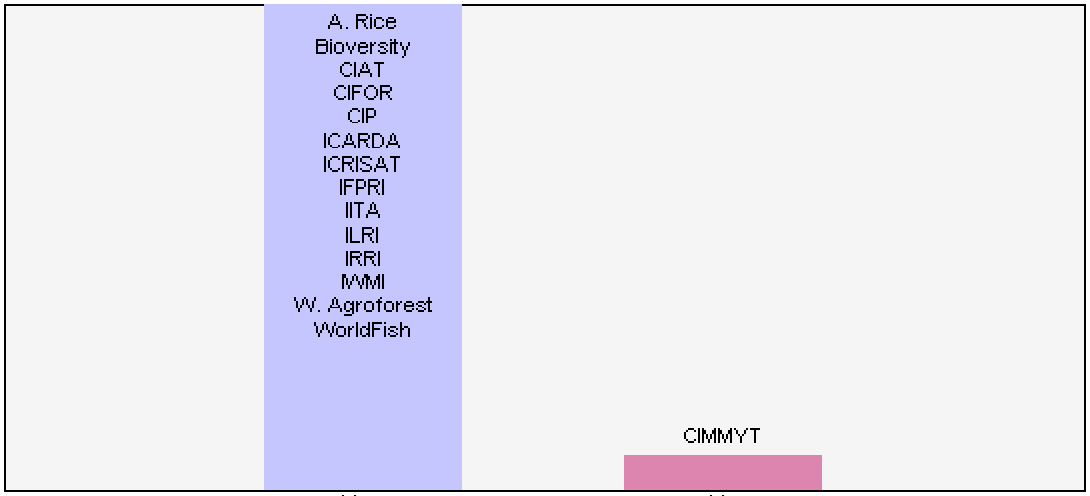
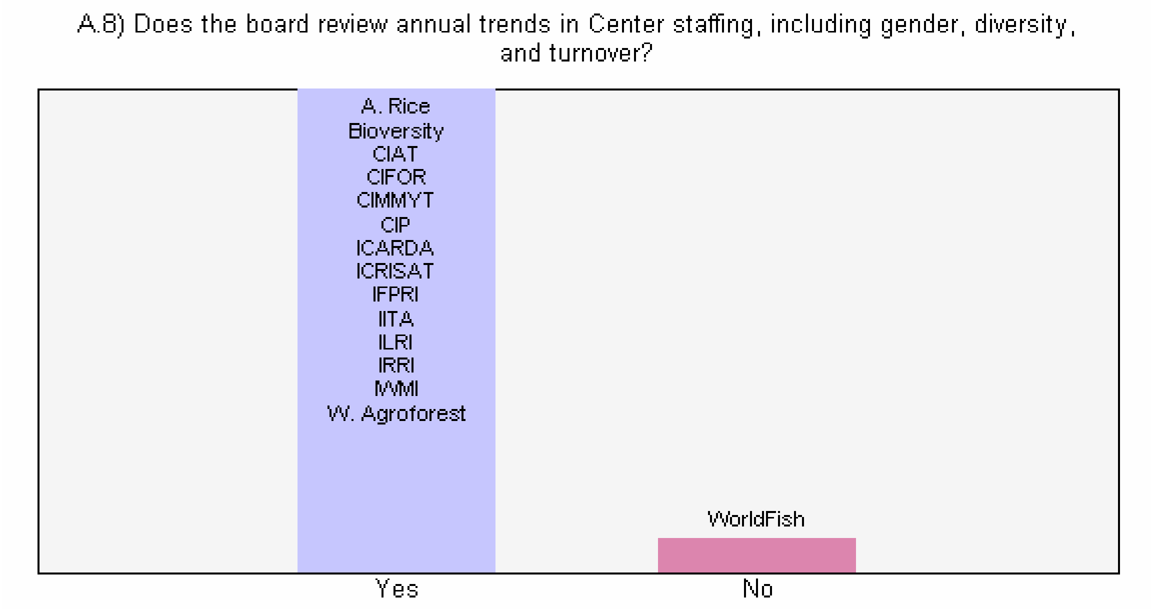
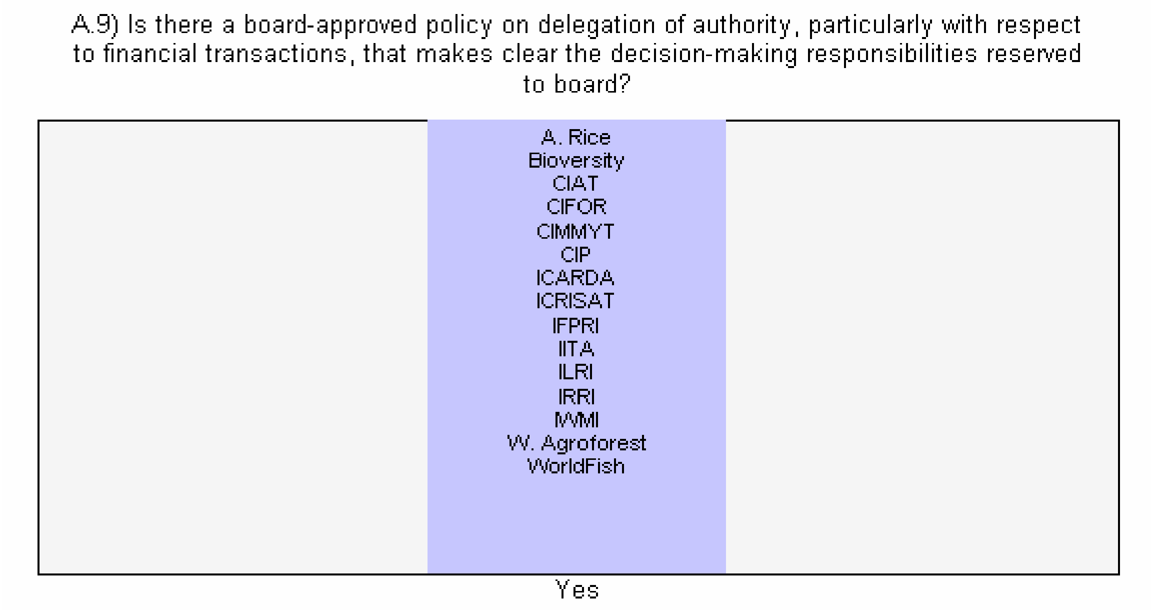
A.6) In 2008, did the board act on any significant deviations (10% +/--) from the approved budget?



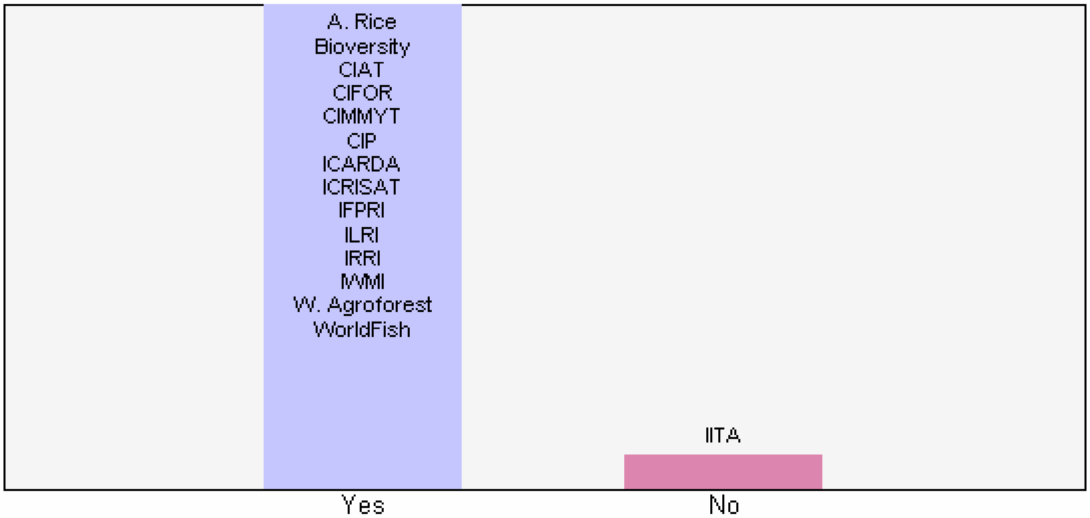
A.7) Did the full board participate in the annual performance appraisal of the DG, including decisions on compensation?



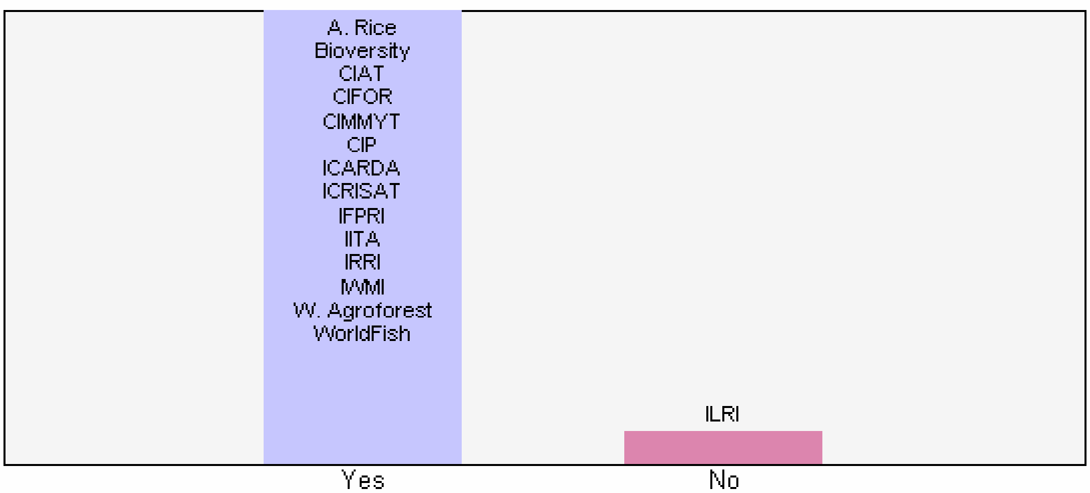

A.8) Does the board review annual trends in Center staffing, including gender, diversity, and turnover?
A. Rice
Bioversity
CIAT
CIFOR
CIMMYT
CIP
ICARDA
ICRISAT
IFPRI
IITA
ILRI
IRRI
IWMI
W. Agroforest
WorldFish
Yes
No


A.9) Is there a board-approved policy on delegation of authority, particularly with respect to financial transactions, that makes clear the decision-making responsibilities reserved to board?
A. Rice
Bioversity
CIAT
CIFOR
CIMMYT
CIP
ICARDA
ICRISAT
IFPRI
IITA
ILRI
IRRI
IWMI
W. Agroforest
WorldFish
Yes

A.10) Has the board reviewed the adequacy of the Center's risk management and internal control mechanisms as an explicit agenda item in the past two years?



A.11) As part of planning, program evaluation or ongoing board development, did the board take the opportunity to engage directly with partners, stakeholders and beneficiaries?



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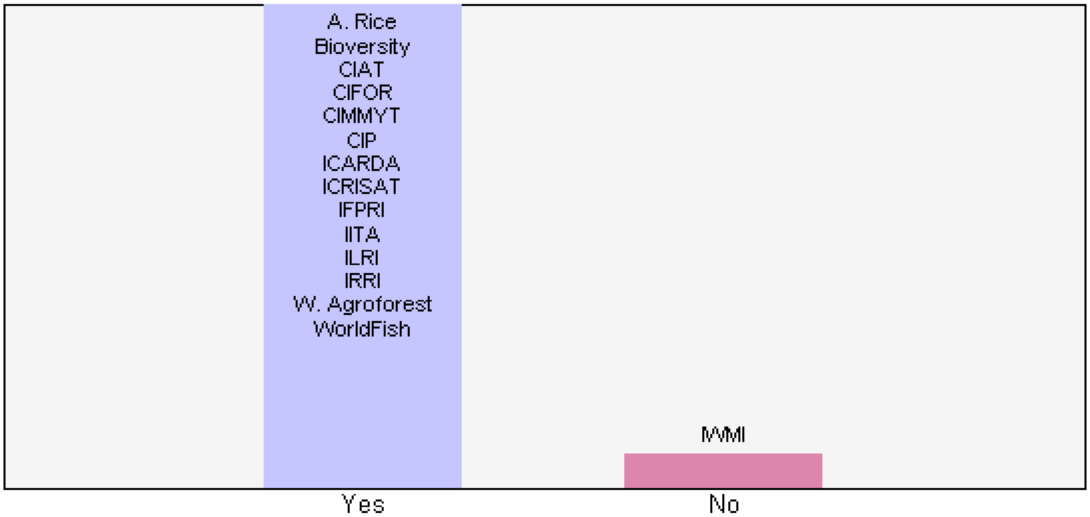
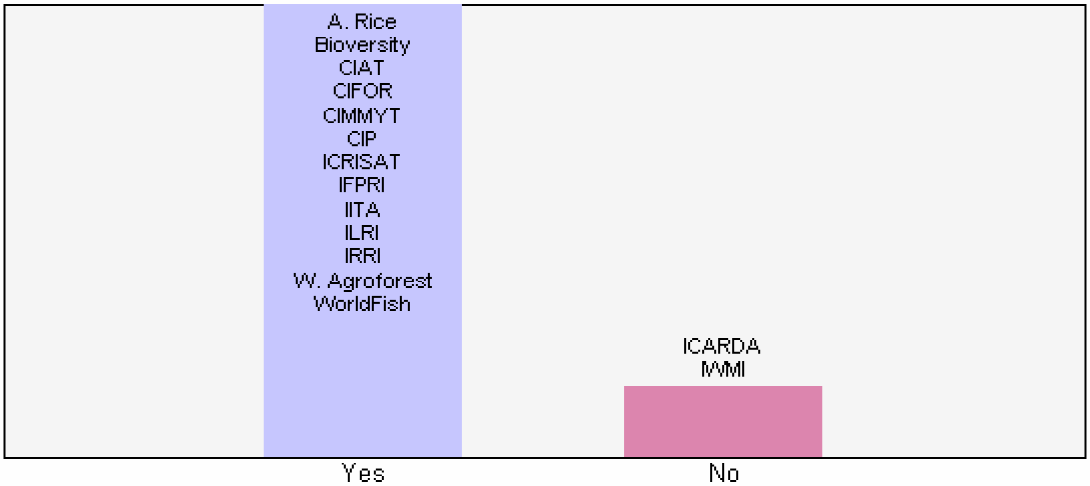
A.12) Is the role of board members in serving as ambassadors and advocates for the Center included in the terms of reference describing board member responsibilities?



A.13) Does the board have a formal mechanism for regular, independent communication with staff through meetings with staff councils or other representative staff groups?



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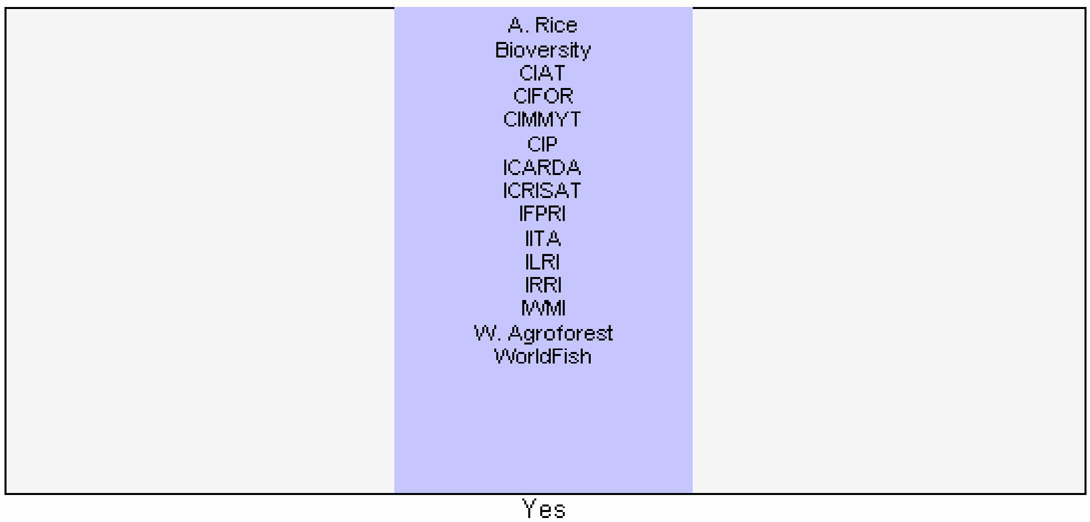
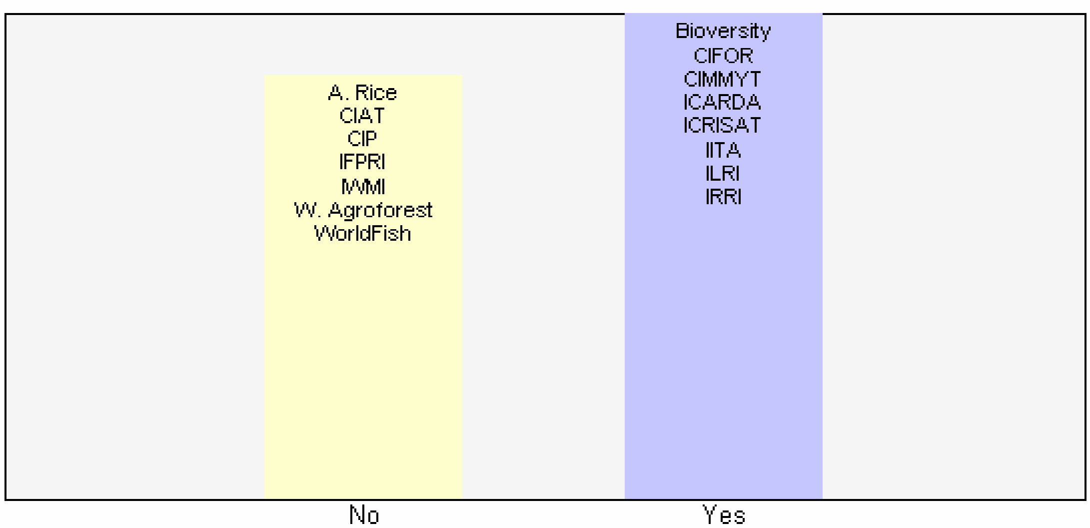
A.14.1) Is the following information publicly available on the Center's website?
Mission, vision and strategic goals



A.14.2) Is the following information publicly available on the Center's website?
Annual report (including full presentation of financials and performance indicators)



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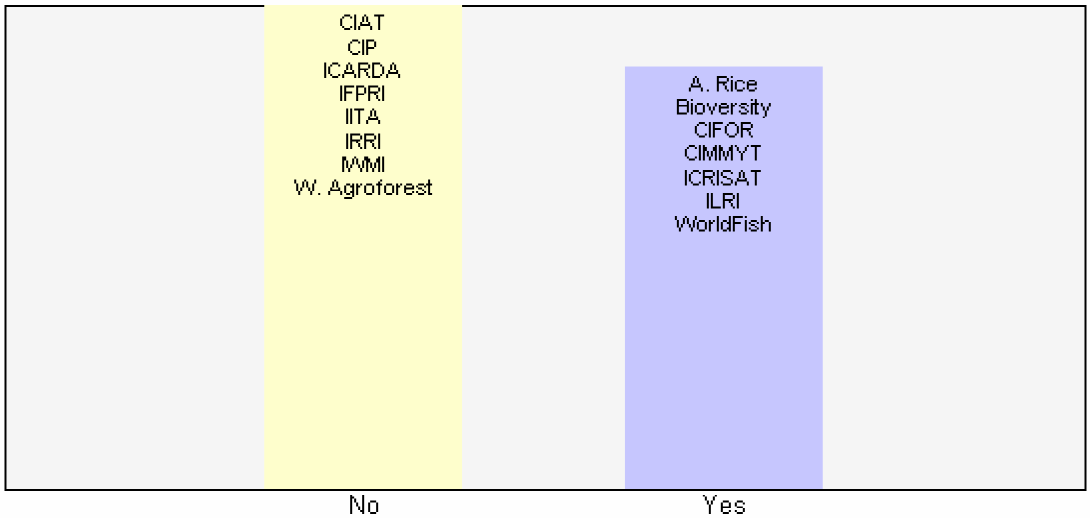
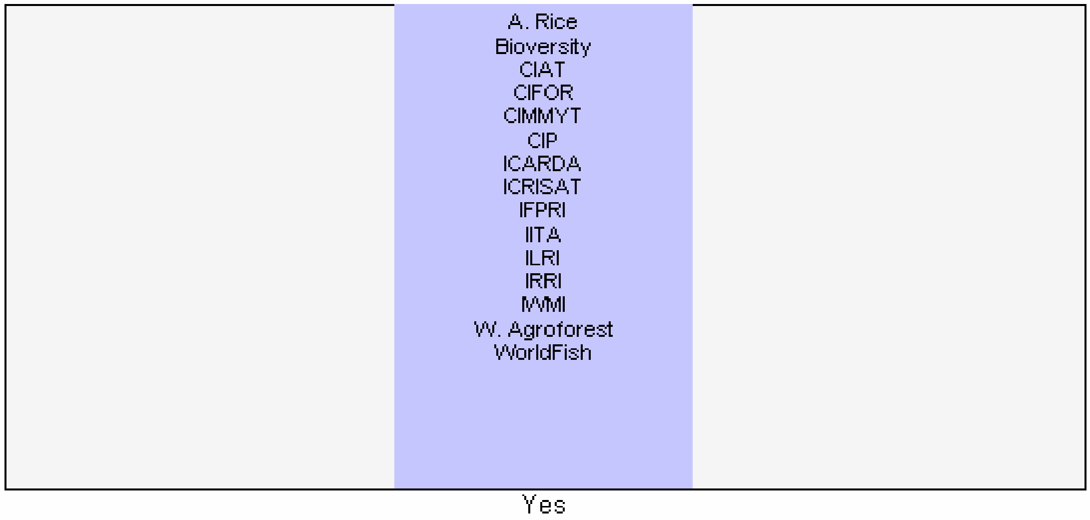
A.14.3) Is the following information publicly available on the Center's website?
Staff compensation schedule (salary scales)



A.14.4) Is the following information publicly available on the Center's website?
List of current board members with biographical information



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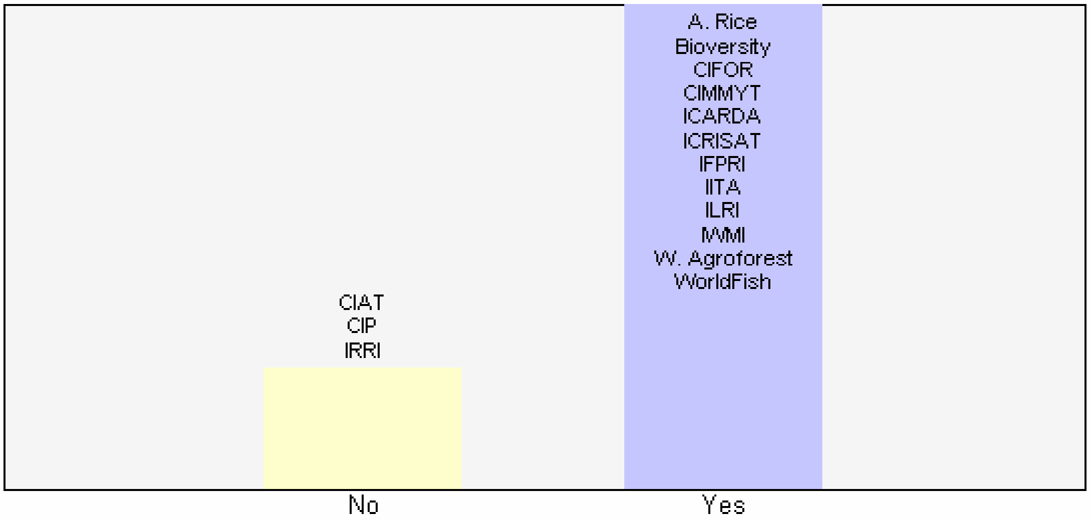
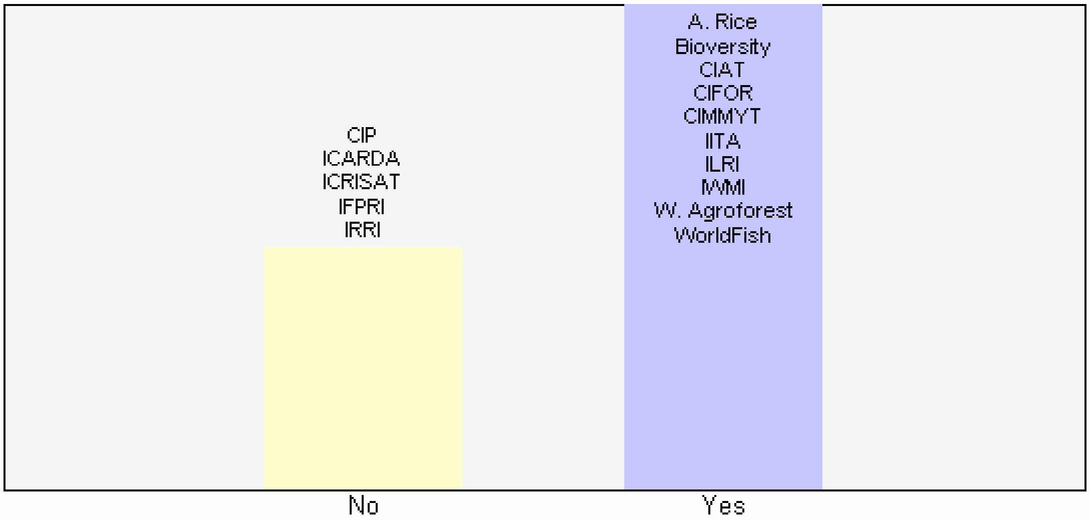
A.14.5) Is the following information publicly available on the Center's website?
Schedule of board and executive committee meetings



A.14.6) Is the following information publicly available on the Center's website?
Archive of board meeting agendas and summaries (recommended 2 year minimum)



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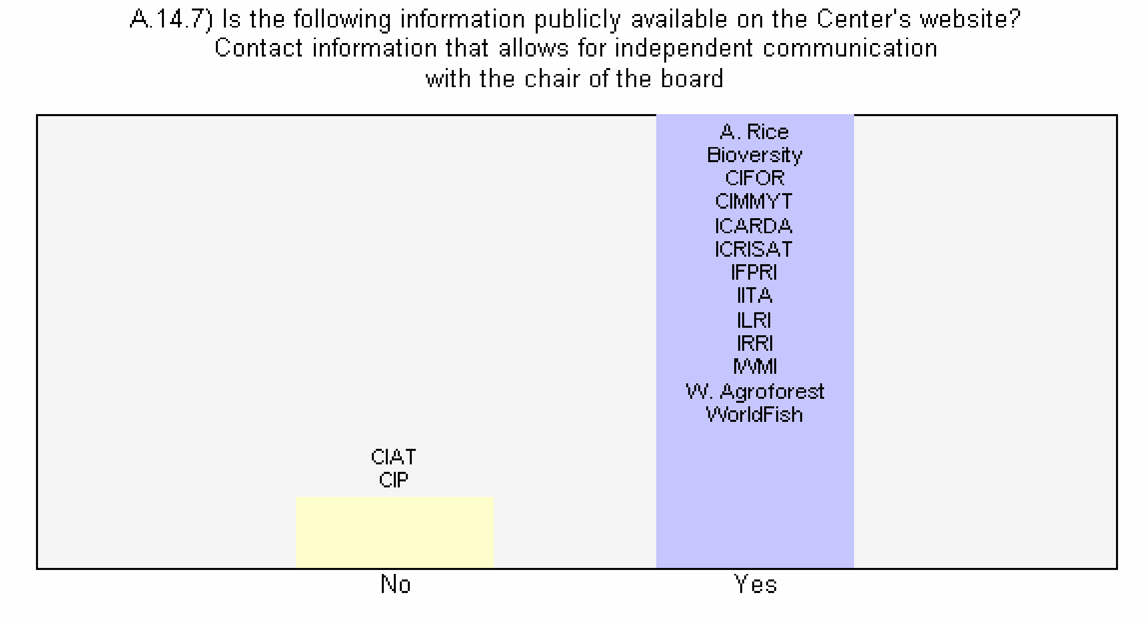

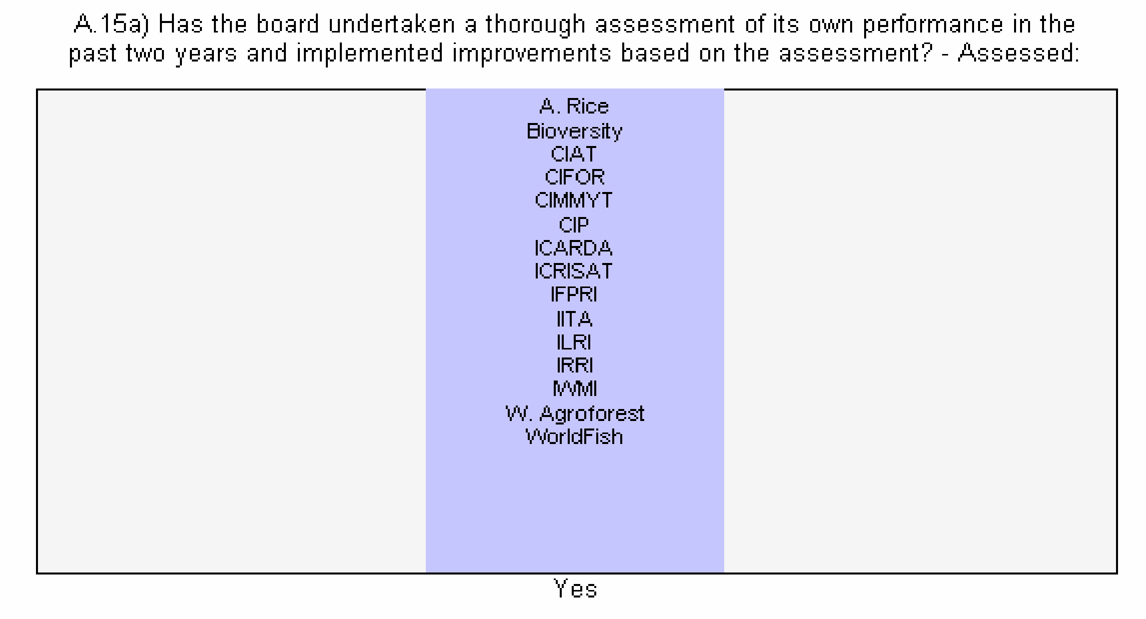

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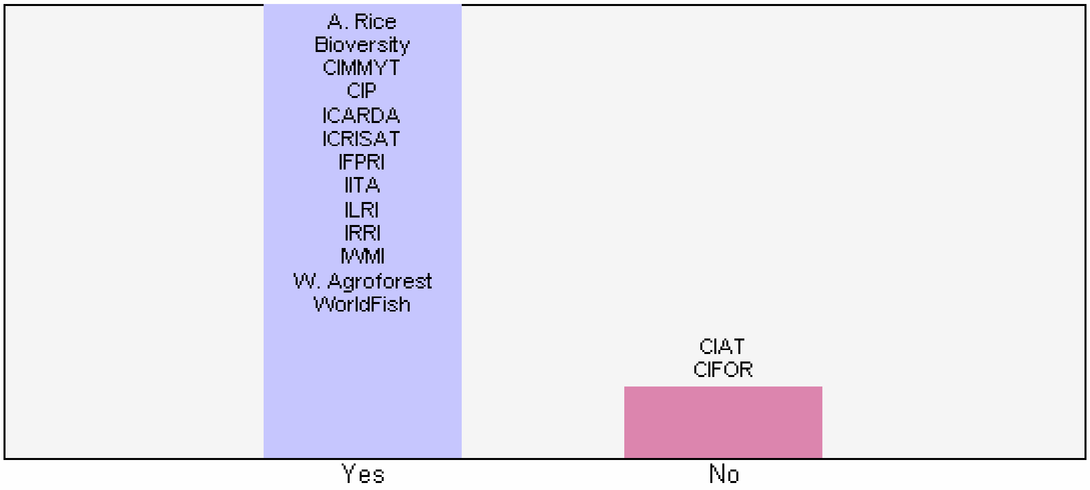
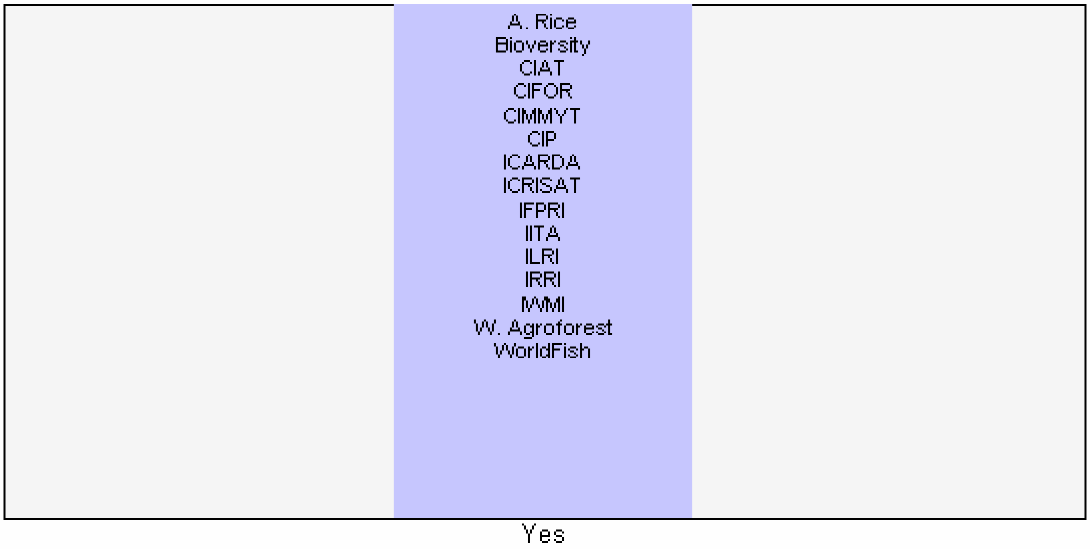
A.15b) Has the board undertaken a thorough assessment of its own performance in the past two years and implemented improvements based on the assessment? - Implemented improvements:



A.16) Does the full board perform an annual evaluation of the board chair?



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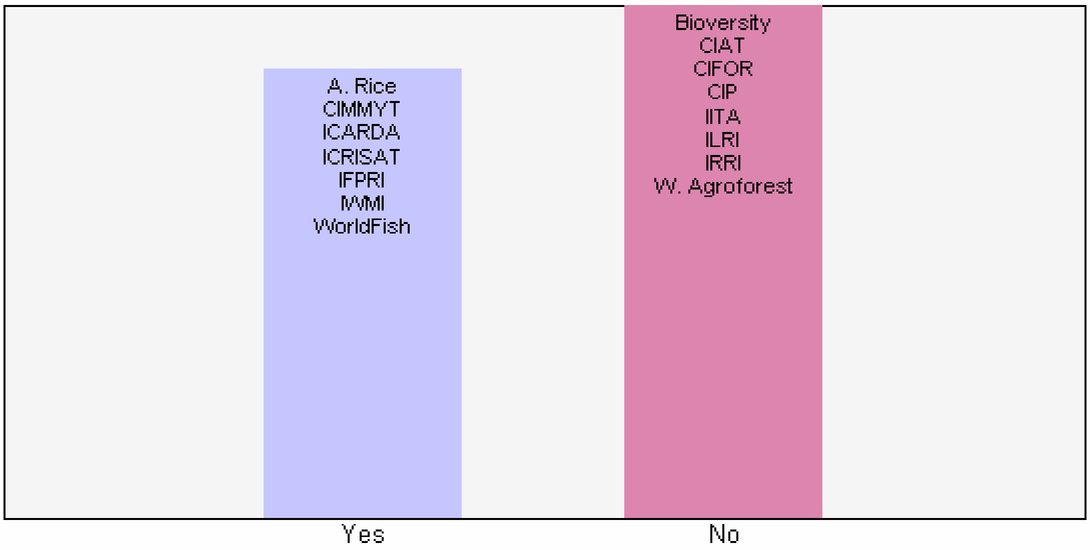
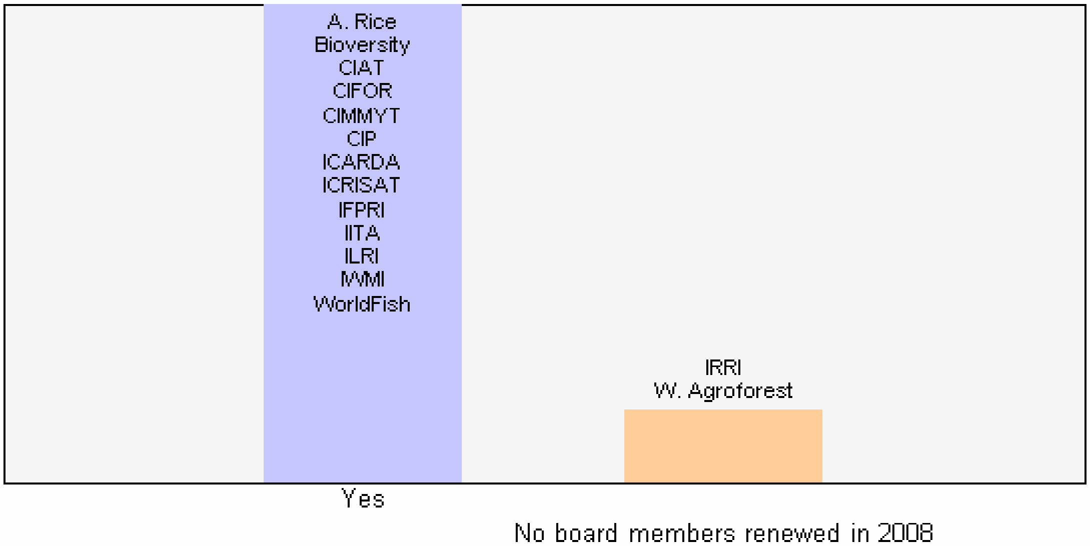
A.17) Are committee chairs evaluated by the respective committee members annually?



A.18) Was a formal evaluation of board members conducted before reappointment?



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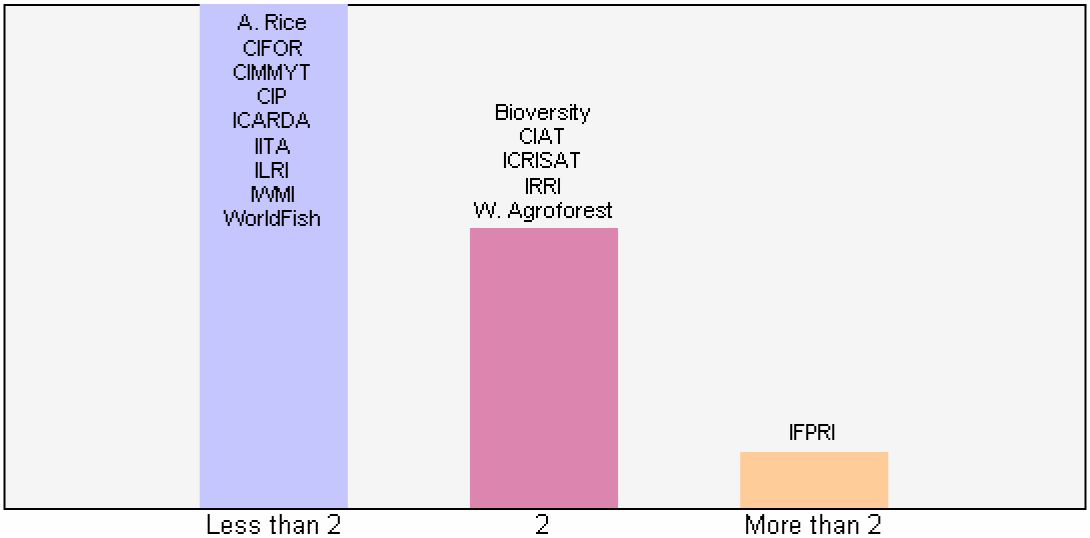
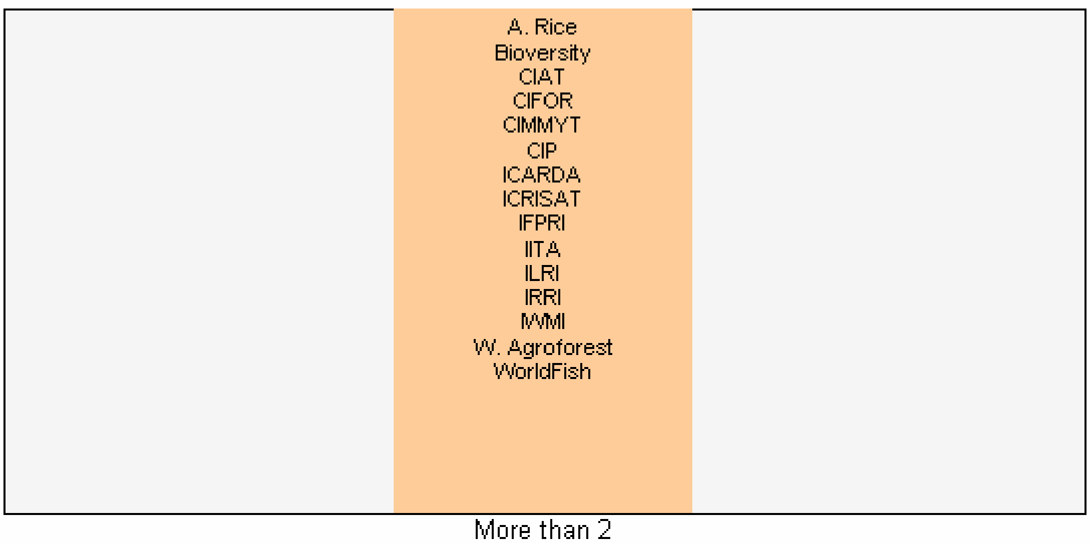
A.19) Does the board have at least two members with professional qualifications in financial management?



A.20) Does the board have at least one member with professional expertise in corporate, nonprofit or public governance?



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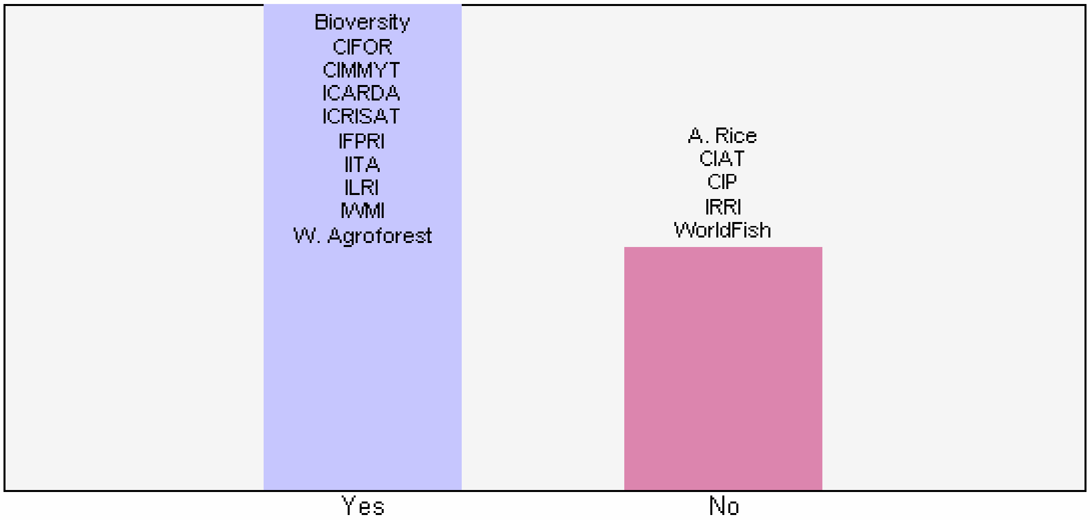
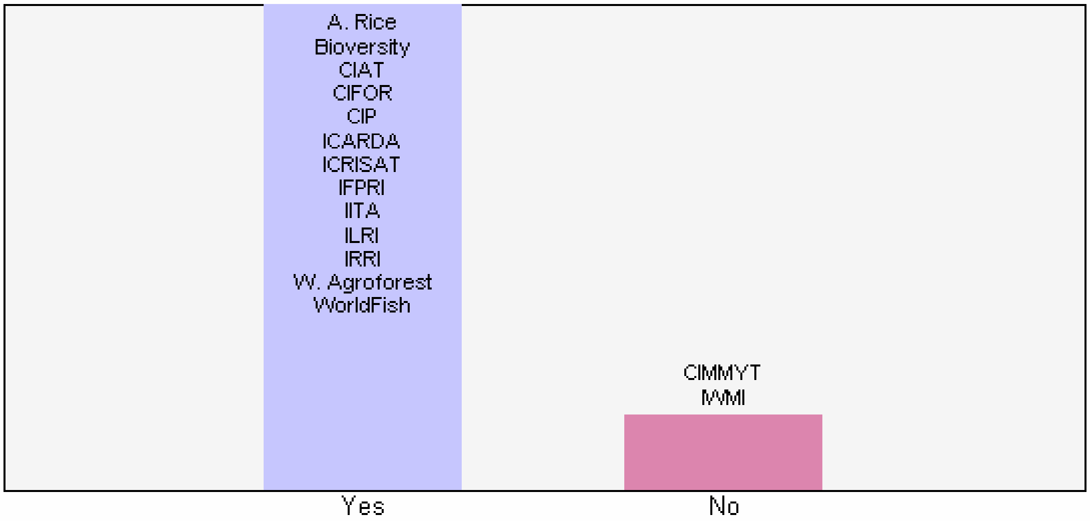
A.21a) Have all new board members (who started their terms in 2007 or earlier): - attended a CGIAR board orientation program?



A.21b) Have all new board members (who started their terms in 2007 or earlier): - attended a comprehensive Center-specific orientation program?



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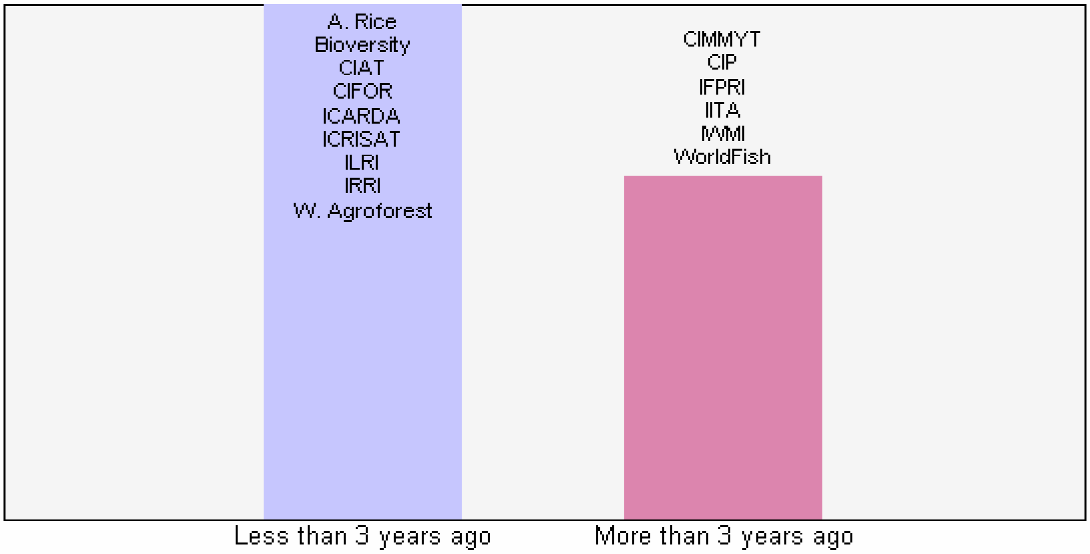
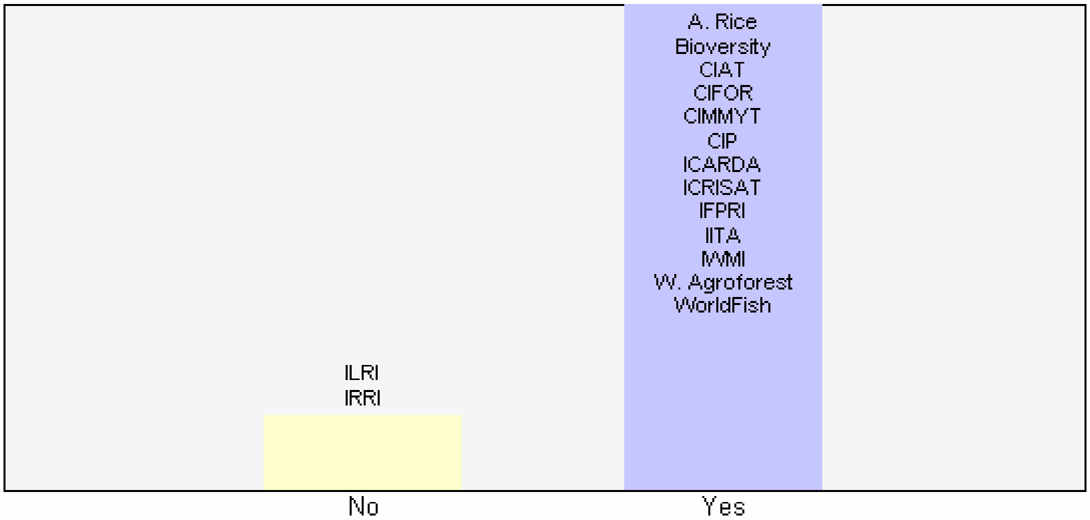
A.22) When did the board commission the last CCER on Center governance?



A.23.1) In the last two years, has the board approved or reviewed the following policies: External audit



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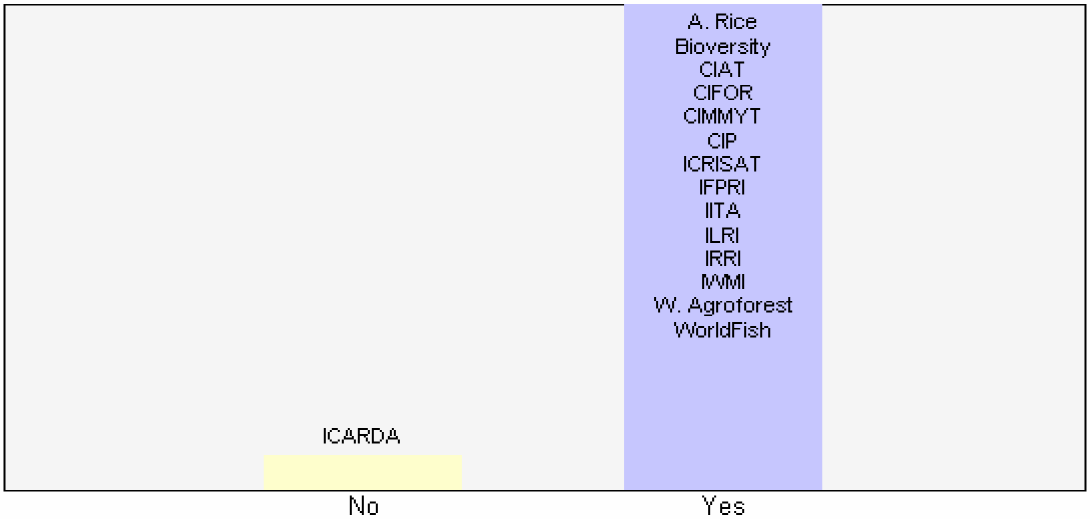
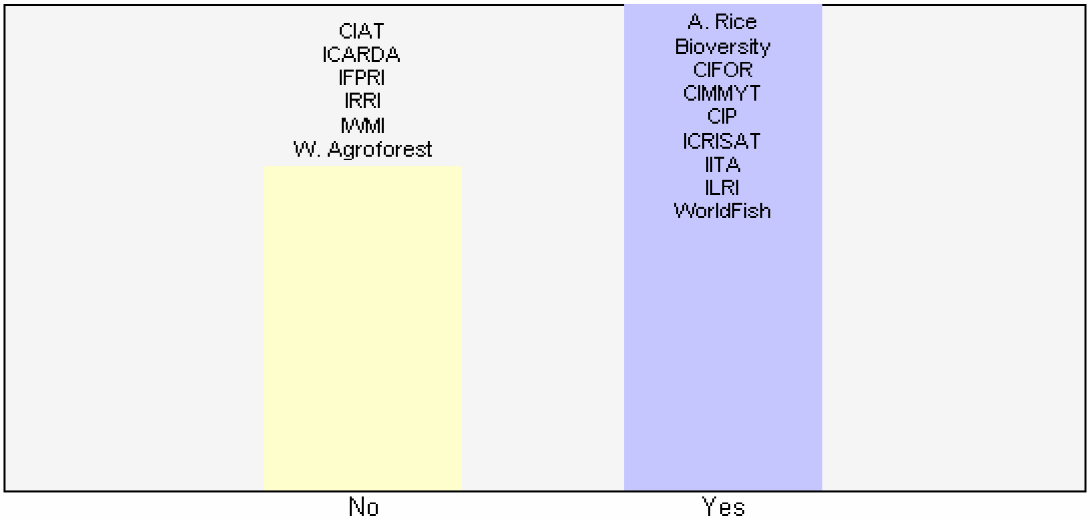
A.23.2) In the last two years, has the board approved or reviewed the following policies: Investment



A.23.3) In the last two years, has the board approved or reviewed the following policies: Procurement



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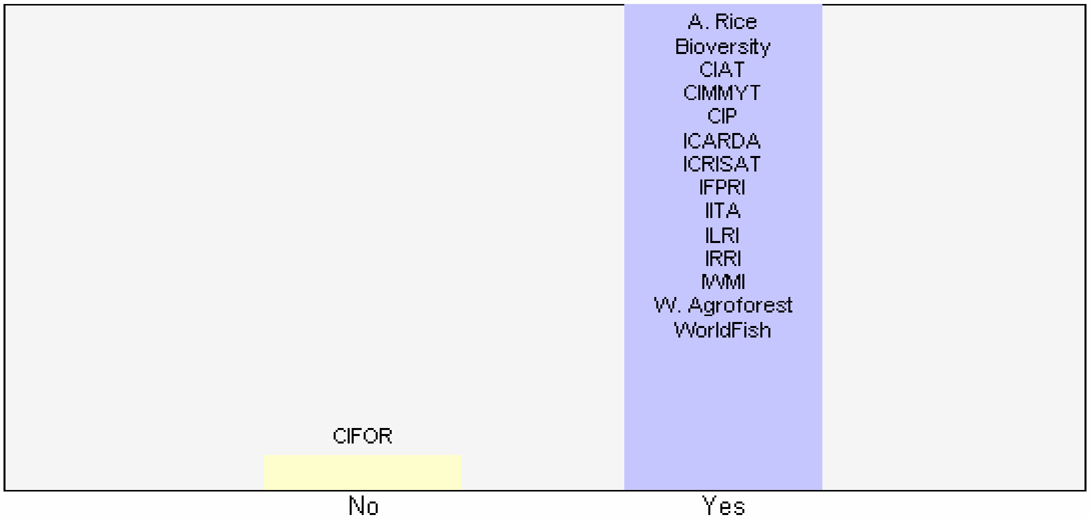
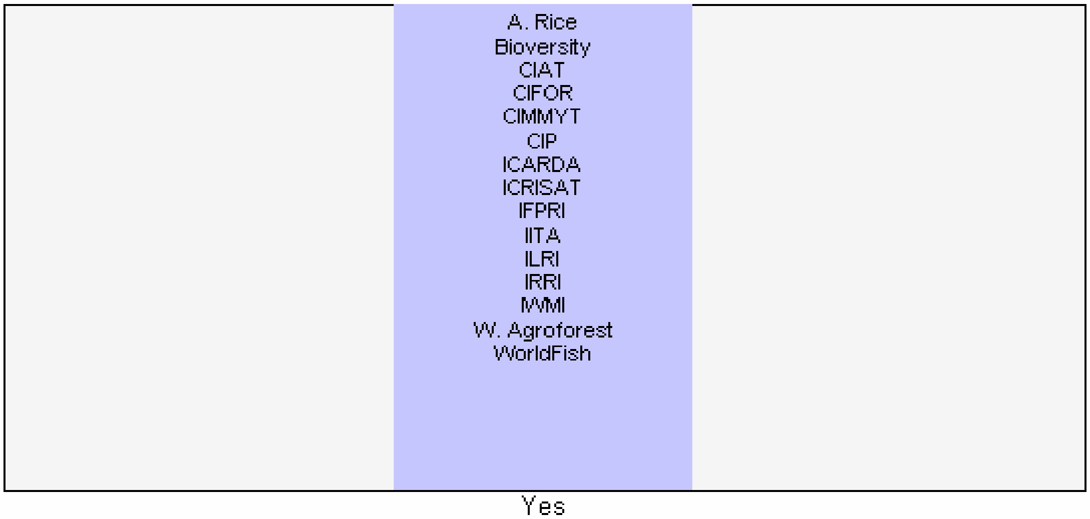
A.23.4) In the last two years, has the board approved or reviewed the following policies: HR policy (including grievance procedures)



A.23.5) In the last two years, has the board approved or reviewed the following policies: Whistle blower



CGIAR

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Performance Measurement System

	A. Rice	Bioversity	CIAT	CIFOR	CIMMYT	CIP	ICARDA	ICRISAT	IFPRI	IITA	ILRI	IRRI	IWMI	W. Agroforest	WorldFish
A.1	Yes - Fully	Yes - Fully	Yes - Fully	Yes - Fully	No	Yes - Fully	Yes - Fully	No	Yes - Fully	Yes - Fully	Yes – Partially	Yes - Fully	Yes - Fully	Yes - Fully	Yes - Fully
A.2a	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
A.2b	No deviations	No deviations	No deviations	Yes – Fully	No	No deviations	No deviations	Yes – Fully	No deviations	No	No deviations	No deviations	No deviations	Yes – Fully	No deviations
A.3	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
A.4	Yes – both	Yes – both	Yes – only EPMRs	Yes – both	Yes – only CCERs	Yes – both	Yes – both	Yes – both	Yes – both	Yes – only EPMRs	Yes – both	Yes – only CCERs	Yes – only EPMRs	Yes – both	Yes – both
A.5	At least quarterly	At least quarterly	At least quarterly	At least quarterly	At least quarterly	At least quarterly	At least quarterly	At least quarterly	At least quarterly	At least quarterly	At least quarterly	At least quarterly	At least quarterly	At least quarterly	At least quarterly
A.6	No deviations	No deviations	No deviations	No deviations	No deviations	No deviations	No deviations	No deviations	No deviations	No deviations	No deviations	No deviations	No deviations	No deviations	No deviations
A.7	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
A.8	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
A.9	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
A.10	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
A.11	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
A.12	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
A.13	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
A.14.1	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
A.14.2	No	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes	Yes	No	No	No
A.14.3	Yes	Yes	No	Yes	Yes	No	No	Yes	No	No	Yes	No	No	No	Yes
A.14.4	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
A.14.5	Yes	Yes	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
A.14.6	Yes	Yes	Yes	Yes	Yes	No	No	No	No	Yes	Yes	No	Yes	Yes	Yes
A.14.7	Yes	Yes	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
A.15a	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
A.15b	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
A.16	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
A.17	Yes	No	No	No	Yes	No	Yes	Yes	Yes	No	No	No	Yes	No	Yes

Consultative Group on International Agricultural Research
Performance Measurement System

A.18	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No board member s renewed in 2008	Yes	No board members renewed in 2008	Yes
A.19	Less than 2	2	2	Less than 2	Less than 2	Less than 2	Less than 2	2	More than 2	Less than 2	Less than 2	2	Less than 2	2	Less than 2
A.20	More than 2	More than 2	More than 2	More than 2	More than 2	More than 2	More than 2	More than 2	More than 2	More than 2	More than 2	More than 2	More than 2	More than 2	More than 2
A.21a	No	Yes	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No
A.21b	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
A.22	Less than 3 years ago	Less than 3 years ago	Less than 3 years ago	Less than 3 years ago	More than 3 years ago	More than 3 years ago	Less than 3 years ago	Less than 3 years ago	More than 3 years ago	More than 3 years ago	Less than 3 years ago	Less than 3 years ago	More than 3 years ago	Less than 3 years ago	More than 3 years ago
A.23.1	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes
A.23.2	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
A.23.3	Yes	Yes	No	Yes	Yes	Yes	No	Yes	No	Yes	Yes	No	No	No	Yes
A.23.4	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
A.23.5	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

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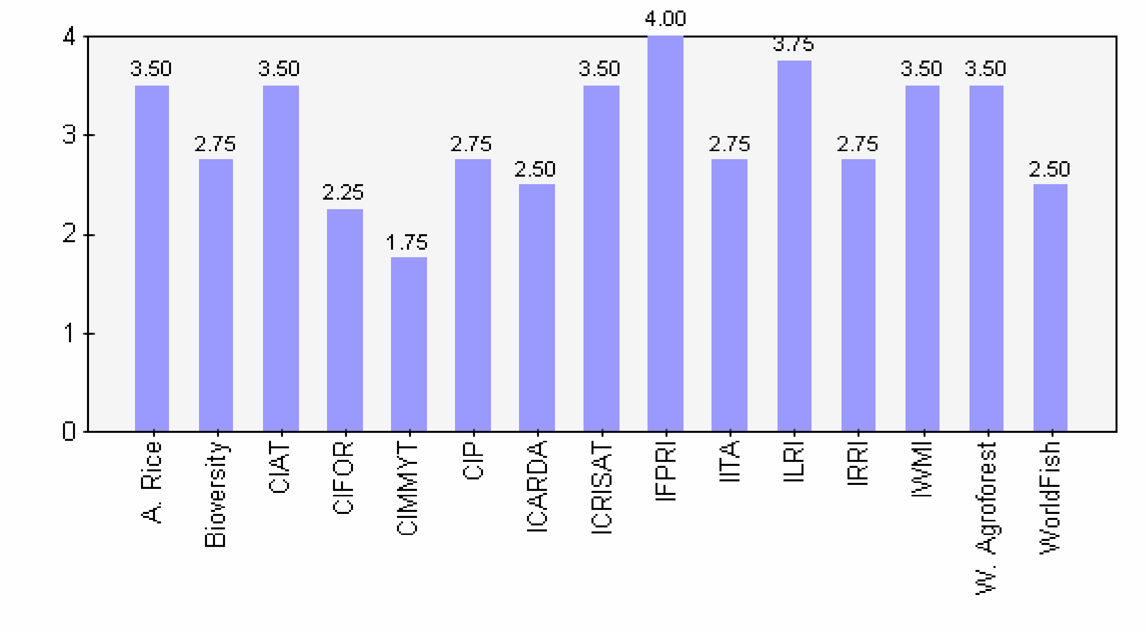
Performance Measurement System

INDICATOR 5B: Board Statements Assessment (1-4) - 2008



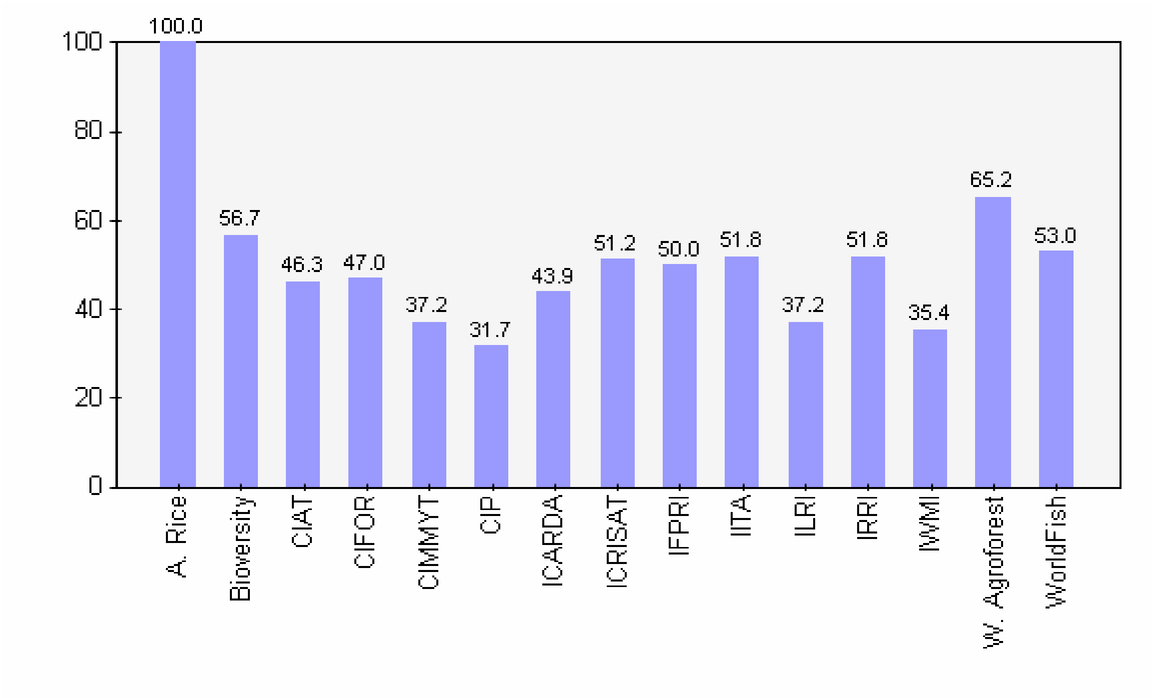
Center	Rating
A. Rice	3.5
Bioversity	2.75
CIAT	3.5
CIFOR	2.25
CIMMYT	1.75
CIP	2.75
ICARDA	2.5
ICRISAT	3.5
IFPRI	4
IITA	2.75
ILRI	3.75
IRRI	2.75
IWMI	3.5
W. Agroforest	3.5
WorldFish	2.5

Consultative Group on International Agricultural Research
Performance Measurement System

Culture of Learning and Change

INDICATOR 5A: Composite Score on Culture of Learning and Change Checklist – 2008

INDICATOR 5C: Overall Score on Culture of Learning and Change Checklist - 2008



Center	Score
A. Rice	100
Bioversity	56.7
CIAT	46.3
CIFOR	47
CIMMYT	37.2
CIP	31.7
ICARDA	43.9
ICRISAT	51.2
IFPRI	50
IITA	51.8
ILRI	37.2
IRRI	51.8
IWMI	35.4
W. Agroforest	65.2
WorldFish	53

CGIAR

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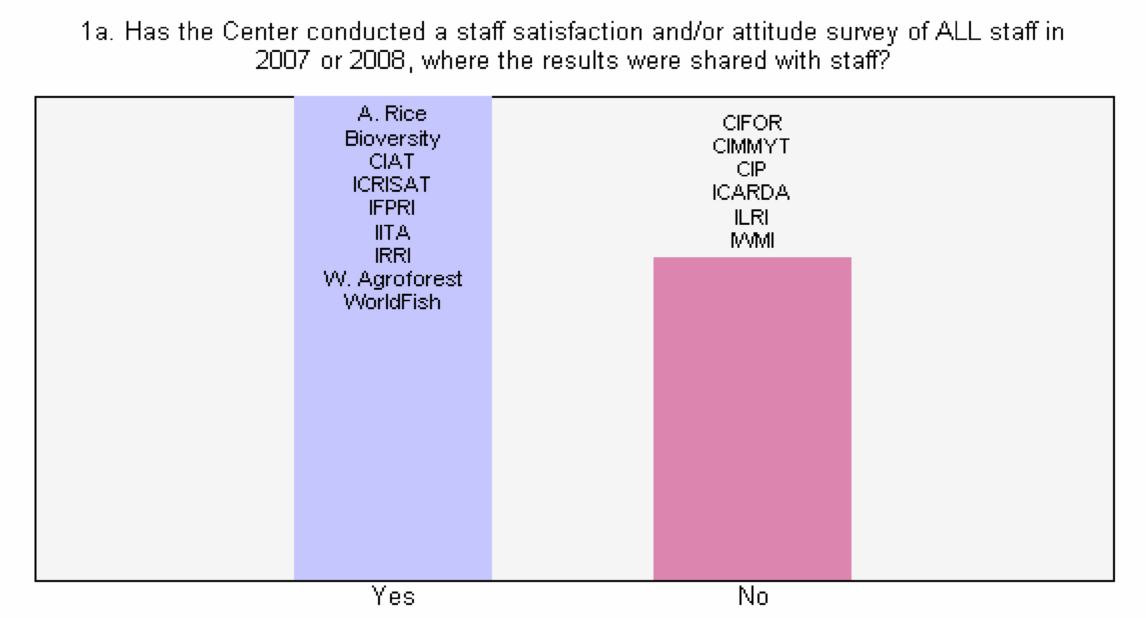
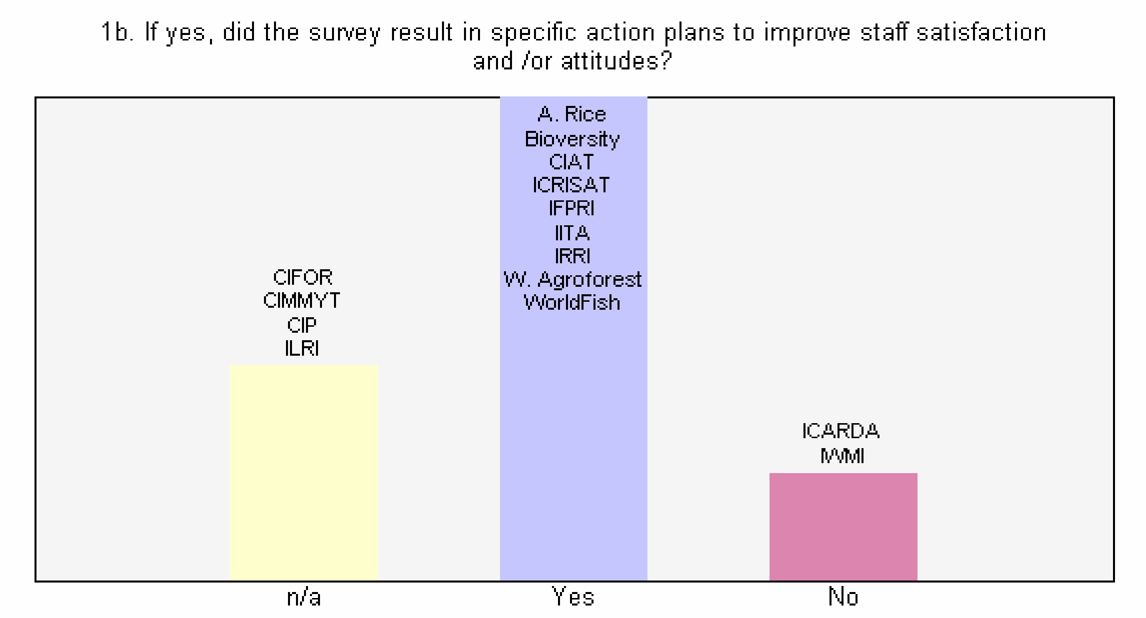
Checklist on Culture of learning and change - 2008





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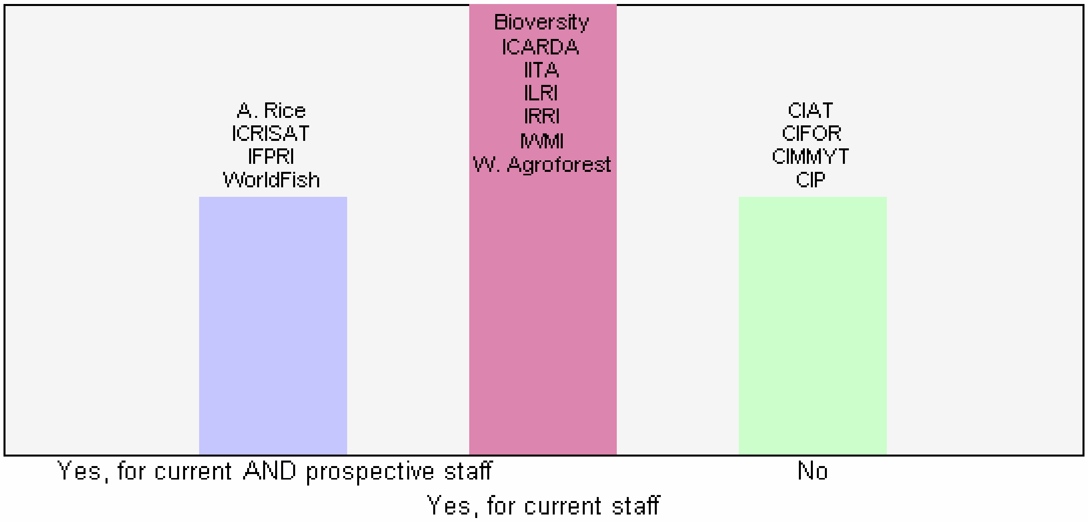
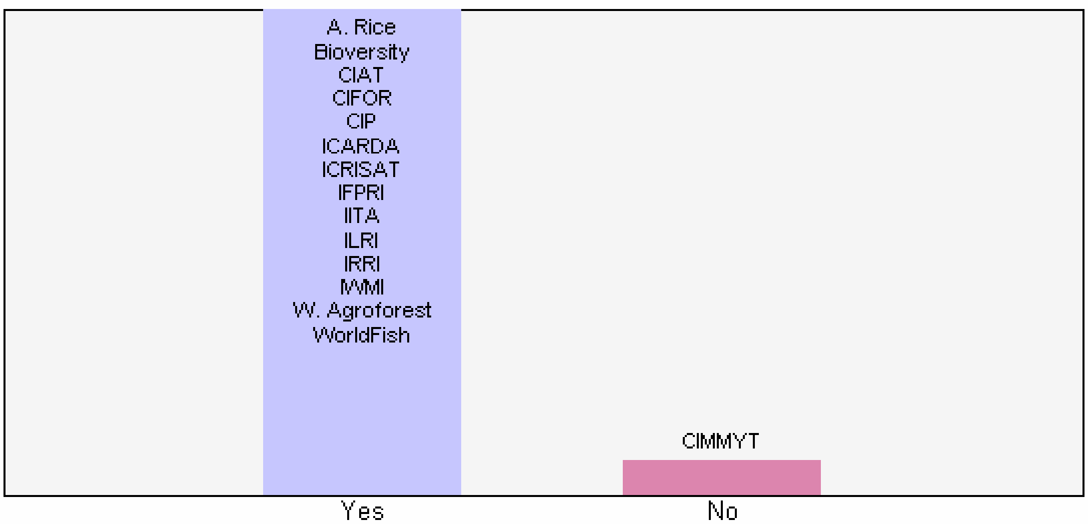
2a. Does the Center have an active leadership development program covering current and prospective staff in managerial positions?



3a. Does the staff appraisal system include the development and follow-up of annual individual learning plans?



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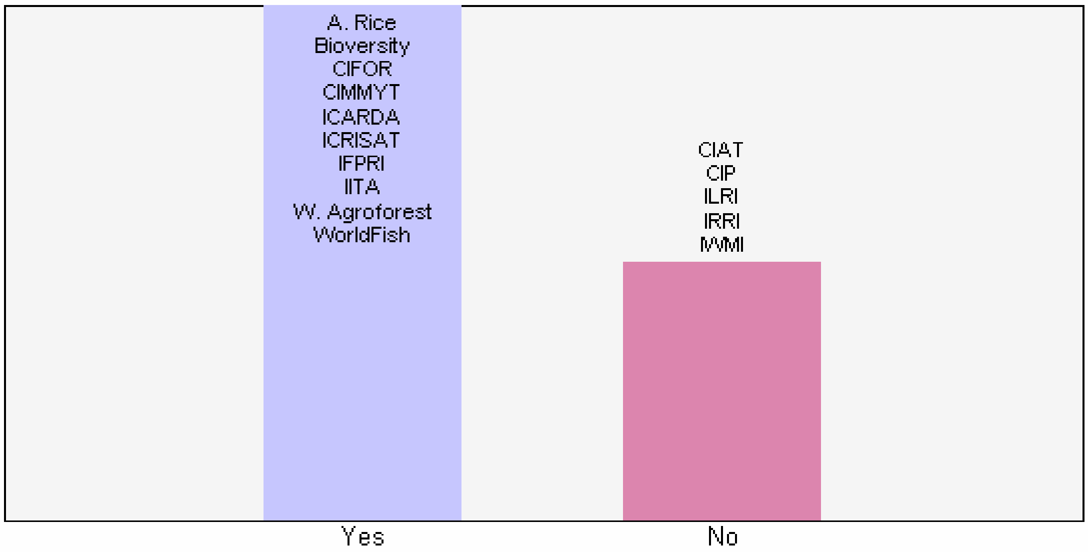
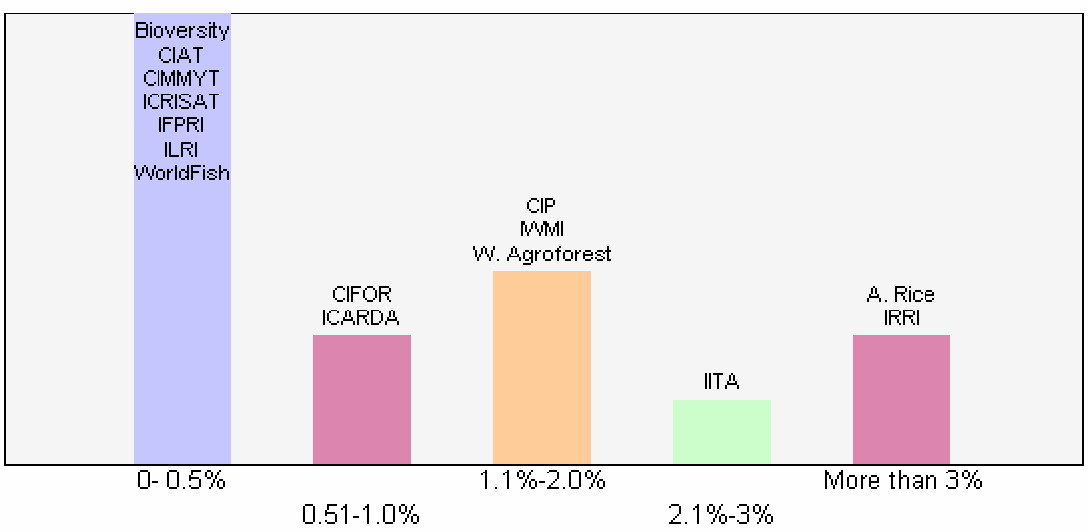
3b. Does the Center have a mentoring program for young scientists?



4a. What percentage of the overall 2008 budget was spent for attendance at international conferences or professional society meetings or for a short sabbatical at a



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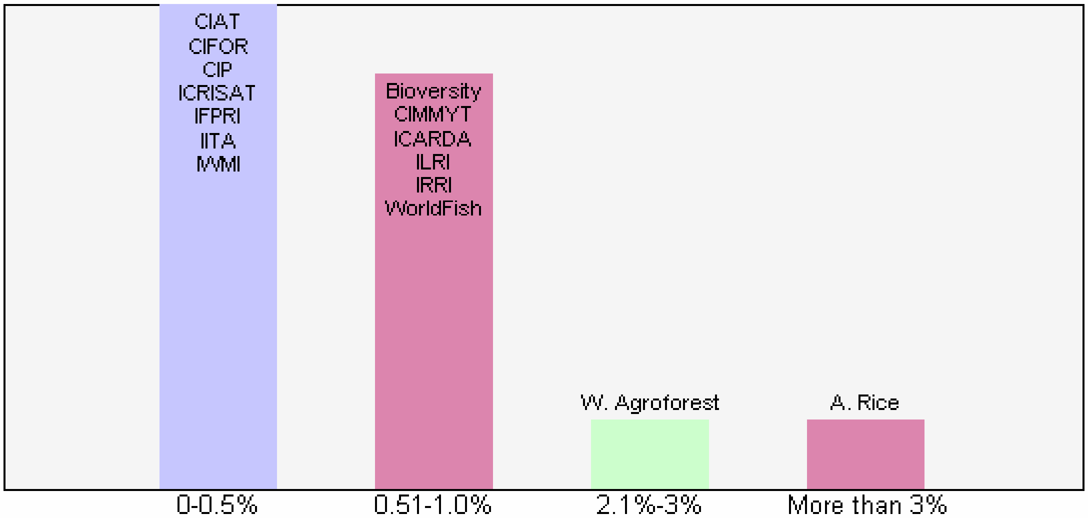
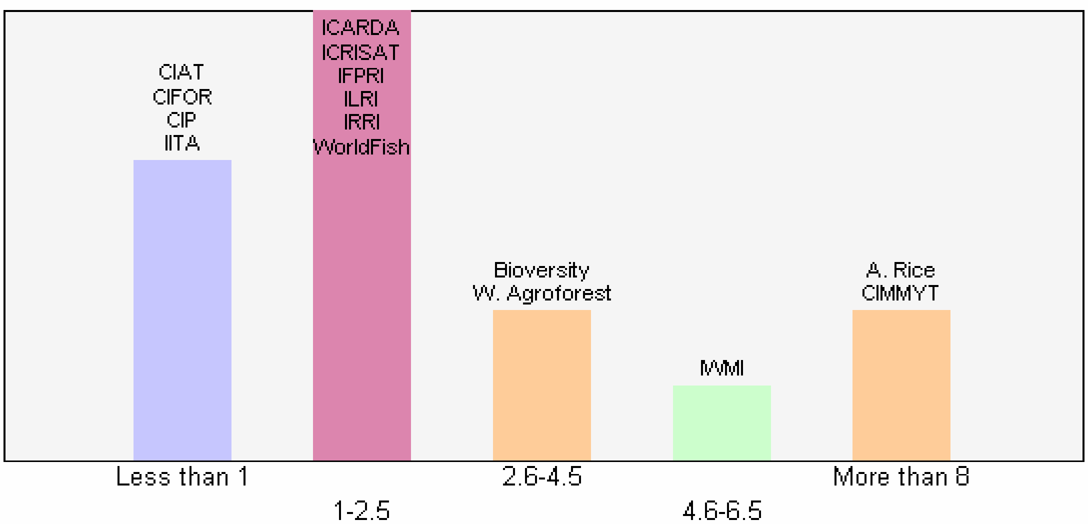
4b. What percentage of the overall 2008 budget was spent on staff training (e.g. computer, language, project management, leadership training etc.)?



4c. Considering staff training only (b), what is the total number of training days in 2008 for all IRS staff, divided by the total number of IRS staff?



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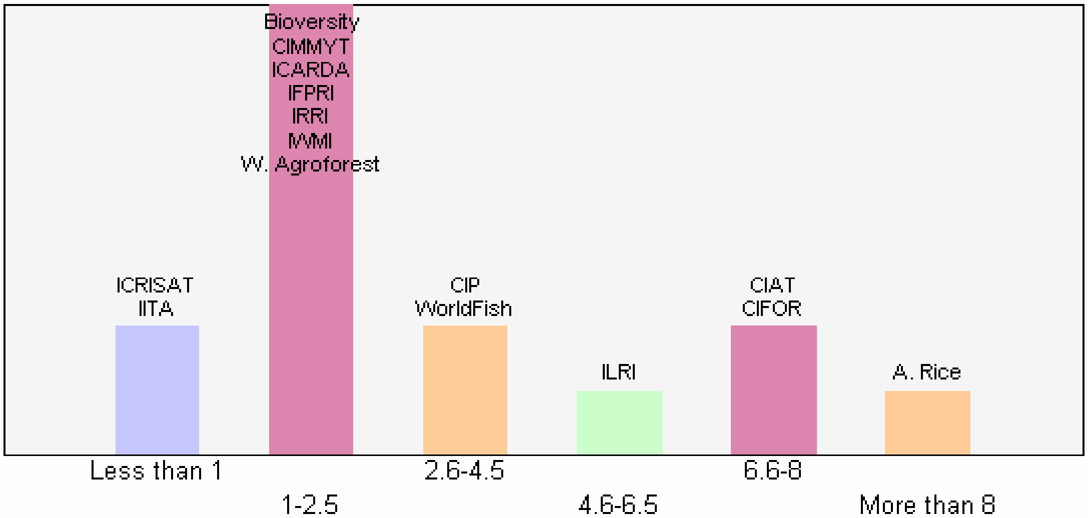
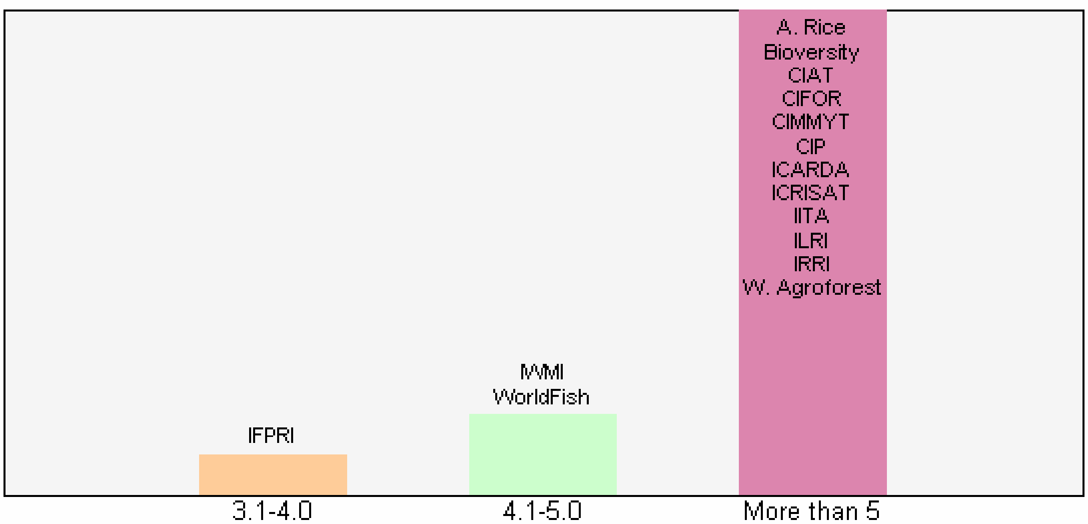
4d. Considering staff training only, what is the total number of training days in 2008 for all NRS staff, divided by the total number of NRS staff?



5a. On average, how many days did an IRS staff spend in 2008 on program planning and review?



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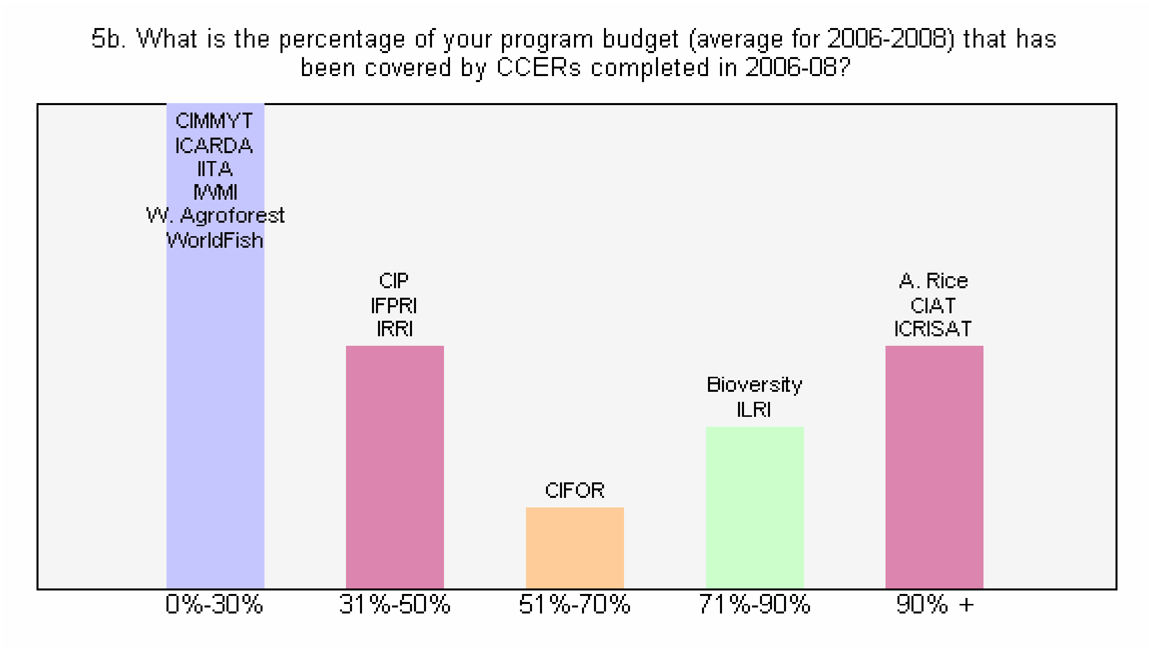

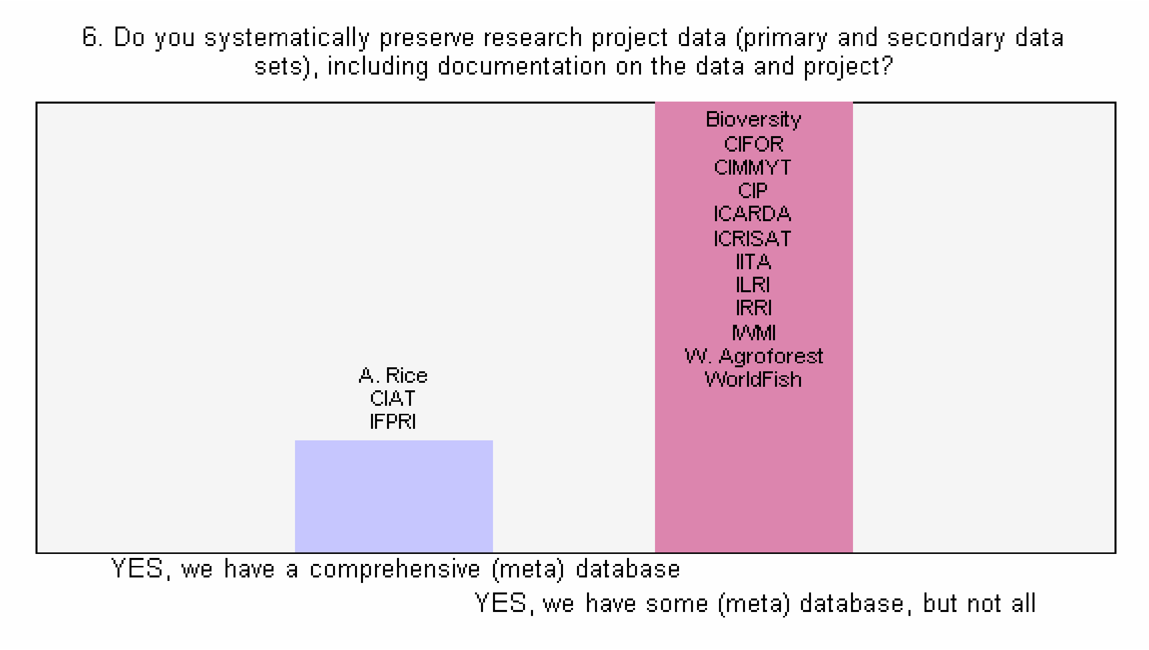

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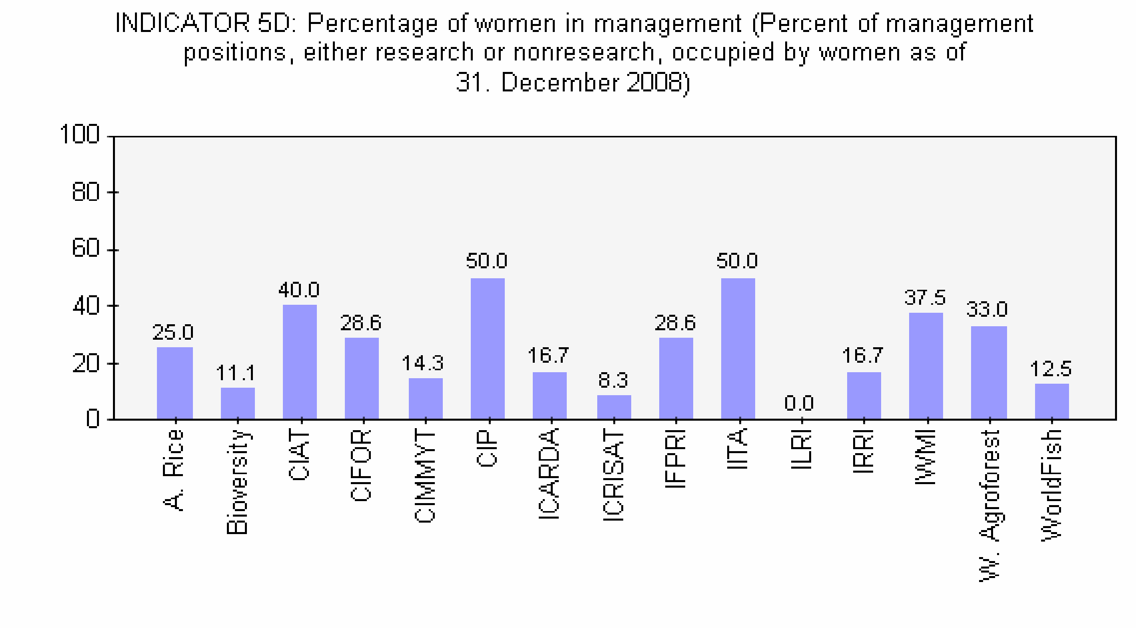
Performance Measurement System

	A. Rice	Bioversity	CIAT	CIFOR	CIMMYT	CIP	ICARDA	ICRISAT	IFPRI	IITA	ILRI	IRRI	IWMI	W. Agroforest	WorldFish
1a	Yes	Yes	Yes	No	No	No	No	Yes	Yes	Yes	No	Yes	No	Yes	Yes
1b	Yes	Yes	Yes	n/a	n/a	n/a	No	Yes	Yes	Yes	n/a	Yes	No	Yes	Yes
2a	Yes, for current AND prospective staff	Yes, for current staff	No	No	No	No	Yes, for current staff	Yes, for current AND prospective staff	Yes, for current AND prospective staff	Yes, for current staff	Yes, for current staff	Yes, for current staff	Yes, for current staff	Yes, for current staff	Yes, for current AND prospective staff
3a	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3b	Yes	Yes	No	Yes	Yes	No	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes
4a	More than 3%	0- 0.5%	0- 0.5%	0.51-1.0%	0- 0.5%	1.1%-2.0%	0.51-1.0%	0- 0.5%	0- 0.5%	2.1%-3%	0- 0.5%	More than 3%	1.1%-2.0%	1.1%-2.0%	0- 0.5%
4b	More than 3%	0.51-1.0%	0-0.5%	0-0.5%	0.51-1.0%	0-0.5%	0.51-1.0%	0-0.5%	0-0.5%	0-0.5%	0.51-1.0%	0.51-1.0%	0-0.5%	2.1%-3%	0.51-1.0%
4c	More than 8	2.6-4.5	Less than 1	Less than 1	More than 8	Less than 1	1-2.5	1-2.5	1-2.5	Less than 1	1-2.5	1-2.5	4.6-6.5	2.6-4.5	1-2.5
4d	More than 8	1-2.5	6.6-8	6.6-8	1-2.5	2.6-4.5	1-2.5	Less than 1	1-2.5	Less than 1	4.6-6.5	1-2.5	1-2.5	1-2.5	2.6-4.5
5a	More than 5	More than 5	More than 5	More than 5	More than 5	More than 5	More than 5	More than 5	3.1-4.0	More than 5	More than 5	More than 5	4.1-5.0	More than 5	4.1-5.0
5b	90% +	71%-90%	90% +	51%-70%	0%-30%	31%-50%	0%-30%	90% +	31%-50%	0%-30%	71%-90%	31%-50%	0%-30%	0%-30%	0%-30%
6	YES, we have a comprehensive (meta) database	YES, we have some (meta) database, but not all	YES, we have a comprehensive (meta) database	YES, we have some (meta) database, but not all	YES, we have some (meta) database, but not all	YES, we have some (meta) database, but not all	YES, we have some (meta) database, but not all	YES, we have some (meta) database, but not all	YES, we have a comprehensive (meta) database	YES, we have some (meta) database, but not all	YES, we have some (meta) database, but not all	YES, we have some (meta) database, but not all	YES, we have some (meta) database, but not all	YES, we have some (meta) database, but not all	YES, we have some (meta) database, but not all

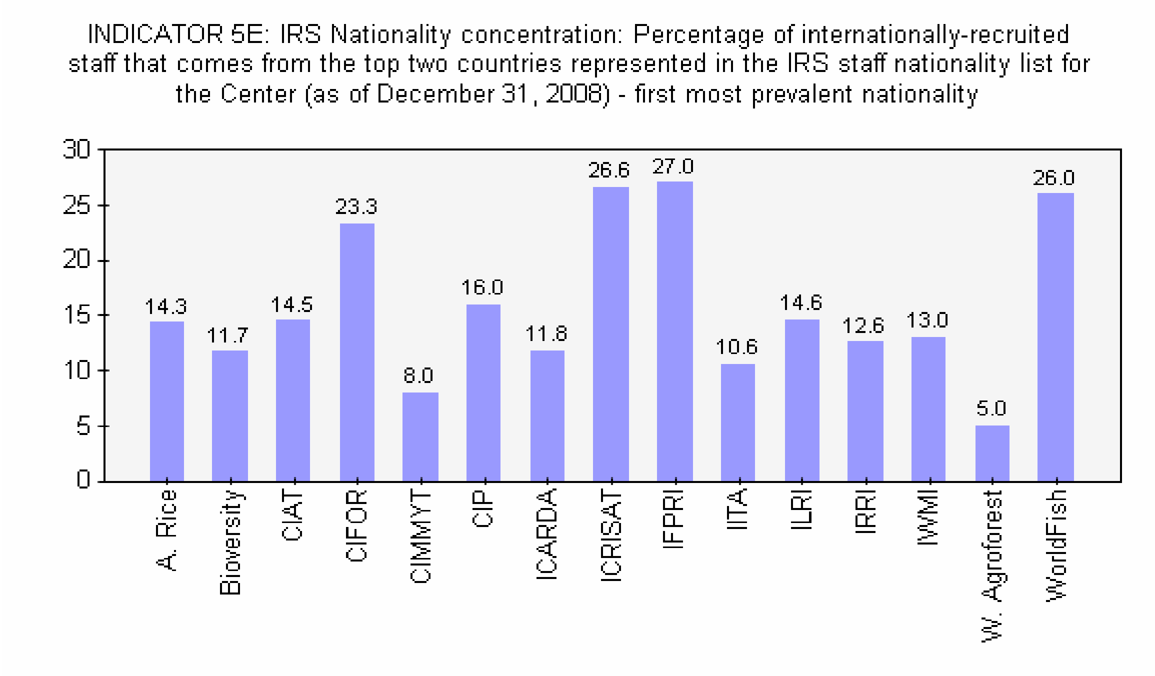
Consultative Group on International Agricultural Research
Performance Measurement System

Diversity – 2008



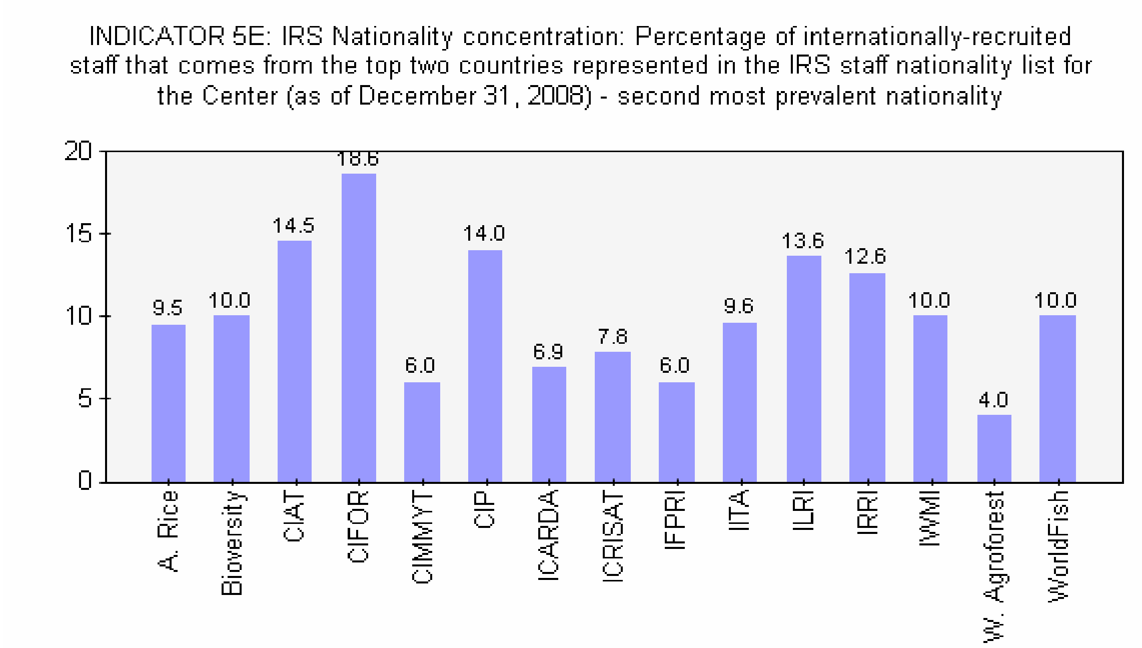
Center	%
A. Rice	25
Bioversity	11.1
CIAT	40
CIFOR	28.6
CIMMYT	14.3
CIP	50
ICARDA	16.7
ICRISAT	8.3
IFPRI	28.6
IITA	50
ILRI	0
IRRI	16.7
IWMI	37.5
W. Agroforest	33
WorldFish	12.5

Consultative Group on International Agricultural Research
Performance Measurement System



Center	Country	%
A. Rice	Japan	14.3
Bioversity	Italian	11.7
CIAT	USA	14.5
CIFOR	American	23.3
CIMMYT	China and Australia	8
CIP	Peruvian	16
ICARDA	Syrian	11.8
ICRISAT	India	26.6
IFPRI	United States of America	27
IITA	United Kingdom	10.6
ILRI	United Kingdom	14.6
IRRI	Philippines	12.6
IWMI	France	13
W. Agroforest	U.K.	5
WorldFish	British	26

Consultative Group on International Agricultural Research
Performance Measurement System



Center	Country	%
A. Rice	Nigeria	9.5
Bioversity	American	10
CIAT	Kenyan	14.5
CIFOR	French	18.6
CIMMYT	Kenya, USA, UK and India	6
CIP	German	14
ICARDA	German and Indian	6.9
ICRISAT	Kenya	7.8
IFPRI	India, China, and United Kingdom	6
IITA	Nigeria	9.6
ILRI	Kenya	13.6
IRRI	USA	12.6
IWMI	India and USA	10
W. Agroforest	Belgium, Germany, U.S.A.	4
WorldFish	Australian and Canadian tie at 10%	10

Financial Health

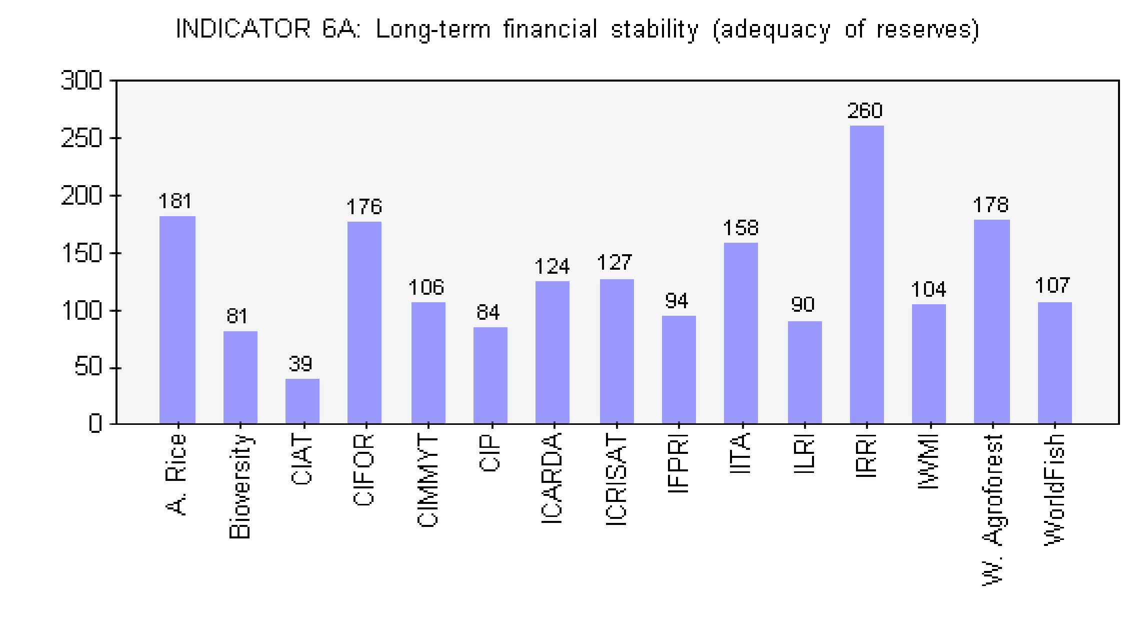
Definition

Note: The data for all finance indicators will be computed from the Audited Financial Reports of each Center, and will be confirmed by the peer-review exercise. Centers do not need to submit these data separately.

Consultative Group on International Agricultural Research
Performance Measurement System

INDICATOR 6A:
Long-term financial stability (adequacy of reserves)
This indicator is computed as unrestricted net assets less net fixed assets divided by per day operating expenses excluding depreciation. Only audited numbers and the final results from the peer-review exercise should be used.
The lower benchmark is 75 days, but will be increased to 90 days with a transition period of 3 years.

INDICATOR 6B:
Cash Management on Restricted Operations
This indicator is computed as restricted donors accounts receivable divided by restricted donors accounts payable expressed as a ratio. The data for this computation should be taken from the notes on accounts receivable and accounts payable in the audited financial statements, and confirmed by the peer-review exercise.
The benchmark for cash management on restricted operations is less than 1.0

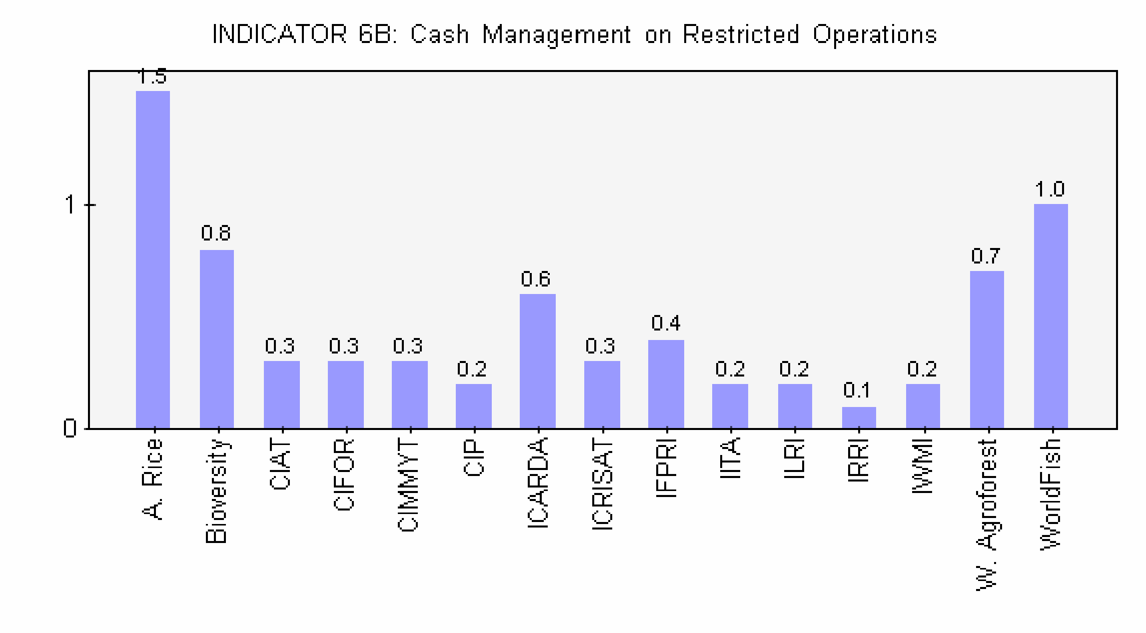


The minimum benchmark is 75 days of reserves

Center	Days
A. Rice	181
Bioversity	81
CIAT	39
CIFOR	176
CIMMYT	106
CIP	84
ICARDA	124
ICRISAT	127
IFPRI	94
IITA	158
ILRI	90
IRRI	260
IWMI	104

Consultative Group on International Agricultural Research
Performance Measurement System

W. Agroforest	178
WorldFish	107



The benchmark is less than 1.0

Center	Ratio
A. Rice	1.5
Bioversity	0.8
CIAT	0.3
CIFOR	0.3
CIMMYT	0.3
CIP	0.2
ICARDA	0.6
ICRISAT	0.3
IFPRI	0.4
IITA	0.2
ILRI	0.2
IRRI	0.1
IWMI	0.2
W. Agroforest	0.7
WorldFish	1

CGIAR

Consultative Group on International Agricultural Research Performance Measurement System

Full Reports for the CGIAR Performance Measurement

IRRI Publications - 2008

INDICATOR 1: Composite measure of Center research publications

SC Assessment

Score: 7.29
SC Comments:

1A: Number of externally peer-reviewed publications per scientist in 2008 that are published in journals listed in Thomson Scientific/ISI (50%) 1.26 papers per scientist

List of publications: Indicator 1 Measure 1A Thomson Scientific.pdf

List of scientists: FTEs for publications.xls

1B: Number of externally peer-reviewed publications per scientist in 2008 (excluding articles published in journals listed in the Thomson Scientific/ ISI (20%)
- number of externally peer-reviewed publications per scientist in externally published journals and books: 1.02 papers per scientist
- number of externally peer-reviewed publications per scientist in Center-produced book/research report series or journals: 0.16 papers per scientist
- Total number of externally peer-reviewed publications per scientist: 1.18 papers per scientist

List of publications: Indicator 1 Measure 1B.pdf

INDICATOR 2: Percentage of scientific papers that are published with developing country partners in refereed journals, conference and workshop proceedings in 2008

43.18 % of scientific papers

List of publications: Indicator 2 % papers with developing country partners.pdf

IRRI Outputs - 2008

Monitoring of achievement of MTP output targets in - 2008

Project 01

Raising productivity in rainfed environments: attacking the roots of poverty

Output 01.01

Superior drought-tolerant and aerobic rice germplasm and management options developed for water-short rainfed environments by 2012.

Target 01.01.01 Materials Fully Achieved

Five new populations for drought tolerance improvement in the rainfed lowlands.

Comments/Explanations:

In context of the background specificity of the major QTLs for grain yield under drought and taking into account the possibility that single major QTLs for grain yield under drought may not provide the required yield improvement under severe drought stress, the research plan targeted identification of two or more major QTLs in the background of popular varieties grown in the targeted drought prone regions. In the first phase six popular varieties- Swarna, MTU1010, IR64, Sambha Mahsuri, BR11 and Sabitri were selected for such study. All these popular varieties have been crossed with three to four drought tolerant donors and mapping populations have been developed. For Swarna, the populations developed are – Apo/Swarna, Basmati 334/Swarna, CT9993-5-10-1-M/Swarna, N22/2*Swarna and IR77298-14-1-2-10/Swarna. For IR64 - IR77298-14-1-2-10/IR64, IR77298-5-6-18/IR64, IR77298-14-1-2-10/IR77298-14-1-2-13. For MTU1010- Dagad deshi/3*MTU1010, N22/3*MTU1010, IR77298-14-1-2-10/MTU1010. Similarly for Sambha Mahsuri, the populations developed include Dagad deshi/Sambha Mahsuri, IR55419-04/Sambha Mahsuri, Basmati 334/2*Sambha Mahsuri, N22/2*Sambha Mahsuri, IR 77298-14-1-2-10/Sambha Mahsuri. For BR11- CT9993-5-10-1-M/BR11, IR55419-04/BR11 and Basmati 334/2*BR11 and for Sabitri-CT9993-5-10-1-M/Sabitri, IR55419-04/Sabitri, IR77298-14-1-2-10/Sabitri populations have been developed. Some of the above mentioned populations are being phenotyped in DS 2009 season and at the same time is also being genotyped. Other populations will be phenotyped and genotyped subsequently.

Target 01.01.02 Practices >75% Achieved

Large-scale and high throughput drought phenotyping systems for the rainfed lowlands.

Comments/Explanations:

Rainfed lowland field-managed drought screening at IRRI was significantly increased in 2007-2008. Facilities have been upgraded (field laser leveling, installation and upgrading of drainage and irrigation systems, soil mapping for control of field variation and improvement of screening precision). The drainage of flooded paddy fields results in progressive soil drying. Lateral water movement from adjacent wet plots is avoided by physical separation or by placing 1-m deep plastic sheets. A variety of devices are used for monitoring soil moisture profiles, new imaging techniques have been introduced for monitoring the effects of drought. The system for rainfed lowland drought screening is used at large-scale at IRRI for screening large collections of rice germplasm, breeding lines, hybrids and transgenic lines, and to identify new donors for drought-resistance breeding. This screening system was standardized in 2008 for multi-location trials in more than 15 sites across South Asia. The progress was documented in the following publications: Atlin et al., 2008; Serraj et al. 2008; Serraj et al., 2009; Herve and Serraj, 2008; 1st annual report of STRASA project and STRASA newsletter. This output target will be fully achieved by the completion of rainout shelters for drought screening at IRRI (planned for 2009).

Target 01.01.03 Policy strategies Fully Achieved

A joint IRRI-NARES research strategy of the Drought Frontier Project and drought research networks in South and Southeast Asia.

Comments/Explanations:

The Drought Frontier Project (DFP) and consortium were initiated after a meeting of a number of experts in 2006 to promote drought research, particularly for the development of drought resistant varieties. A first component of the DFP, with a focus on the development of rice varieties adapted to drought-prone rainfed environments was embedded in the BMGF-funded project on Stress-Tolerant Rice for Africa and South Asia (STRASA). A second component focusing on the generation and multi-location screening of a large number of putative drought-tolerant DREB gene constructs and other transcription factors was integrated in a project funded by the Japanese Government (2007-2012). A second thematic symposium of the DFP focused on Root Biology and MAS strategies for drought resistance improvement. This has led to the development of a research strategy and new GCP-funded project targeting drought-avoidance root traits to enhance rice productivity under water-limited environments. This work is conducted in collaboration with WARDA, NARES (India Drought Breeding Network) and several ARI partners. The progress is documented in the DFP website http://seeds.irri.org/drought/ , book of proceedings (Serraj et al., 2008), and particularly in the concept note on drought-resistant rice for increased rainfed production and poverty alleviation (Atlin and Serraj, 2008).

Target 01.01.04 Policy strategies >75% Achieved

Detailed analysis of the severity, timing and spatial coverage of drought at the district level in key sites in South and Southeast Asia.

Comments/Explanations:

A simulation framework was developed in collaboration with colleagues at IFPRI to study drought and other stresses for rice and other crops using simulation models driven by large spatial databases of daily weather data derived from satellite data. This framework was applied to study drought stress in Asia, and, to some extent, the benefits of drought tolerance. The research is ongoing; and a final paper providing a spatial-temporal characterization is in preparation. As new information on drought tolerant varieties becomes available the research is moving from more general characterization towards understanding of inter-annual variation, genotype by environment interaction, and targeting varieties. References: Hijmans, R., 2008; Hijmans, R.J., and R. Serraj, 2008.

Target 01.01.05 Practices >75% Achieved

Validated decision support systems for nutrient management for the rainfed lowlands of Laos and northeast Thailand.

Comments/Explanations:

Activities conducted within CURE and at CURE WG1/5 key sites during the last few years prepared the way for a basic understanding of management options in drought-prone rainfed lowlands (Haefele and Bouman, 2008). This included the outline of mechanisms and principals determining efficient nutrient management for drought-prone lowland rice in general (Haefele et al., 2009a), and region-specific management recommendations (presented as IRRI Thursday Seminar 27

November 2008, published online). The complete analysis of field experiments conducted in northeast Thailand and Laos was prepared for publication (Haefele and Konboon, 2009; Haefele et al, 2009b). The decision support system for nutrient management of rainfed lowland rice in NE Thailand was used in on-farm activities during the 2008 wet season, and further dissemination is targeted for 2009. In Laos lowlands, no IRRI activities were ongoing in 2008 but the decision support system for nutrient management of rainfed lowland rice in Laos was used for training of Laos extension staff, and dissemination activities could start in 2009 depending on donor support.

Target 01.01.06 | Materials | Fully Achieved

IR64 lines with significantly improved drought tolerance and yield potential by pyramiding QTLs from 2-3 donors.

Comments/Explanations:

In order to develop elite lines with drought tolerance (DT) and yield potential improvement, a large number of crosses were designed and made between promising first round pyramiding lines which already had better yield potential and unrelated QTLs for DT from different donors (including Indica and Japonica cultivars) to produce (Z.K. Li et al, 2008). The cultivar IR64, widely grown in irrigated areas of tropic Asia, with good yield potential, satisfactory grain type, resistance to numerous biotic stress and susceptible to drought was used as a recurrent parent. Through this approach, essential advantageous traits, contributed to higher yield under drought stress in the promising lines developed from pyramiding crosses between first round DT pyramiding lines (PDLs). Forty-two promising indica PDLs were identified, in two consecutive seasons, in under different water regimes and development stages. The most promising lines could incrementally be released in the future, into broadly adapted, popular lowland rice cultivars through further selection and evaluation under managed drought stress.

Target 01.01.07 | Materials | >75% Achieved

Options for improved soil health management for sustainable rainfed aerobic rice systems of Eastern India, Nepal, the Philippines, and Indonesia.

Comments/Explanations:

Decline in aerobic rice yield under continuous rice cultivation in light soil was reported. Root knot nematode (RKN) (M. graminicola) and root-rotting fungus (Pythium arrhenomanes) were identified as two of the probable causes of yield decline. Pythium attacks rice roots at early stage causing seedling death and stunting whereas nematode affects rice roots at all growth stages causing reduction in plant height, tillers, biomass, panicle size, grain filling and grain yield, although the decrease was not always significant for every genotype and in every parameter. Frequency of occurrence of Pythium decreased, while that of RKN increased under field conditions as the crop matures. The large variation among tested varieties and the consistent performance of some varieties suggest that improvement in tolerance of aerobic rice is feasible. Breeding line IR78877-208-B-1-2 was identified to possess tolerance to both RKN and Phythium. Suitable crop rotations (rice-groundnut, rice-mungbean, rice-cowpea) that help to sustain aerobic rice yield were developed. Aerobic rice in plot with previous crop of rice produced 15-30% lower grain yield than did rice in plot with previous crop of groundnut, mungbean and cowpea indicating that crop rotation of aerobic rice with legume crops is a good practice in aerobic rice-based cropping systems.

Output 01.02

Superior germplasm and management options to overcome submergence stress developed by 2012.

Target 01.02.01 | Practices | Fully Achieved

Analysis of farmers' current CNRM practices, coping mechanisms to submergence, and livelihood systems in the flood-prone ecosystem for selected sites in Bangladesh and India.

Comments/Explanations:

In eastern UP, India, submergence mostly occurs during vegetative stage, and few fields survived within 1-2 months of sowing. In Siddarthnagar farmers cope by growing traditional varieties as Sarya, Jarethwa, Bhaislot and Kalamanak with yields < 1 t/ha. Kalanamak, the most popular genotype, had good eating quality, aroma, and market price. Sambha Mahsuri, an improved variety, is also popular because of its good yield (2.5 t/ha), fine quality, good taste, and high market price. Aside from low yields, farmers had small landholdings, and production is barely enough for home consumption. Rice, wheat and other farm sources contribute 25% of total household income. Non-rice crops as wheat, oilseeds and pulses are grown during rabi but with low yields. Remittances from male family members and other non-farm sources comprise 75% of household income. Labor cost is the highest input in rice production. Female members from the lowest social ladder provide unpaid family and paid labor contributions in field activities. Fertilizer use is low and weeding is uncommon. Farmers direct seed in flash flood areas and transplant 30-40 day old seedlings in shallow lowland areas. Submergence tolerant genotypes validated by farmers recovered well with an average yield of 3 t/ha.

Target 01.02.02 Materials >50% Achieved

Understanding of the spatial and temporal distribution of flooding in rice in eastern India and Bangladesh.

Comments/Explanations:

We approach this by looking at floods that have occurred over the past 6 years, using high spatial and temporal resolution satellite images (MODIS sensor); and by using a landscape based hydrological model to be able to simulate probabilities of occurrence of floods under current and future weather patterns. We developed software for the hydrological modeling (in the open source GIS package GRASS) and for the satellite image analysis (in GRASS and in R) . We now have good working software, and we have preliminary results but these needs to be refined and analyzed further. A first draft methods paper is available.

Target 01.02.03 Materials Fully Achieved

Breeding lines combining good agronomic and quality traits with tolerance of submergence during germination.

Comments/Explanations:

Ten breeding lines with tolerance to flooding during germination, or anaerobic germination (AG), were identified for detailed characterization. All these lines had improved plant type (semidwarf or intermediate height), and acceptable grain type. Grain yield ranged from 3164 kg/ha to 5176 kg/ha. The highest yielding line, IR81159-48-2-4-4, had low amylose content, which is a preferred quality type with many rice consumers in Southeast Asia. It inherits its AG trait from the land race variety Khao Hlan On, which is a low-yielding traditional variety that was one of the best sources of this trait in the rice germplasm collection. Another line derived from Khao Hlan On, IR81935-85-1-1, had high yield as well, 5008 kg/ha. The breeding line IR83770-9-3-23 possessed moderate yield (4337 kg/ha), but also had the SUB1 gene conferring tolerance to submergence during the vegetative stage. This line had resistance to two races of the bacterial blight disease. These lines are currently undergoing further field tests and are used in the hybridization program to develop lines with higher yield potential.

Target 01.02.04 Practices Fully Achieved

Improved submergence-related seed and nutrient management options from farmer participatory research in two sites.

Comments/Explanations:

Floodwater conditions, seed storage and handling strategies and nutrient management in nursery and field affect seedling survival and crop establishment of both direct seeded and transplanted rice. For direct seeded rice, better seedling growth and higher survival were observed under these conditions: (i) floodwater had less algal growth, (ii) floodwater temperature in the range of 24-26 oC; (iii) shallower water depth of 2 to 4-cm; (iv) newly harvested (fresh) seeds than in older seeds, (v) seeds stored properly at lower temperatures and low humidity than under ambient conditions, and (vi) seeds primed for 12-24 hours before seeding. Low lipid peroxidation and high activities of superoxide dismutase and catalase in dry seeds before seeding, and high amylase activity in germinating seedlings are associated with better seedling growth and higher seedling survival following flooding during germination and early seedling growth in rice. Tolerant lines are more responsive to management. Management practices for flash flood-prone areas were also validated in numerous farmers' fields in UP, India and Rangpur, Bangladesh. These include proper nursery management (optimum organic and inorganic fertilizers, spacing, seedling age) and post submergence nutrient management. These options are being outscaled through PVS trials involving farmers.

Output 01.03

Superior germplasm with tolerance of salinity and other soil problems, together with suitable management options, developed by 2012.

Target 01.03.01 Practices Fully Achieved

Validated improved CNRM practices (integrated with salt tolerant rice germplasm) for efficient use of inputs and stabilized productivity for saline/alkaline regions for India and Bangladesh.

Comments/Explanations:

Productivity of salt-affected areas can substantially be improved and sustained when high yielding, salt tolerant varieties and best management practices were combined. For saline coastal areas, management options developed and validated for salt-tolerant rice varieties included transplanting of older seedlings, proper nutrient management in nursery, early transplanting (before 15 January) in boro season in coastal areas (Orissa, India), use of green manures and biofertilizers in the field

(Azolla and Sesbania), monitoring salinity in surface water and storage of freshwater in irrigation and drainage canals for extended use during the dry season. For inland alkaline soils, chemical amendment equivalent to 25% of the gypsum requirement (half recommended), combined with salt-tolerant varieties, root dipping of seedlings in ZnO slurry and use of pressmud (a byproduct of the sugarcane industry) and phospho-gypsum (a byproduct of the phosphatic fertilizers industry) were evaluated as cheap alternative amendments. These options were validated in farmers' fields at CRRI, Cuttack; CSSRI-RRS, Lucknow; NDUAT, Faizabad, India and BRRI, Bangladesh. Farmers' varieties and management (FVFM) practices were compared against improved varieties and improved management (IVIM) options, with the later having an advantage of over 90% over FVFM, equivalent to an average increase in grain yield of 1 to 1.5 t/ha.

Target 01.03.02 | Materials | Fully Achieved

One mega-variety into which the *Saltol* locus for salinity tolerance has been introgressed using markers.

Comments/Explanations:

Salt stress commonly affects one million hectares of rice grown in coastal areas in Bangladesh. A major QTL for salinity tolerance on chromosome 1, Saltol, provided the opportunity to apply marker-assisted backcrossing to precisely introduce tolerance into the popular, but salt-sensitive, Bangladeshi mega-variety BRRI dhan28 (BR28). Molecular markers were used for foreground, recombinant and background selection through successive backcross generations to transfer the tolerant allele from the donor parent FL478 (IR66946-3R-178-1-1), a highly tolerant RIL from an IR29/Pokkali population, into BR28. A BC3F2 homozygous individual was identified using marker selection with a 1.4 Mb Pokkali introgression at the Saltol region (10.8-12.2 Mb) with 99% recurrent parent content across the rest of the genome. The effect of the Saltol introgression was evaluated by comparing the physiological characters of the recurrent parent (normal BR28) and the converted Saltol version of BR28 under control and salt stress conditions in the phytotron. When salt stress (12 dS m-1) was applied 5 days after seeding, 58% survival was recorded with BR28-Saltol while no plants of BR28 and the susceptible check IR29 survived. Seed multiplication of the BR28-Saltol line (IR89573-84) is under way to distribute to NARES partners for field trials.

Target 01.03.03 | Practices | Fully Achieved

Recommended technologies (integrated use of improved germplasm, CNRM, and amendments) to reclaim saline/alkaline soils.

Comments/Explanations:

1) Salt-tolerant varieties: Several lines identified from multi-location testing over several years at target environments. In coastal Orissa, IR72046-B-R-3-3-3-1 and IR72593-B-19-2-3-1 were selected with high yield (3.2-4.8 t/ha) for the dry season under high salinity (10-12 dS m-1), where farmers' varieties usually fail. For wet season, SR26B, Lunishree, CR2093-7-1, CR2069-16-1 and CR2096-71-2 were selected that increased farmers' yield from < 2.0 t/ha to 3.5 t/ ha. Most of these lines were nominated for ACRIP multi-location testing and potential release as commercial varieties for coastal saline soils. Bangladesh released BRRI dhan 47 (IR63307-4B-4-3) for the boro season in saline areas. For inland saline/ sodic soils (UP, India) a few varieties including CSR30, (aromatic fine-grain salt-tolerant) 2K262, 2K219, NDRK5089, Narendra Usar Dhan 3 and NDRK 5083 were selected in PVS trials. 2) Recommended NRM technologies include i) a package for nursery management options (organic/inorganic fertilizer, seed rate, age at transplanting); ii) seedling handling (number per hill, ZnO dipping); iii) chemical, organic and biofertilizer packages for transplanted rice in saline soils; and iv) low cost reclamation technologies including the use of low gypsum, industrial byproducts, and organic fertilizers to reduce soil pH. Yield advantages of over 1 t/ha were reported in farmers fields.

Output 01.04

Superior germplasm and improved management options for uplands developed by 2012.

Target 01.04.01 | Practices | >75% Achieved

Knowledge of interactions and resource flows between sloping uplands and upland paddies in Laos.

Comments/Explanations:

In a pilot mini-watershed of northern Laos, a hydrological model was developed for estimating the effect of alternative land use on the stream flow which determines the area of lowland paddy that can be irrigated downstream. The model results show that freshly cleared and burned land for upland cropping reduced water retention, increased surface runoff, and contributed to variation in streamflow discharge at the outlet. A farm household model was developed and applied to analyze the effect of alternative land use in sloping uplands on the production of environmental services (proxied by soil fertility) in a micro-watershed in northern Vietnam. The results show that the overall net environmental effect of an involuntary land set-aside program is negative as farmers intensify the remaining part of the sloping land for food production. Analysis of farm survey data showed that upstream and downstream communities are tightly linked in terms of resource flows and water-intensive activities in upstream areas reduced water availability and adversely affected agricultural activities downstream.

Output 01.05

Resource management options and strategies for intensification and diversification of rainfed systems developed by 2012.

Target 01.05.01 Practices Fully Achieved

Improved rice-aquaculture systems for salt-affected coastal areas of the Mekong Delta, Vietnam and in Bangladesh.

Comments/Explanations:

In the current cropping system of many saline coastal areas only rice is grown during the wet season (WS). But the introduction of high-yielding, short-maturing varieties enabled new cropping sequence options for the dry season (DS). These include: rice-rice when fresh water is available in the DS and salinity is limited, rice-non-rice in areas where salinity is high during the DS and fresh water is scarce, and rice-aquaculture when salinity is high during the DS and no fresh water is available. In the later system, shrimp or fish were raised during the DS, and sometimes fish is intercropped with rice during the WS. Successful systems in Tra Vinh, Vietnam, are: rice-shrimp, rice-fish, rice-peanut intercropped with mungbean or maize, and rice-watermelon-sesame. In Bac Lieu, promising systems are rice-shrimp/fish, and rice-watermelon. Rotation of shrimp during the DS with rice during the WS reduced the problem of shrimp diseases and stabilized productivity. Outscaling in south Vietnam (Tra Vinh and Bac Lie) and south Bangladesh (Satkhira) showed good promise particularly in saline areas where no DS rice can be grown. Detailed results were published in e.g., Ni et al. (2007), Lange et al. (2009), Sharifullah et al. (2008), and Alam et al. (2008).

Target 01.05.02 Practices Fully Achieved

Integrated crop management technologies for rice-wheat and rice-legume systems from farmer-participatory research in rainfed regions of eastern India and Bangladesh.

Comments/Explanations:

More than 500 on-farm trials and technology demonstrations were conducted at the ADB project sites (Enhancing farmers income and livelihoods through integrated crop and resource management in the rice-wheat system in south Asia, ADB RETA 6208) in India, Bangladesh, Nepal and Pakistan for refining, validation, and dissemination of the integrated crop management (ICM) technologies and enhancing their adoption to improve productivity and income of farmers and minimize adverse environmental impact. The studies at different project sites on ICM showed an increase in yield and income compared with conventional practices. A large number of farmers are using the LCC, which results in N savings of up to 40 kg N ha–1 compared with farmers' practice. In Bangladesh, it is immensely popular and widely publicized at other sites. By 2008, more than 8000 LCCs were distributed to farmers for efficient N management. Detailed information is provided in semi-annual and annual reports to the ADB and a publication is in preparation (Ladha JK, Singh Yadvinder, Erenstein O, editors. 2009. Integrated crop and resource management technologies for sustainable rice-wheat systems of South Asia. Manila (Philippines): International Rice Research Institute, in press).

Target 01.05.03 Practices Fully Achieved

A tested RICE CHECK-based methodology to improve crop management for intensified rice production in Cambodia.

Comments/Explanations:

IRRI in collaboration with CARDI and financed by PLAN Cambodia (an international development agency working with and for children) developed guidelines for integrated crop management of rainfed lowland rice similar to the RICE CHECK model developed in Australia. The ICM guidelines were tested on-farm, together with variety testing trials, in six villages and two provinces (Siem Reap and Kampong Cham) of Cambodia during the 2007 and 2008 season. In 2007, the adoption of the ICM guidelines in combination with improved CARDI varieties and quality seed almost doubled grain yields (3.3 to 3.7 t ha-1) in comparison with farmers practice (1.8 to 1.9 t ha-1). Apart from good crop management practice, the ICM guidelines did include a higher investment (about one third higher than farmer's practice), mainly due to higher fertilizer rates, more intense manual weeding, and higher total harvest costs (as a result of the higher grain yield). However, net profits were at least doubled. 2007 result are reported in the annual project report, the 2008 results will be reported in March 2009. The reports also contain information material produced for the dissemination of ICM guidelines to farmers and extension services.

Target 01.05.04 Materials Fully Achieved

Maps of resource management domains to facilitate land use planning in Bac Lieu Province, Mekong Delta, Vietnam.

Comments/Explanations:

Because of changing hydrological conditions due to infrastructure development to prevent salinity intrusion into the coastal zone, local authorities in Bac Lieu Province, Vietnam, faced complex natural resource management issues concerning managing saline and freshwater resources supporting diverse production activities in the coastal zone. The resource management domain (RMD) concept was applied, using geospatial techniques, to delineate spatial clusters of hamlets reflecting the influence of key environmental factors on land-use changes and the resulting socioeconomic conditions of rural communities (Kam et al., 2006). While some socioeconomic differentiation was discernible among the hamlet clusters, the clustering was mainly dominated by land-use change and hydrological characteristics. The RMD approach is meant to provide an analytical platform to support an adaptive land-use planning process to support the use and management of coastal resources regionally and locally. The results, interpreted on a broader scale, supported the identification of land-use and water management zones to accommodate rice-based, rice-shrimp, and aquaculture-based production systems in the area. These helped the local government reverse an earlier policy of intensifying rice cultivation over the whole province. The hamlet clusters also provided a sampling frame for selecting pilot sites for evaluating improved production systems and techniques with farmers.

Project 02

Sustaining productivity in intensive rice-based systems: rice and the environment

Output 02.01

Improved rice germplasm and management practices to enhance yield potential and achieve sustainable productivity developed by 2012.

Target 02.01.01 Materials Fully Achieved

Four promising IRRI inbreds and three hybrids for evaluation in collaboration with Asian NARES

Comments/Explanations:

An aromatic line IR75483-385-2-2 has been released as 'Punjab Mehak 1' in India. This is the first IRRI bred semi-dwarf high yielding aromatic line released in India and is resistant to all the bacterial blight races prevalent in Punjab state. A tropical japonica elite line 'IR65600-21-2-2' was released as INPARI 5 Merawu in Indonesia, on the feed back of farmers' in Banjarnegara district, Central Java. The variety was released on July 17, 2008 (Decree of ministry of agriculture for released variety No.955/SR.120/7/2008). Four breeding lines, namely IR77512-128-2-1-2, IR 78581-12-3-2-2, IR 78555-68-3-3-3 and IR72903-99-2-3-2 were evaluated in National Cooperative Testing Project in the Philippines and promoted to Multilocational Advanced Trials (PhilRice publication). More than 10 hybrids were evaluated with Asian NARES across countries of China, Indonesia, India, Philippines and Vietnam. Data were collected and analyzed, and some hybrids were recommended for further testing.

Target 02.01.02 Materials Fully Achieved

Marker aided selection (MAS) protocols for BPH, tungro, cold tolerance, amylose content and gelatinization temperature.

Comments/Explanations:

The STS marker (6871.T4A) was tightly associated with BPH resistance conferred by Bph18 gene, and was MAS validated in the advanced backcross breeding lines developed from Junambyeo (BPH susceptible) and IR65482-7-216-1-2 cross. Three QTLs associated with cold tolerance phenotype for high spikelet fertility at reproductive stage were identified on chromosomes 3, 7 and 9, while two QTLs for seedling cold tolerance were identified on chromosome 4. The flanking SSR markers at the QTL locations are available for MAS. We fine-mapped an RTSV (causing tungro) resistance gene, and found DNA markers closely linked to the gene. The locus for RTSV resistance was mapped in a 100-kb region near 22Mb of chromosome 7. DNA markers tightly linked to RTSV resistance were developed. The DNA markers are useful for MAS of RTSV resistance to develop tungro-resistant rice varieties. A GCP germplasm set was completely genotyped for 4 GT markers and 3 amylose markers. A database of genotype for GT or amylose compiled for all varieties genotyped was placed on the website for use by the International Network of Quality Rice for selection of breeding parents. Markers operating in the laboratory are offered to Quality Evaluation users.

Target 02.01.03 Materials >75% Achieved

Germplasm resistant to stem borer and sheath blight from transgenic and other breeding approaches.

Comments/Explanations:

Breeding lines tolerant to yellow stemborer derived from the cross of IR65600-81-5-3-2 (NPT) x O. longistaminata accession 110404 have been identified. Field evaluation under hotspots will be carried out. Two O. rufipogon accessions 80671 and 105757 were found to be moderately tolerant to sheath blight. BC1F4 and F4 progenies are under evaluation for introgression from wild species for tolerance to sheath blight. Many transgenic lines with Bt gene have been produced. These lines have shown high degree of tolerance to stemborer under screenhouse conditions which still need to be evaluated under field conditions. Production of transgenic rice resistant to sheathblight was deferred because of non availability of well defined gene constructs. Regarding resistance of rice to sheath blight, a series of actions are under way: new, epidemiology-based, phenotyping procedures are being developed and tested; inter-specific crosses (O. sativa x O rufipogon) have been made; new research plans addressing the epidemiology of the disease, including simulation modeling, have been developed. These above steps will be used to establish a methodology that enables us to quantify and separate confounding factors, and will accelerate progress in the identification of reliable traits that can be incorporated in breeding programs.

Target 02.01.04 | Practices | < 50% Achieved

Validated options for integrated water and sheath blight management

Comments/Explanations:

Published research conducted at IRRI has shown that the epidemiology of rice sheath blight strongly depends, in the following order, on: (1) the geometry of the crop canopy; (2) the microclimate within the canopy; (3) the level of resistance (either from morphological, or from physiological traits). This order of course reflects the current, very low, level of resistance present in cultivated varieties, which we want to improve (see previous item). Water management influences the above points 1 and 2. Experiments at IRRI have been conducted during the past rainy season 2008 to test the interaction: WaterRegime x Crop Age on both inoculum mobilization and disease increase. This experiment will have to be replicated in the next rainy season 2009. Further, genotypes with varying architecture will be tested in 2009 for their vulnerability to sheath blight. These steps are necessary to fully understand and quantify the factors that determine canopy moisture (i.e., duration of leaf wetness), including water management. These steps, also, are necessary in order to design ideotypes of rice varieties that have (1) high potential yield; (2) are resistant to sheath blight epidemics, and (3) are less vulnerable to sheath blight injury.

Target 02.01.05 | Materials | Fully Achieved

Host resistance and genetic diversification strategies for blast and bacterial blight.

Comments/Explanations:

We developed pyramid lines with three bacterial blight resistance genes (Xa4, Xa7, and Xa21). To improve maintainer and restorer lines, resistance from donors was introgressed through MAS in parental lines of Mestizo hybrids. Phenotypic analysis of plants confirmed that these lines provide broad-spectrum resistance to bacterial blight. We introgressed Xa4, Xa7 and Xa21 to a temperature-sensitive genetic male sterile line from a three-way cross of AR32-19-3-3/TGMS1//IRBB4/7, which produced 1,364 F2 plants carrying various combinations of the Xa genes. Phenotypic and molecular marker analyses confirmed PR36944-450, PR36944-473 and PR36944-700 as homozygous for Xa7 and Xa21 and highly resistant to bacterial blight. The efficiency of association of resistant and susceptible rice varieties in reducing blast intensity was analysed with respect to the proportion of resistant genotype and the level of susceptibility of susceptible genotypes. Genotype association did not impose a penalty on the performance of the resistance cultivar. ANOVAs and logistic regressions allowed predicting the odds for reduction in disease intensity and yield gain increased with respect to the proportion of resistant cultivar, and the type of susceptible variety. These results can be used as a basis to guide decisions in the use of genotype association to control blast.

Target 02.01.06 | Policy strategies | Fully Achieved

Analysis of the factors influencing labor availability in the intensive rice based systems in SE Asia.

Comments/Explanations:

A key finding of this research is that because of the increasing labor scarcity in rural area, the skillful labor management is crucially important for profitable rice production, resulting in the requirement of a more knowledge-intensive production management. In this regard, schooling investments and the creation of educated farmers becomes important. However, marginal farmers may not be able to catch up with this trend, resulting in widened income gap. Policies supporting schooling investment of such marginal farmers is important. These features are observed in rapidly industrializing SE Asian countries where rural-to-urban migration is in vigor. The case studies are summarized and published as Rural Poverty and Income Dynamics in Asia and Africa (edited by Otsuka, K., J. P. Estudillo, and Y. Sawada, Abingdon, UK: Routledge, 2008) where most of the chapters are written by current and ex- IRRI scientists with IRRI data sets.

Output 02.02

Integrated resource management options and germplasm to address threats to sustainability related to trends of increasing intensification and diversification and decreasing freshwater resources developed by 2012.

Target 02.02.01 Practices Fully Achieved

Concepts for integrated crop management (water, nutrients, weeds and land leveling) under water-scarce conditions in lowland rice in the Philippines, Vietnam, India, Bangladesh and Myanmar.

Comments/Explanations:

Integrated crop management (weed control, nutrient management, land leveling) was designed for the water-saving irrigation technology Alternate Wetting and Drying, and was disseminated in collaboration with NARES partners among farmers in the Philippines, Vietnam, Bangladesh, and Myanmar. Specific field trials were conducted in India, Bangladesh, Philippine and Myanmar on the integrated effects of crop establishment and weed management in water-scarce conditions. Findings on crop-weed interactions have been analyzed and are incorporated into management recommendations. For nutrient management, results from past research were compiled into computer-based decision support tools, which identify optimal field-specific nutrient management practices. This tool named 'Nutrient Manager for Rice' was released and distributed on CD in the Philippines. Location-specific versions of 'Nutrient Manager for Rice' were developed for Vietnam, Bangladesh, and one state in India. A concept of integrated nutrient management with very low inputs tailored to conditions in Myanmar was promoted in the country. Laser leveling was demonstrated, and training conducted, in Vietnam, Myanmar and Lao PDR. In Vietnam, laser leveling is practiced at Bac Lieu Seed Center, a private contractor in An Giang province, and by two commercial seed producers. Laser leveling was included in the three reductions three gains government extension program.

Target 02.02.02 Policy strategies Fully Achieved

Map of water footprint of rice in Asia describing current and future water availability in Asian irrigation systems.

Comments/Explanations:

This target was achieved ahead of schedule: Mom, 2007, a high spatial resolution analysis of the water footprint of global rice consumption, IRRI, University of Twente, Netherlands. This study calculated the global water footprint of rice (water used by evapotranspiration) for 1999 – 2003. To simulate water-limited rice growth the crop model ORYZA2000 was used. The total volume of water used was calculated based on total rice production and its virtual water content (m3 ton-1). ORYZA2000 was integrated with GIS to calculate global and national water use for rice growth on a high resolution using spatial explicit weather and land use data. We distinguished three types of water footprint: used rainwater ('green' water), used irrigation water ('blue' water), and water pollution ('grey' water). Detailed trade data were used to identify the location of impact and assess virtual water flows which were derived from statistics on trade in rice products and their virtual water content in the country of origin. 919 billion m3 year-1 of water was used for the production of rice, of which 65% was green water, 29% blue water (irrigation) and 6% grey water. The external (traded) water footprint is only 5% of the global water footprint.

Target 02.02.03 Practices Fully Achieved

Understanding of the weed shifts in the Indo-Gangetic Plains due changes to direct seeding, and validated weed management options in India and Bangladesh

Comments/Explanations:

Weed population shifts were determined in long-term experiments, and weed management practices were validated on farmers' fields in three states in India and in NW Bangladesh over several years. A review of literature on weed management was published, and five journal / conference articles published or accepted that describe the germination ecology of key weeds in these systems and the effects of tillage on emergence. Data sets of weed populations in long term experiments established.

Target 02.02.04 Practices Fully Achieved

Understanding of the causal factors of yield decline in aerobic rice and prototype management interventions to reduce the yield decline.

Comments/Explanations:

Field and pot experiments in the Philippines showed that gradual or rapid yield decline in aerobic rice was associated with increases in soil pH, which led to reductions in soil N availability and plant N uptake, sometimes to micro-nutrient deficiencies, and subsequently at some sites to the development of secondary biotic stresses in the soil such as nematodes and/or pathogenic fungi. Nematodes may occur in fields without increase in soil pH. The application of biocides led to favorable soil conditions by reducing biotic stresses such as nematodes and improving nutrient availability. At some sites, irrigation with low-quality ground water impaired plant growth, induced chlorosis and increased soil pH. The application of ammonium sulfate reduced soil pH to values below 6, increased micronutrient (Fe, Mn and Zn) content and plant growth. A combination of soil acidification and N fertilization (urea or ammonium sulfate) was more effective in improving plant N nutrition and consequently plant growth of aerobic rice than soil acid treatment or fertilizer-N input alone. The occurrence of nematodes can potentially be decreased by crop rotations and solarization of the seed bed. Initial screening led to the identification of varieties with enhanced resistance to nematodes and fungi.

Target 02.02.05 Policy strategies Fully Achieved

Strategic assessment of the current and future potential for rice-maize systems in Asia (IRRI-CIMMYT alliance).

Comments/Explanations:

Documentation on the strategic assessment of rice-maize productions systems for 29 locations across Asia was completed as part of the IRRI-CIMMYT Alliance. The analysis highlighted the yield potential for each crop and the opportunities for optimizing the rotation of the two crops within cropping calendars, crop management practices, and socioeconomic conditions. It provides background information and guidance for future research on rice-maize systems and crop diversification in rice-based systems.

Output 02.03

Integrated management options for improved environmental sustainability in rice-based landscapes developed by 2014.

Target 02.03.01 Practices Fully Achieved

Assessment of the role of surrounding habitats in pest management (insects, diseases, rodents and weeds)

Comments/Explanations:

We showed that surrounding grasses are useful habitats for natural enemies and we are evaluating nectar-producing plants that can attract parasitoids to control insect pests. We identified field sites in Thailand, Vietnam, and China for trials on ecological engineering: modify landscape components to increase ecosystem resilience against pest outbreaks. Survey work in Thailand showed that farmers actively manage landscapes to support functions such as provision of food, medicine, and pest and weed control. We synthesized the effect of neighboring nonrice crops on arthropod diversity and the occurrence of pests and their natural enemies in Rangpur, Bangladesh. Compared to rice/non-rice habitats, overall rice/rice habitats had same or lower abundance of natural enemies, same or higher abundance of most insect pests, lower diversity of arthropods (insect pests and natural enemies), but no significant differences in yield. We studied the relative abundance of rodent species in different types of habitats of the Sierra Madre Biodiversity Corridor, Philippines. A high diversity was found of pest and non-pest rat species in major habitats associated with agriculture, eg R. tanezumi (pest) in rice and coconut and R. everetti (non pest) in forests. Rodent control in agricultural habitats has potential implications on non-pest native species.

Target 02.03.02 Policy strategies Fully Achieved

Framework and partnerships for studying ecosystem services in rice landscapes

Comments/Explanations:

The DPSIR framework is being adapted for use in evaluating pest management ecosystem services in Malaysia, and is being extended to Thailand, Vietnam, and China. Potential partners for hydrological ecosystem services were identified in China, Korea, Taiwan, and Japan, and joint field visits are planned for 2009 in China. An outline of various ecosystem services of paddy landscapes was developed ahead of time and presented as a chapter on rice in the Comprehensive Assessment of Water Management in Agriculture in 2007. Rice fields provide unique, but often unrecognized, ecosystem services. Depending on the method of cultivation and the physical characteristics of the landscape, these 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, and regulating temperature/climate. The International Society of Paddy and Water Environment Engineers provides a partnership platform for the study of ecosystem services and awarded the international PAWEES 2008 award to IRRI staff dr TP Tuong at its Conference on Ecosystem Engineering in Taipei.

Target 02.03.03 Policy strategies Deferred

Survey of the extent of heavy metal contamination of rice soils and uptake into straw and grain

Comments/Explanations:

This target is deferred because of two reasons; 1) IRRI's Board of trustees recommended not prioritizing research on arsenic as this is mainly a human health issue (through drinking water), and 2) we need to refine the sensitivity of the detection methods for heavy metals such as cadmium by our laboratories.

Target 02.03.04 Other kinds of knowledge Fully Achieved

New classification system for rice lands based on climate, hydrology, and soil characteristics

Comments/Explanations:

IRRI's 1984 'international' environmental terminology for rice (classification) was reviewed. Common ambiguities and confusions were analyzed, and major recent developments in rice production systems presented. Guiding principle were developed as basis for a new terminology and classification of 'rice fields': a piece of land where rice is grown. The new classification system leaves intact the original concept as much as possible. Two levels of classification are defined, using as much as possible "defining criteria" which are based on quantifiable biophysical characteristics of the rice land. Management and cultural practices are not defining criteria except when they change the environment in which rice is grown, such as the use of irrigation. At the first level, the defining criteria are the dominant water regime (flooded versus "nonflooded") and the presence or absence of irrigation. At the second level, the defining criteria are "modifiers" that express specific abiotic constraints related to more detailed water regime, soil, slope, and temperature. The classification is followed by a narrative or description that includes such things as the landform in which the field under classification is located, the main plant types grown in the environment and popular management practices.

Output 02.04

Options to adapt rice systems to climate change, particularly higher temperatures and raised sea levels, and to minimize greenhouse gas (GHG) emissions developed by 2014.

Target 02.04.01 Materials Fully Achieved

Classification of current and future high temperature stress environments for rice

Comments/Explanations:

Climate data and rice cropping calendars were combined in GIS to map regions with high risk for high-temperature damage to rice. These maps are input for collaborative research with NARES partners on mitigation strategies for future climates. Promising germplasm is being identified from areas with current high risk for high temperatures to enter breeding programs for genetic improvement.

Target 02.04.02 Materials Fully Achieved

Evaluation of germplasm for tolerance/avoidance of high temperatures and other climate-induced stresses in target areas

Comments/Explanations:

We have exposed a set of putatively heat-tolerant rice accessions to defined heat stress at flowering and are currently finalizing the data analyses. High level of heat tolerance was found only for the aus-type variety N22. Measurement protocols for early daytime flowering were developed. A germplasm screening for heat avoidance (early morning flowering, EMF) has been finalized. A representative set of EMF accessions is now being assessed for tolerance of high temperature after flowering QTL mapping and molecular characterization the underlying processes have been initiated. Field screening for heat tolerance of 455 germplasm accessions from 'hot' countries was also initiated and promising accessions will be screened further under controlled conditions in 2009. Breeding populations involving known putative donors and popular varieties as parents were developed and advanced to the F2 and F3 generations for further use in pedigree breeding and selection work. Two mapping populations have been developed for mapping QTLs for heat tolerance at flowering.

Target 02.04.03 Policy strategies Fully Achieved

Assessment of the impact of sea level rise in the Mekong Delta

Comments/Explanations:

We assessed the impact of sea level rise on water levels in the Vietnamese Mekong Delta. We used a hydraulic model to compute water levels from August to November – when flooding is critical – under sea level rise of 20 cm (+20) and 45 cm (+45). The contour lines of water levels will shift up to 25 km (+20) and 50 km (+45) towards the sea due to higher sea levels. At the onset of the flood season, the average increment in water levels is 14.1 cm (+20) and 32.2 cm (+45). At the peak of the flood season, high discharge from upstream attenuates the increment in water level, but average water level rise of 11.9 cm (+20) and 27.4 cm (+45) still imply a substantial aggravation of flooding problems. GIS techniques were used to delineate areas with different levels of vulnerability, i.e., area with high (2.3 million ha), medium (0.6 million ha) and low (1 million ha) vulnerability due to sea level rise. Rice production will be affected through excessive flooding in the tidally inundated areas and longer flooding periods in the central part of the Delta. These adverse impacts could affect rice cropping unless preventive measures are taken.

Output 02.05

Strategies for uptake and impact of research results in place by 2010.

Target 02.05.01 Practices Fully Achieved

Two integrated technologies and principles for sustainable, intensive, rice-based production in Myanmar and Indonesia

Comments/Explanations:

Knowledge and research results in Indonesia were compiled into a computer-based decision support tool, which provides a guideline of optional nutrient management based on rice management practices within the context of integrated crop management. This tool, "Pemupukan Padi Sawah Spesifik Lokasi" (Site-Specific Rice Fertilization) was released by President Yudhoyono in July 2008 together with a training module. A partnership of organizations at national and local levels was established for distribution of the CD and training module to extension workers and farmers. Myanmar is working with several improved rice production technologies and moving towards integration at selected sites. Building on earlier-established "lighthouse sites", we expanded verification of improved technologies in farmers' fields in 4 regions. Improved nutrient and water management practices are tested with improved crop establishment. Some 25 flat-bed dryers were constructed (nine linked to farmer communes) and training was provided for farmer groups, millers, and seed producers. On average, 105 farmers in each village benefited each season by using the dryers. This led to farmers having better quality rice, which in turn led to higher prices obtained. An environmentally friendly community method to control rats was adopted by Myanmar as national policy for rodent management.

Target 02.05.02 Capacity strengthening Fully Achieved

Improved capacity of consortium NARES partners to conduct participatory research

Comments/Explanations:

Capacity for participatory research and development (R&D) of technologies has been strengthened through the Irrigated Rice research Consortium (IRRC). Partners in R&D included various stakeholders such as farmers, NGOs, national and local government agencies, institutes, universities, irrigation agencies, and private sector such as fertilizer companies and machine- and equipment-producing firms. Capacity on participatory R&D was developed mainly by implementation in the field by the IRRC workgroups. We worked with farmers, extension agents, irrigation managers, and researchers in the development, adaptation, and delivery of water-saving technologies in the Philippines, Bangladesh, and Vietnam. Farmers, local government agencies, universities, extension agents, and the fertilizer industry worked together to develop site-specific nutrient management options in the Philippines, Indonesia, and Vietnam. Farmers, millers, manufacturers, and researchers joined forces in the research and development of post-harvest technologies such as the super bag for grain storage, dryers, and grain moisture meters in Vietnam, Laos, Cambodia, Myanmar. Participative IRRC research has generated substantial impacts on resource-poor smallholder farmers in the irrigated lowlands of Southeast Asia. Our impact among the ultra-poor has been of greatest magnitude in the Indo-Gangetic Plains.

Target 02.05.03 Capacity strengthening Fully Achieved

Scientific platform for developing and assessing adoption pathways

Comments/Explanations:

There has been effective NARES-led dissemination of science-based technologies through the IRRC platform called "Country Outreach Programs (ICOPs)". These ICOPs were established formally in three countries (Indonesia, Myanmar, and the Philippines). The model strengthened research-extension linkages and adoption pathways, developed linkages to policy advocates, and enabled IRRI to respond to important new national rice policy initiatives in Indonesia and Myanmar. The ICOP approach was implemented at an informal level where there was already an effective research-extension mechanism in place for delivery of IRRC technologies (e.g., Vietnam). We undertook independent assessment of the adoption and impacts of IRRC technologies in India (direct-seeding technology), Vietnam (site-specific nutrient management [SSNM]), and China (aerobic rice). Using the dynamic research evaluation management model (DREAM), a 2%, 1.4%, and 2% increase in gross present values (GPVs) for farmers using direct-seeded rice in Uttaranchal, Uttar Pradesh, and Bihar was observed. The GPVs of the project in the rice-producing areas of Uttaranchal, Uttar Pradesh, and Bihar are estimated at $12.6 million, $165 million, and $80 million, respectively. A preliminary economic analysis for SSNM indicates a 2% and 3% increase in net present values for smallholder farmers in Ha Tay and Ha Nam provinces, respectively.

Project 03

East and southern Africa: rice for rural incomes and an affordable urban staple

Output 03.01

Research priorities and policy options formulated by 2009 through characterization of the rice production environment and markets with regard to productivity potential and environmental stress and their interface with poverty.

Target 03.01.01 Policy strategies >75% Achieved

A network of key policy makers and researchers in the six target countries

Comments/Explanations:

During 2008, IRRI strengthened our working relationship with the Ministry of Agriculture and higher level institutes in Burundi, Kenya, Mozambique, Rwanda, Tanzania, and Uganda by undertaking joint research and training activities. More than 76 rice breeders, agronomists and technicians from Burundi, Kenya, Mozambique, Rwanda, Tanzania, and Uganda were identified and attended training courses in Africa and Philippines. Varietal nurseries were also established with researchers in the 6 countries. Memorandums of Understanding were also signed between IRRI and the governments of Burundi, Tanzania and Uganda. In Mozambique, IRRI combined with IIAM, Tropical Research Institute of Portugal and Eduardo Mondolane University of Mozambique to undertake a new village level program for growing rice as a sustainable business in the Zambezi province. WARDA and IRRI combined there programs in ESA and now work as one entity under the East and Southern Africa Rice Program (ESARP). In this program Mozambique, Tanzania and Uganda were identified as major working hubs for the next three years.

Target 03.01.02 Policy strategies >50% Achieved

Understanding of the rice environment in the six target countries for research, production, and marketing.

Comments/Explanations:

A socio economic survey was completed in southern Mozambique during 2008 which identified constraints to production in the Chokwe irrigation scheme. Low levels of inputs especially fertilizer and improved varieties, labor unavailability at crucial time, unreliability of irrigation water and credit all contributed to low yields. A second survey was initiated in central Mozambique in late 2008 in 3 provinces and will be completed by early 2009. In Tanzania, a survey was initiated in the major rice growing areas studying the effect that drought has on rice production.

Target 03.01.03 Capacity strengthening < 50% Achieved

Analysis of the capacity of regional scientists and extension officers to conduct research and extension in the six target countries

Comments/Explanations:

A planned field visit to Kenya in May to meet researchers and visits universities and research institutes was deferred due to civil unrest. A regional planning meeting was conducted for the six countries to develop a regional work plan both for capacity building and combined research activities across the region. This meeting endorsed the regional approach to plant breeding and further highlighted the need for capacity building in all aspect of rice research and extension.

Output 03.02

Elite lines including O. glaberrima derivatives with genes for stress tolerance validated by 2010.

Target 03.02.01 Materials Fully Achieved

A coordinated breeding program across at least two ESA target countries

Comments/Explanations:

More than 2000 lines were tested in the 3 different rice eco systems in ESA during 2008. Regional nurseries were established in Chokwe (irrigated) and Quelimane (rainfed) in Mozambique and Dakawa (irrigated) in Tanzania. From these nurseries, more than 160 lines were selected by each of the 6 target countries for advancement in their own national nurseries. Cold tolerant material was also tested in farmers fields in Burundi and Rwanda as well as more than 500 new lines from

IRRI and CIAT are being evaluated under favorable upland conditions in Uganda. Fifteen PVS trials have already been established in Mozambique and Tanzania using 60 lines selected from the 2008 trials. In Mozambique, IRRI and IIAM produced more than 500kg of breeder seed for the three most popular varieties from joint purification trials. This material will be used to produce more than 30tons of foundation seed in 2009.

Output 03.03

Sustainable production and postharvest rice-based technologies for both seed and grain farms validated by 2010.

Target 03.03.01 Practices >75% Achieved

Understanding of existing crop production and post-harvest management systems and opportunities for change in selected countries of the region.

Comments/Explanations:

A number of crop production experiments were conducted in Mozambique during 2008. Plant nutrition, plant establishment and time of planting, weed management and herbicide studies were conducted in southern Mozambique. Results from these studies showed yields of 5t/ha could be attained without the use of fertilizer if good weed and water management practices were applied along with early planting. There were no yield differences between transplanted and directed seeded crops. Yield reductions of more than 50% were encountered through late planting (after December). Mechanical cone weeders gave good weed control and reduced the time taken for manual weeding by a factor of 6. Small scale farm equipment was also demonstrated to farmers, equipment manufacturers and scientists in Mozambique. From these demonstrations, a mobile thresher has already been manufactured locally. In central Mozambique a tractor mounted levee builder was introduced to give better water control and is being evaluated in the rainfed areas.

Output 03.04

Capacity of key rice scientists, technicians, and extension staff to conduct research and to validate and disseminate technologies strengthened by 2010.

Target 03.04.01 Capacity strengthening >75% Achieved

Enhanced capacity of scientists from ESA through targeted in-country and regional training courses and international training opportunities.

Comments/Explanations:

During 2008, 36 plant breeders from the 6 ESA countries attended varietal selection workshops in Mozambique and Tanzania. Breeders were taught techniques for selection and also conducting their own national nurseries. Another 18 scientists attended a 3 week rice production and post harvest workshop at IRRI in the Philippines. Twelve pathologist and plant breeders from the region also attended a 2 week plant pathology workshop at IRRI in Philippines. A Rice Bank Knowledge workshop and writing workshop was conducted for 24 scientists and researchers from IIAM in Mozambique. One PhD student is being supported to undertake a studies into the effect that drought has on rice production in Tanzania.

Project 04

Rice and human health: overcoming the consequences of poverty

Output 04.01

Nutritionally enhanced rice germplasm developed by 2009

Target 04.01.01 Materials Fully Achieved

The leading two high- zinc and iron germplasm lines from conventional breeding for NARES.

Comments/Explanations:

Three advance breeding lines of high-zinc rice developed with the Bangladesh Rice Research Institute are now in advance yield trials in Bangladesh. The Indonesian Center for Rice Research formally released on July 2008 a new high-iron rice variety, INPARI 5 Merawu, which was developed from IR6560 (decree of Indonesian Ministry of Agriculture for released variety No.955/SR.120/7/2008). At IRRI, More than 800 anther culture derived doubled haploids from nine crosses were field evaluated in replicated experiments during 2008 wet season. Harvesting and data collection for various agronomic traits has been completed. Grain sample preparation for grain zinc/iron analyses is ongoing. Molecular data on one DH mapping population has been completed. These data will be utilized to map genes/QTLs governing grain iron/zinc. Three large DH mapping populations will be field evaluated during 2009DS for this purpose. A set of 92 agronomically promising DH was selected from the above trial for further testing in replicated trials. A user friendly high-throughput photometric protocol for zinc estimation has undergone beta testing. We are in the process of developing standard curves facilitating sample processing. Spectrophotometric preliminary screening for iron and zinc of more than 800 doubled haploids obtained from nince crosses were completed. A set of 18 elite breeding lines evaluated in 2008DS RYT and another set of 20 promising donor lines evaluated during 2007WS and 2008DS in RYT were screened. Another set of 81 lines evaluated in 2007WS potentially with high grain zinc and 47 advanced pedigree lines obtained from PhilRice were also screened. Samples from 24 genotypes with three replications were analyzed using ICP method in order to compare Grainman and modified Kett mills. A new set of 18 lines from Zn deficiency breeding team evaluated in replicated trials in normal and zinc deficient plots were screened. A set of 20 promising donor lines evaluated during 2008DS in RYT were screened. Six genotypes were evaluated in replicated experiments in two farmers' fields known to have zinc deficiency with and without basal zinc application in Iloilo province. A large Recombinant Inbred Lines (>500; F6) population from a single crosses involving lead donor and IRRI bred recently released variety 'NSIC RC 110' was derived. Similarly, 17 RIL populations were derived from crosses between lead donors and popular indica varieties, with 250 lines from each of the crosses are at F5 stage. To breed promising germplasm possessing superior agronomic performance in target areas, F1 seeds from crosses between four lead Fe/Zn materials and the Sub1-derivatives of Asian mega varieties IR64, Swarna, Sambha Mahsuri, TDK1, Cihrang, BR29 and BR11 were produced. More than 400 anther culture derived doubled haploids from selected seven F1 crosses from above have been produced. Another set of six selected crosses from above have been selected for DH production.

Output 04.02

Strategies for the development, promotion, and delivery of biofortified rice, including transgenic rice, by 2010 for India and the Philippines, and then for Bangladesh, China, and Vietnam.

Target 04.02.01 Policy strategies >75% Achieved

Nutrition policy-based deployment plan for biofortified rice for the Philippines (formerly India and the Philippines)

Comments/Explanations:

In 2008-2010 MTP, India was dropped from this output target following the formation of the Indian Golden Rice Product Development Committee. The Committee includes representatives of different Indian government departments and ministries (e.g. Department of Biotechnology and the Ministry of Children and Women), and the Program 4 Leader. A Project Management Unit has been established and reports to the Committee through the Program 4 Leader. IRRI submitted a proposal for the project contract being offered by the McLaughlin-Rotman Centre for Global Health (MRC) and its Ethical, Social and Cultural Program for the Grand Challenges in Global Health (GCGH) Initiative. The proposal will cover the initial public engagement initiatives for the deployment of Golden Rice in the Philippines and India. This fund will complement the Golden Rice product development and deployment 4-year grant (2009-2012) from the Rockefeller Foundation, which is focused on Bangladesh, Indonesia, and the Philippines. The University of the Philippines Los Baños College of Development Communication has completed in 2008 the key stakeholders' perception survey and meta-analysis of previous Golden Rice related studies. A social marketing study team has been formed in partnership with the Asian Institute of Management. The Biotechnology Coalition of the Philippines has also agreed to be our lead partner in developing the policy advocacy strategy for Golden Rice in the Philippines

Output 04.03

Increased understanding of the roles of macromolecules in rice grains for caloric efficiency by 2010

Target 04.03.01 Other kinds of knowledge Cancelled

Understanding of the target populations, product concepts, and lead technical approaches.

Comments/Explanations:

Progress on this Output is dependent on research activities in another Program. Program 4 has no current funding and has deferred working on this Output for the 2nd year.

Output 04.04

Strategies to reduce contamination of rice grains and to improve practices that decrease risks to human health developed by 2012

Target 04.04.01 Materials >75% Achieved

Germplasm resistant to accumulation of toxic contaminants in grains.

Comments/Explanations:
. IRRI/Program 4 has deemphasized its efforts to produce rice varieties with lower As in the grain. This decision is based on peer-reviewed studies, especially those from the food science community, that have shown arsenic contamination of "rice on the plate" is at most a minor source of As in the diet. IRRI's Dhaka office remains active in the more productive mitigation-of-contamination of drinking water efforts. Exploratory studies were conducted at IRRI to compare the best-practice postharvest management with simulated traditional management practices like field drying and temporary storage of wet grains, which are often practiced by smallholder farmers and small processors. It was concluded that the synthesis of aflatoxin B1 is very likely in suboptimal postharvest systems, with average levels of 43.8 ppb and a maximum of 81 ppb in paddy. Assuming an 85% reduction in the milling process and another 50% in cooking, the cooked rice would result in an estimated average of 3.3 ppb, respectively. This is below the limits of the EU of 4 ppb but, considering that rice is the staple food for most Asians, the daily intake would still be significant. Assuming a body weight of 50 kg and an average milled rice consumption of 270 g/day in the Philippines, the potential daily intake would amount to 17.7 ng/kg body weight, far above the tolerable daily intake. Follow-up research will focus on adapting a low-cost aflatoxin detection method for rice and the quantification of the potential problems in selected villages in the Philippines and another country.

Target 04.04.02 Policy strategies >75% Achieved

Understanding and selection of target regions and practices.

Comments/Explanations:
Dependent on Output 4.1: For arsenic in Bangladesh and Eastern India, this output target has been achieved, as a result of the clarification of the role of cooked rice and arsenic in the diet. Output 4.2. On-going for the mycotoxin output.

Project 05

Rice genetic diversity and discovery: meeting the needs of future generations for rice genetic resources

Output 05.01

Genetic diversity platform for gene function identification in domestic and wild rice gene pool established by 2011.

Target 05.01.01 Practices >75% Achieved

Genome-wide genotyping (using SNP tags or alternative sequencing tools) and phenotypes for target traits for 1000 multiple varieties, key donors, and wild relatives samples.

Comments/Explanations:
Approximately 160,000 high-quality genome-wide SNPs were discovered in the OryzaSNP project. These SNPs are annotated in release 2 of the database (http://www.oryzasnp.org) and provide the means to select tag SNPs for genotyping further lines. An international consortium of partners was formed in 2008 for a second phase of OryzaSNP to undertake high density genotyping of 2000 or more varieties using the phase 1 data and additional SNPs from next generation sequencing of additional genomes. Phenotyping data to define phenology were collected on 800 lines in preparation for reproductive stage drought screening. Initial SNP and phenotype association focused on grain quality traits, including gelatinisation temperature, amylose content and aroma. 3000 diverse varieties of rice were genotyped and phenotyped for these after developing SNP-based primers. The association between SNP and phenotype was proven. For gelatinisation temperature SNPs in starch synthase lla were identified. For amylose, SNPs in the amylose gene were discovered and tested for association with amylose and for gel consistency, a trait that is regularly mapped to the Waxy locus (amylose). For aroma, the gene, betaine aldehyde dehydrogenase was sequenced in hundreds of varieties, and we found 10 different alleles of the gene that all affect the amount of the aromatic compound that accumulates in rice. Supporting evidence: OryzaSNP database (http://www.oryzasnp.org) Corpus H. 2008. Starch fine structures in relation to gel consistency variations in high amylose rices. MS thesis University of the Philippines. Fitzgerald, MA, Sackville Hamilton, NR, Calingacion M, Verhoeven H, Butardo V. Is there a second fragrance gene in rice? 2008 Plant Biotechnology Journal 6: 416-23. Kovach MJ1,Calingacion MN ,Fitzgerald MA, McCouch SR.Where's that aroma coming from?: the origin and evolution of fragrance in rice (Oryza sativa L.) submitted to Genetics Cuevas R, Daygon D, Corpuz, H, Reinke, R, Waters D, Fitzgerald M. Melting the secrets of gelatinisation temperature. submitted to Plant Biotechnology Journal

Target 05.01.02 Practices Fully Achieved

High-throughput rice genome engineering capacity to produce 10,000 transgenic plants.

Comments/Explanations:

A high-throughput rice genome engineering based on Agrobacterium transformation of rice immature embryo was established on IR64 with the transformation efficiency of 20-40% and in average of 40-55% single copy event depending on the construct; on other mega varieties a transformation frequency of 5-15% was achieved. More than 4000 independent transgenic IR64 plants were developed in 2008 from 12 gene constructs for drought resistance and 9 gene constructs to increase iron content in rice. A quality control system was applied in the pipeline to ensure quality assurance of transgenic products. The current transformation efficiency allowed the laboratory to produce 10,000 plants/year as planned. However, the capacity and facilities to undertake a quick gene copy analysis to obtain a single-copy event and phenotypic analysis of transgenic material needs to be strengthened.

Target 05.01.03 Practices Fully Achieved

A validated artificial micro-RNA as a gene-silencing tool in rice using three candidate genes.

Comments/Explanations:

In collaboration with Max Planck Institute at Tuebingen, Germany, artificial micro-RNA gene silencing system in rice was established using three different genes (Pds, Spl11, and Eui1/CYP714D1) as case studies. Upon constitutive expression of these amiRNAs in the varieties Nipponbare (japonica) and IR64 (indica), the targeted genes were down-regulated by amiRNA-guided cleavage of the transcripts, resulting in the expected mutant phenotypes. The effects are highly specific to the target gene, the transgenes are stably inherited and they remain effective in the progeny. This is the first report that artificial miRNAs efficiently trigger gene silencing and mimic mutant phenotypes in monocots. The same tool has been applied to study functions of genes relevant to drought tolerance and C4 characteristics. Supporting evidence: Warthmann N, Chen H, Ossowski S, Weigel D, Herve P. 2008. Highly specific gene silencing by artificial miRNAs in rice. PLoS One 3(3): e1829, 10p. Software tools and a protocol to apply artificial miRNA constructs for rice are provided in http://wmd2.weigelworld.org.

Output 05.02

Specialized genetic stocks for trait dissection produced by 2011.

Target 05.02.01 Materials < 50% Achieved

Chromosome segmental substitution lines (CSSL) from one accession each of *O. glaberrima*, *O. longistaminata* and *O. rufipogon* in the background of *O. sativa* and shared with NARES and ARIs

Comments/Explanations:

Populations have been generated to develop CSSL in the background of O. sativa (IR64, Ilpumbyeo) using O.rufipogon (Acc 106407), O. longistaminata (acc 110404) and O. glaberrima (acc 96717). A set of 120 SSR markers was used to characterize these populations. Chromosomal segments from the donor species in some of these lines were identified.

Target 05.02.02 Materials Fully Achieved

Set of introgression lines segregating for chalk and with specific QTLs for dissection of chalk

Comments/Explanations:

A set of introgression lines were grown for several seasons to purify the genetic background. We obtained a purified set that differs for chalk values, for tolerance to forming chalk at high temperature and for tolerance to high temperature for other traits of yield and quality. The set was genotyped by RFLP markers that led to the identification of QTLs at the loci of 2 isoamylase genes and 2 starch branching enzyme genes. Further genotyping will be done with SNP technology. Once the finding is verified, the set we have selected will be of use to other research programs at IRRI working on temperature tolerance.

Output 05.03

Genetic pathways for selected traits determined using genome-wide and comparative biology approaches with priorities on stress tolerance, nutrition and grain quality, and yield by 2015.

Target 05.03.01 Other kinds of knowledge >75% Achieved

Validated functions and roles of *Pup1* candidate genes in tolerance mechanism against P-deficiency.

Comments/Explanations:

Comparative sequence analyses of the Pup1 locus of the tolerant donor variety Kasalath and rice reference genomes revealed that Pup1 is a hot spot of transposon integration and that only 4 of the 68 putative Kasalath genes show some degree of conservation. Based on detailed in silico and gene expression analyses, the number of candidate genes has been narrowed down to six.

Transgenic plants have so far been generated for 2 gene constructs (PupK20: dirigent-like, PupK46: protein kinase) and will be completed for the remaining genes once the full length cDNAs have been cloned. RNAi plants for four genes are already available and are currently being analyzed. Pup1 gene-based markers were developed and used for a rice germplasm survey. Data suggested that Pup1 is mainly present in genotypes adapted to drought-prone unfavorable environments whereas it is largely absent from irrigated rice varieties (Chin et al, manuscript in preparation). First field experiments suggest Pup1 might have the potential to improve yield considerably (>20%) under stress conditions. The data are now being validated. Supporting evidence: Heuer S, Lu X, Chin JH, Tanaka JP, Kanamori H, Matsumoto T, De Leon T, Ulat VJ, Ismail AM, Yano M, Wissuwa M (2009). Comparative sequence analyses of the major QTL Phosphate uptake 1 (Pup1) reveal a complex genetic structure. Journal of Plant Biotechnology Journal. (In press.)

Target 05.03.02 Other kinds of knowledge >50% Achieved

Validated roles of *Sub1* upstream regulators and downstream genes in tolerance to submergence and other stresses.

Comments/Explanations:

The promoter regions of tolerant and intolerant specific alleles of the submergence tolerance gene Sub1A have been analyzed in detail and candidate regulatory cis-elements were identified. We are now preparing promoter-deletion constructs for GUS and GFP reporter- gene studies to validate these elements in transgenic plants. A germplasm screening of more than 178 rice accessions was conducted with the objective to identify submergence tolerant accessions without the Sub1A gene or with the intolerant Sub1A-2 allele. From this screening, no tolerant accessions without the Sub1A was identified. The data further suggest that high expression of the intolerant Sub1A-2 confers an intermediate level of tolerance. It remains to be clarified if higher levels of submergence tolerance depend on the presence of the tolerant-specific Sub1A-1 allele or trans-acting regulatory factors. Supporting evidence: manuscript in preparation.

Target 05.03.03 Other kinds of knowledge Fully Achieved

Validated function of 5 defense genes conferring broad-spectrum disease resistance through RNAi or virus-induced gene silencing.

Comments/Explanations:

Of the candidate defense genes identified in multiple mapping populations, we focused on germ-like protein genes on chromosome 8 and oxidate oxalate genes on chromosome 3. We showed that an advanced backcross line carrying a cluster of 12 germin-like protein (OsGLP) gene members on chr 8 exhibited resistance to rice blast disease over 14 cropping seasons. To determine if OsGLP members contribute to resistance, and if the resistance was broad-spectrum, a highly conserved portion of the OsGLP coding region was used, via RNAi silencing, to suppress the expression of a few to all chr 8 OsGLP family members. Challenge with two different fungal pathogens (causal agents of rice blast and sheath blight diseases) revealed that as more chr 8 OsGLP genes suppressed, disease susceptibility of the plants increased. On chromosome 3, there are 4 members of oxalate oxidate genes. Preliminary work on the silencing of oxidase oxalate genes on chromosome 3 suggested a similar pattern of loss of broad spectrum resistance. The demonstration of a role in sheath blight resistance is particularly interesting because of the limited genetic understanding of sheath blight resistance. Supporting evidence: Manosalva PM, Davidson RM, Liu B, Zhu XY, Hulbert SH, Leung H, Leach JE. 2009. A germin-like protein gene family functions as a complex quantitative trait locus conferring broad-spectrum disease resistance in rice. Plant Physiol. 149: 286-296.

Target 05.03.04 Other kinds of knowledge Fully Achieved

Established relationship between SNP and temperature tolerance of amylose content in high amylose rice.

Comments/Explanations:

A SNP on the waxy gene, which is responsible for amylose has been identified. The SNP we discovered does not affect temperature tolerance of amylose. The SNPs on the waxy gene determine amylose content. We verified the association using IRRI germplasm set. Screening of the IR64 mutant collection has identified a mutant with much lower amylose than the wildtype, but the mutation is not in the waxy gene. The work suggests that the mutation is in one of the genes that direct the binding of enzymes to the starch granule, which is necessary for some to carry out elongation of the chains. Supporting evidence: Fitzgerald MA, McCouch SR, Hall, RD. 2009. The global quest for quality rice. Trends in Plant Science (online Feb 18 2009). Willoughby D. 2009. Master thesis, submitted to University of Sydney.

Target 05.03.05 Please select... Cancelled

Knowledge of the causal effects between intermediate amylose class and SNP variation.

Comments/Explanations:

This output target probably should have been part of previous one; we made an unnecessary "split"; it essentially said the same thing as "establishing the relationship between…."

Target 05.03.06 Practices Fully Achieved

A phenotyping system and technologies for identifying C_4 attributes and C_3-C_4 intermediate traits in rice plants

Comments/Explanations:

Reliable and high throughput screening technologies were developed to identify the phenotypes that could be used as platforms of discovery for the C4 rice. Low CO2 chambers were constructed to identify wild species of rice that have high photosynthetic efficiency and therefore survive at low CO2 levels as well as C4 mutants that have reverted to having higher CO2 compensation point. Another screening technique using hand-held microscopes was developed to provide a speedy way to identify phenotypes with high vein density which is characteristic of the C4 Kranz anatomy. Fluorescence microscopy protocols were used on the selected phenotypes for anatomical features associated with Kranz anatomy. These technologies were used in a pilot study using sorghum to identify C4 to C3 revertants in anatomy and/or CO2 compensation point. Supporting evidence: Protocols for each phenotyping technique documented in laboratory manuals of Applied Photosynthesis and Systems Modeling Laboratory, IRRI CO2 chambers available at IRRI

Target 05.03.07 Materials Deferred

Quantified contribution of endophytes to BNF in a set of wild species and traditional germplasm.

Comments/Explanations:

This activity was started in collaboration with Dr. Barbara Reinhold, University of Bremen, Germany. Preliminary results indicated O. longistaminata as the potential donor for endophytes for BNF activity. Dr. Reinhold has been provided roots to examine the BNF activity in parents, F1 and BC1 progenies. Due to lack of funding, this activity was continued on at a low level. A concept note was submitted to IRRI and also discussed with BMZ; however, no funding could be secured.

Target 05.03.08 Materials >50% Achieved

Over-expressed Oscdc25 as a means of blocking meiosis in secondary megaspore mother cells of msp1 mutant.

Comments/Explanations:

To create aposporous apomixis for cheaper hybrid rice production, IRRI needed to develop aposporous initials from nucellar cells. A two-step process was envisioned: (i) production of secondary megaspore mother cells (MeMCs) using the msp1 mutant and (ii) prevention of meiosis in the secondary MeMCs by over-expressing the rice orthologue of cdc25, a gene encoding a protein phosphatase that prevents meiosis in yeasts. However, because of male-sterility, the msp1 mutant was replaced by fertile RNA-interference lines targeted against OsTDL1A, a ligand of the MSP1 protein. Furthermore, reports of the existence of cdc25 orthologues in plants proved incorrect, requiring IRRI to identify another way of blocking the initiation of meiosis. There was no rice homologue for the yeast transcription factor INITIATION OF MEIOSIS1 (IME1), or for IME2, a protein kinase. However, a close homologue was found for IME4, an mRNA N6-adenosine methyltransferase. OsIME4 sense transcripts accumulate in mitotic cells, whereas OsIME4 antisense transcripts accumulate in meiotic cells. IRRI is now able to explore how to use over-expression and RNA interference to block the initiation of meiosis through OsIME4. Supporting evidence: Zhao X, de Palma J, Oane R, Gamuyao R, Luo M, Chaudhury A, Hervé P, Xue Q, Bennett J. 2008. OsTDL1A binds to the LRR domain of rice receptor kinase MSP1, and is required to limit sporocyte numbers. Plant J. 54: 375-387. Final report to donor (ACIAR), November 2008.

Output 05.04

Ex situ conservation of rice germplasm expanded and enhanced through better understanding of the genetic diversity within and between collections in a global network by 2011 to contribute to long-term conservation efforts, harmonized with genebanks in other CGIAR institutes through the SGRP

Target 05.04.01 Other kinds of knowledge Fully Achieved

Identified gaps in coverage of traditional and wild species accessions across collections within the global network.

Comments/Explanations:

Gaps have been identified by country for traditional varieties of Oryza sativa by comparing the number of accessions conserved ex situ with the area under rice cultivation, in relation to recent results on SSR diversity. The analysis suggests that the countries holding most genetic diversity that is not yet conserved in genebanks are, in order, Myanmar, Bangladesh, Thailand, Vietnam and Pakistan. Significant gaps in wild relatives have been identified by comparing the documented native distribution of AA genome species with their representation in ex situ collections. The comparison revealed many non-Asian countries where wild rice grows native but have absolutely no known representatives conserved in genebanks: Oryza barthii from 20 African countries, O. longistaminata from 28 African countries, and O. glumaepatula from 11 Latin American countries. These should be a priority for future gap-filling to conserve novel diversity from these species.

Target 05.04.02 Materials Fully Achieved

Additional genetic resources and 5000 specialized genetic stocks available in the International R ice Genebank.

Comments/Explanations:

Additional stocks 3,374 samples have been have been placed in storage replacing depleted stocks, and 3,056 new samples in 18 shipments have been added to the genebank, including 1,033 from other groups within IRRI. We added IR64 mutant lines (stored in foil pouches) to the Genebank as long-term resource for genetic screen and gene discovery. These include 18,575 random M4 lines and 4,331 fixed lines with known phenotypes. They represent approximately 40% of the IR64 mutant collection established at IRRI. Phenotypes for the mutant lines can be searched via the IR64 mutant database and seeds are publicly available upon request. The packages stored at Genebank are meant for future use after working stocks are exhausted. Supporting evidence: IR64 mutant database at http://www.iris.irri.org/action/mutant?method=viewTerm

Output 05.05

Long-term broadened access to genomic resources and associated tools, particularly for NARES.

Target 05.05.01 Practices Fully Achieved

A simplified microarray-based technique for marker and SNP analysis.

Comments/Explanations:

A microarray for detecting single feature polymorphism (SFP) was developed at the University of Arizona and was tested at IRRI. The chip comprises 24 multiplexed subarrays, comprising 880 oligos designed based on differences in genome sequences between japonica variety Nipponbare and indica variety 93-11. The oligos correspond to unique genes evenly spaced along the chromosomes (median spacing approximately 250 kb). We tested different labeling methods and hybridization conditions to optimize a protocol which has a dramatically lower cost per sample than current methods. We applied the genotyping chip to dissect QTL responsible for durable blast resistance, 244 BC4F3 lines were evaluated for blast resistance in the greenhouse and blast nursery. We used the SFP chip to monitor chromosomal introgressions from blast resistant donor into the recurrent parent, which enable us to rapidly define three QTLs on chromosomes 2, 6, and 9. In summary, we have achieved the following: a) a low-cost multiplexed genotyping chip is ready for wide applications, b) application for rapid mapping demonstrated (bulked segregant analysis), and c) demonstrated application for detecting introgression chromosomal regions in advanced backcross lines. Supporting evidence: Edwards JD, Janda J, Sweeney MT, Gaikwad AB, Liu B, Leung H, Galbraith DW. 2008. Development and evaluation of a high-through, low-cost genotyping platform based on oligonucleotide microarrays in rice. Plant Methods 4:13. DOI 10.1186/1746-4811-4-13.

Target 05.05.02 Materials Fully Achieved

Allele-indexed elite breeding lines with multiple stress tolerance (salinity with other soil stresses, e.g., Fe toxicity, Zn deficiency, sodicity).

Comments/Explanations:

Elite salt-tolerant (salinity and sodicity) breeding lines were screened and indexed for Zn deficiency, Fe toxicity, sodicity and high temperature tolerance at seedling stage. Elite lines which posses positive alleles for two or more for stresses along with salt-tolerance were identified and shared with NARES partners through soil-stress nurseries of the International Network for Genetic Evaluation of Rice (INGER). Some elite lines (e.g., IR51485-AC-6534-1) are extremely good, possessing positive alleles for multiple abiotic stress tolerance, including Fe toxicity, Zn deficiency and high temperature tolerance. This work is being extended by adding more stress tolerance traits: tolerance to submergence, high temperature at reproductive stage, and salt-related stresses. Supporting evidence: Materials shared with NARES through INGER Nurseries

Target 05.05.03 Materials Fully Achieved

1000 advanced breeding lines from IRRI, ARIs, CG Centers, and NARES exchanged and disseminated in 30 major rice growing countries

Comments/Explanations:

A total of 1053 entries (838 unique breeding lines/varieties: 246 from NARES and 592 from IARCs of which 511 came from IRRI) were organized into 15 types of INGER nurseries (http://www.irrialumni.org-a.googlepages.com/2008.pdf; http://seeds.irri.org/inger/index.php?option=com_facileforms&Itemid=162). Of these nurseries, 10 were ecosystem-oriented (irrigated lowland, rainfed upland, rainfed lowland, aerobic, temperate, boro) and 5 were stress-oriented (both biotic- tungro and blast - and abiotic- salinity and heat). Some 440 nursery sets of these nurseries (28,906 seed packets) were sent to 29 countries in Asia (346 sets; 15 countries), Africa (51 sets; 7 countries), and Europe (16 sets; 2 countries). In addition, 2,154 varieties/breeding lines (not part of INGER nursery sets) were shared by INGER with requesting scientists from 31 countries (http://www.iris.irri.org/smta/home.do?method=initialize) for use in breeding and rice research. Supporting evidence: the respective web links cited above

Target 05.05.04 Capacity strengthening Fully Achieved

One international training course on rice breeding.

Comments/Explanations:

A 16-day training course on rice breeding entitled "Rice Breeding Course: Laying the Foundation for the Second Green Revolution" was held from July 30 to August 14, 2008 where 25 breeders and scientists from universities and institutions (public and private) in South Korea, India, Bangladesh, Philippines, Nepal, Thailand, and Vietnam participated, including 15 funded by the BMGF project on abiotic stresses. Aside from covering theoretical and practical aspects of rice breeding, the course also featured hands-on exercises on molecular marker-aided selection and research data management. As the final output, the participants developed and presented their plans to improve their country's rice breeding programs using lessons learnt from the course. Supporting evidence: (http://bulletin.irri.org/2008.30/default.asp).

Target 05.05.05 Other kinds of knowledge Fully Achieved

DNA-fingerprints of 100 released varieties for NARES

Comments/Explanations:

INGER entries previously found outstanding and released as varieties or used as donors in NARES/IARC breeding programs were genetically characterized using SSR markers, including entries for the irrigated rice, diseases (blast, bacterial blight, tungro), and insect pests (brown planthopper, whitebacked planthopper, gall midge, stemborer) nurseries. Diversity analysis of 161 INGER entries released as varieties in various countries was also initiated using 16 SSR markers and 32 morpho-agronomic characters. Likewise, DNA fingerprints of 2007 and 2008 INGER nominations (123 and 161 breeding lines, respectively) were generated using 28 SSR markers. All results (varietal fingerprints and dendrograms) are posted in the INGER website- http://seeds.irri.org/inger/index.php?option=com_joomnik&Itemid=216 (username - guest; password - inger_guest). Supporting evidence: INGER website: A series of undergraduate thesis projects Adefuin A. 2008. Genetic diversity of blast, bacterial leaf blight, and tungro resistant breeding lines of rice using simple sequence repeat markers. BS Biology Thesis. UPLB, Philippines. Galela H. 2008. Genetic diversity of the elite lowland irrigated varieties of rice grown from 1976 to 2005 based on simple sequence repeat markers. BS Biology Thesis. UPLB, Philippines. Punongbayan A. 2008. Genetic diversity analysis of pest-resistant varieties of rice using simple sequence repeat markers. BS Biology Thesis. UPLB, Philippines.

Project 06

Information and communication: convening a global rice research community

Output 06.01

The rice component of the Crop Science Information Resource (an initiative of the IRRI-CIMMYT Alliance)—which is a global community-curated repository and network of public crop science information resources, established by 2010.

Target 06.01.01 Other kinds of knowledge Deferred

Community-curated online encyclopedia of rice science.

Comments/Explanations:

In 2008, we made significant progress in organizing the IRRI web portal component relating to germplasm, the so called "Seeds" portal covering genetic resources (TT Chang GRC), evaluation (INGER) and crop improvement (PBGB), including the "next generation" web interface for the International Rice Information System (IRIS), based on Generation Challenge Programme and ICIS technology (see http://beta.irri.org/seeds). This included significant progress on the prototyping of an ITPGRFA-compliant SMTA seed ordering interface for INGER nurseries (to be expanded to general GRC seeds stocks in 2009). However, we feel that the main target of community-curated online encyclopedia of rice science remains incomplete, as a review of suitable technology and availability of specific research staff to work on the resource was problematic in 2008. We currently intend to collaborate more closely with CIMMYT CRIL to establish such a resource as a comparative – rice, maize and wheat - genome information catalog focusing mainly on the documentation of candidate genes related to priority crop traits for (abiotic and biotic) stress response and C3 versus

C4 photosynthesis. This resource will build on the comparative stress gene catalog previously funded by the Generation Challenge Programme (hosted at http://dayhoff.generationcp.org).

Output 06.02

The Crop Systems Knowledge Bank, an online resource of knowledge on cereal production for rice, maize, and wheat, containing rice information from IRRI's Rice Knowledge Bank (RKB), by 2010.

Target 06.02.01 | Capacity strengthening | Fully Achieved

In Bangladesh, Laos, Indonesia, and Thailand , the RKB country site is locally owned and controlled by a national committee.

Comments/Explanations:

This has been fully achieved. In Bangladesh, Laos, Thailand and Indonesia the RKB is now under local management. In addition this has been achieved in Vietnam and Cambodia. At an annual meeting in Siem Reap each of the above countries reported progress on the development within their respective countries. It showed that local ownership was in place. For Thailand, , Vietnam and Cambodia a monitoring and evaluation report showed clearly the local ownership.

Target 06.02.02 | Capacity strengthening | Fully Achieved

A community of practice of knowledge bank users generating and sharing information on rice and other cereals established in Asian region.

Comments/Explanations:

IRRI with its partners has developed a process for the management of rice knowledge for the Rice Knowledge Bank. This is reflected in IRRI RKB management and the country management that is inclusive of material development, its testing and the updating of material.

Output 06.03

The World Rice Community Portal—which uses Internet technology for access to information and for interaction on rice by supporting self-organizing communities and multilateral communication—operational by 2010.

Target 06.03.01 | Other kinds of knowledge | >75% Achieved

A community-curated global, multi-lingual rice thesaurus and ontology.

Comments/Explanations:

Considerable progress was achieved in populating the IRRI Rice Thesaurus with a total of 3229 terms defined with subject trees (encoded on the MultiTes platform) to make it searchable and publishable in the WWW. In general terms, IRRI made significant progress in indexing rice digital resources in 2008. Using a collaboration with Google Books and with Flickr.com we have seen a marked increase in the access to IRRI-generated information resources (publications and images). This has resulted in large numbers of book page views (1,500,000 in 2008) , book downloads (9,469 in 2008), and image views (230,000 in 2008). We need to find mechanisms to stimulate more community curation and feedback.

Target 06.03.02 | Capacity strengthening | Fully Achieved

Crop Systems Knowledge Bank communities for three Southeast Asian nations within the World Rice Community Portal.

Comments/Explanations:

Cereals Knowledge Bank (http://www.knowledgebank.irri.org/) provides a comprehensive portal to various NARES communities. Future activities hosted completely under Output 2.

Output 06.04

Phase I of the Informatics and Communication Service for Crop Science and Extension—which is a public research, development, and dissemination service for informatics and communication technology targeting agricultural scientific research and extension—completed by 2010.

Target 06.04.01 | Other kinds of knowledge | >50% Achieved

Curricula for online tutorials and workshop training resources for use of the Crop Science Information Resource and the Crop Systems Knowledge Bank.

Comments/Explanations:

In early 2008, we completed the development of a Generation Challenge Programme funded online introductory course for crop bioinformatics hosted in a Joomla! Web 2.0 content management site (http://mcclintock.generationcp.org). This online course material was specifically used as a key resource in an in-house training session at IRRI in March 2008 (workshop curriculum published at http://seeds.irri.org/cropinfo/). In 2008 the CG ICT-KM program provided support for creating online training and support materials for good practices in research data management. The material is available online (http://cropwiki.irri.org/everest), and a resulting training course has been given

10 times during 2008 at IRRI.

Target 06.04.02 Practices Cancelled

Strategy and methodology for application of AccessGrid technology to multi-site training and scientific conferences.

Comments/Explanations:

Although videoconference and online collaborative technology – Wiki, CropForge, Webex, Joomla! Web 2.0 content - is in general use by and within the IRRI Crop Research Informatics Laboratory, we don't currently see a large public (i.e. NARES) demand for general conference technology such as Access Grid. Such technology will be monitored more closely over the coming years to assess its suitability for future efforts.

Project 07

Rice policy support and impact assessment for rice research

Output 07.01

Updated subnational/farm database and maps on socioeconomic aspects of rice production in major rice-growing countries of Asia prepared by 2012.

Target 07.01.01 Materials Fully Achieved

Updated global administrative boundaries database for mapping of socio-economic variables at the subnational level.

Comments/Explanations:

Database version 1.0 completed. Consists of > 167,000 polygons of subnational boundaries (680 per country, on average) and their names and variant names and in some cases multiple scripts. Is already in use in several projects at IRRI and elsewhere. Database available from website.

Target 07.01.02 Practices Fully Achieved

Compilation and analysis of subnational poverty maps for Asia and major rice growing countries of Africa.

Comments/Explanations:

A compilation of global subnational poverty data was accomplished. Data were compiled for 66 countries. For other countries subnational poverty levels were estimated using statistical methods. Database currently in use to estimate poverty impacts of rice technologies and of climate change. Database available upon request. Will be published on-line.

Output 07.02

Comprehensive knowledge of changes in rural livelihood systems and interactions among technology, infrastructure, and institutions in major rice-growing countries of Asia developed by 2009.

Target 07.02.01 Practices Fully Achieved

Assessment of broader changes in gender roles in rice production, and the welfare impact of dynamic interactions between rice technologies and gender roles in eastern India, Philippines, and Vietnam.

Comments/Explanations:

Rural poverty and migration have led to changes in family male and female labor contributions in rice production. In the Philippines, the relative labor inputs of female family members to total labor inputs per hectare have declined. This maybe attributed to the higher participation of female members in non-farm work. Females left behind do less field work but their roles as de facto farm managers and finance managers increased. They bear the pressure more than men in making ends meet in times of increasing prices of food, fuel and other commodities. In south Vietnam, female family labor inputs are higher those of the males in rainfed villages. In the irrigated villages, their labor inputs are almost equal. In the north, 80% of the total labor inputs come from female family members. Outmigration of principal males compels principal females to substitute for their jobs. Their decision-making authority on farm matters increased. The significant roles that women play in ensuring family food security, calls for a reorientation in the training and extension programs as well in participatory experiments on rice and crop management technologies. Migration of men similarly increased labor inputs of women in farming activities in eastern India.

Target 07.02.02 Policy strategies Fully Achieved

Understanding of drivers and patterns of changes in livelihood strategies and poverty in rural Bangladesh, Philippines, and eastern India.

Comments/Explanations:

A study on rural outmigration revealed that more than half of the rice farming households interviewed in eastern Uttar Pradesh, Bihar and West Bengal, India migrated to rural and urban areas. Migration led to important changes in livelihoods with remittances accounting for nearly one-half of the annual income. The remittances helped households avoid falling into the debt trap. Results from the Philippines and Bangladesh are also in conformity with the findings from India and clearly indicate a rising share of non-farm sources in the total household incomes. These results indicate the need to factor-in these changes in income structures in designing improved agricultural technologies as farm labor increasingly finds remunerative opportunities outside the farm sector.

Output 07.03

Policy reform options based on analyses of long-term changes in comparative advantages in rice production in major rice-growing countries of Asia developed by 2012.

Target 07.03.01 Policy strategies Fully Achieved

Policy options based on the knowledge of pricing and subsidies to improve water use efficiency in India.

Comments/Explanations:

This research revealed that the replacement of communal tank irrigation systems with private pump irrigation systems has been accelerated by the provision of free electricity for pumping. This replacement and subsequent deterioration of communal tanks has made irrigation water less accessible to marginal poor farmers who rely on these traditional tank systems. At the same time, free electricity has encouraged excessive pumping and wasteful use of water and has contributed to a rapid decrease in groundwater table due to overexploitation. Thus, policies that have promoted groundwater irrigation through free electricity have resulted in a lower water use efficiency, overexploitation of groundwater and deterioration of traditional tank irrigation systems. These findings are published in the following two papers. Kajisa, K., K. Palanisami, and T. Sakurai. 2007. Effects on poverty and equity of the decline in the collective tank irrigation management in Tamil Nadu, India, Agricultural Economics, 36 (3), 347-362. Kajisa, K. 2008. Deterioration of tank irrigation systems and poverty in India. in Agriculture in Developing Countries: Technology Issues, Edited by Kalirajan K. and K. Otsuka, New Delhi: Sage Publication

Output 07.04

Knowledge of potential and realized impacts of rice research on poverty reduction and sustainable management of natural resources generated by 2009.

Target 07.04.01 Capacity strengthening Fully Achieved

Strategy for institutionalizing an impact culture in rice research systems.

Comments/Explanations:

Two batches of one-day workshops on "Assessing the Success of a Research Project" were organized to build the capacity of research staff on project evaluation and impact assessment. 28 IRS and NRS scientists involved in varied research activities participated. The participants worked on their existing projects in an exercise that defined research outputs, correct counterfactuals, key stakeholders, beneficiaries, capacity building needs, communication/dissemination strategies, evaluation, and the resulting community level changes in the socio-economic and environmental conditions. A checklist of impact pathway analysis was developed to aid project development. A generic impact pathway for use across the CG-system was published by SPIA in July 2008.

Target 07.04.02 Policy strategies Fully Achieved

Advanced methods and tools to evaluate the influence of policy-oriented research on observed policy changes.

Comments/Explanations:

An analytical framework was developed for addressing methodological challenges in evaluating policy-oriented research (POR). These challenges include clearly defining the policy component of the research and the (regulatory) policy changes that occurred, explicit mapping out of the components of the path from inputs to impact, and attribution of the influence of research on policy changes. Taking these factors into account, a combination of quantitative and qualitative methods was developed to evaluate a POR and applied in the context of the impact of research on policy changes regarding pesticide use in the Philippines.

Target 07.04.03 Policy strategies Fully Achieved

Knowledge of returns to policy-oriented rice research on pesticide use on the health of rice farmers in Philippines.

Comments/Explanations:

IRRI's policy-orientated research (POR) on farmers' health and pesticide use completed in 1992 contributed in changing the country's 1992-96 pesticide policy package (PPP)—banning of hazardous chemicals and improving awareness and adherence to their safe use. An assessment of the impact of this policy change was conducted to measure the economic health benefits of observed changes in pesticide use and pesticide management practices in the Philippines, determine the attribution of those benefits to a suite of pesticide and pest control policy enacted during 1992 to 1996, determine those factors that influenced the policy changes. The results showed a strongly positive return to the investment in the IRRI project. The NPV of IRRI's influence on the policy-makers' decisions to implement the 1992–1996 pesticide policy package is estimated to be US$248 million over the 30-year time horizon (1989–2018). The corresponding BCR is 202:1 and the IRR is 65 percent. The returns to investment are high because for a relatively small investment of a million dollars, the outputs of the IRRI project contributed to a policy change that resulted in very large benefits in terms of the private health costs avoided. Reference: Templeton DJ, Jamora N. 2008. Economic Assessment of IRRI's Policy-orientated Research into the Private Health Costs of Pesticide Use in Rice Farming in the Philippines. IRRI Impact Assessment Report No. 1. International Rice Research Institute (IRRI): Los Baños, Laguna, the Philippines.

Output 07.05

Strategies and policies for facilitating rapid dissemination and diffusion of improved technologies developed by 2009.

Target 07.05.01 Practices Fully Achieved

Improved understanding of farmer decision making processes on use of elite lines and improved crop and water management practices in eastern India and Vietnam.

1) Improved understanding of farmer decision making processes on use of elite lines in eastern India

Comments/Explanations:

Use of Participatory Varietal Selection (PVS) in improved understanding male and female farmer decision: Focus group discussions, household surveys and PVS through researcher- and farmer-managed trials of stress-tolerant rice varieties revealed that a major determinant of varietal choice is the conscious attempt of farmers to match varieties with the land type. Each field position in the toposequence corresponds to a different risk profile in terms of drought, submergence or salinity. Factors which influence poor farmers' selection criteria were found to be environmental, economic and socio-cultural including gender-specific roles, compatibility with existing cropping and farming systems, and other valued traits of the rice plant (eg., straw for animal fodder or as roofing materials). The study revealed that men and women farmer inputs are needed, as certain preferences are gender-based. Finally, taste and quality of cooked rice were found to be important consideration in farmers' choices of rice varieties. PVS also provided opportunities for farmers to test new lines and compare these with their own using their management practices ---- increasing the chances of adoption of varieties suitable to specific target areas.

Target 07.05.02 Practices Fully Achieved

Improved understanding of farmer decision making processes on use of elite lines and improved crop and water management practices in eastern India and Vietnam.

2) Improved understanding of farmer decision making processes on use of improved crop management practices in Vietnam

Comments/Explanations:

Use of multimedia campaign approach to communicate and motivate farmers: A participatory planning process was applied to develop a media campaign to motivate rice farmers in the Mekong Delta to modify pest management practices together with seed and fertilizer inputs. Locally named 'Ba Giam Ba Tang' or 'Three Reductions, Three Gains', campaigns were launched in two provinces, Can Tho and Tien Giang. In both provinces, farmers' practices changed significantly. Their insecticide sprays reduced by 13–33% while their seed rates dropped by 10%, nitrogen rates by 7% and the proportion of farmers using insecticides declined by 11%. These changes in practices were supported by modifications in belief and attitudes that favored high inputs. Farmers who reported significant reductions in the three inputs also changed their perception of yield loss. The campaigns in Can Tho and Tien Giang had significant multiplier effects. They stimulated several provincial governments as well as the Ministry of Agriculture and Rural Development to provide additional resources to reproduce the materials and campaign process for local use which eventually reached more than 3 million farmers in south and central Vietnam. Paper published: Huan, N. H., Chien, H. V., Quynh, P. V., Tan, P. S., Du, P. V., Escalada, M. M. and Heong, K.L. (2008) 'Motivating rice farmers in the Mekong Delta to modify pest management and related practices through mass media',International Journal of Pest Management,54:4,339 — 346.

Target 07.05.03 Practices Fully Achieved

Improved understanding of farmer decision making processes on use of elite lines and improved crop and water management practices in eastern India and Vietnam.

3) Use of farmer participatory model to facilitate extension of Good Agricultural Practice (GAP) for irrigated rice production

Comments/Explanations:

Use of farmer participatory model to facilitate extension of Good Agricultural Practice (GAP) for irrigated rice production: Two farmer participatory demonstration sites of 10 ha each were established in 2006 to facilitate extension of Good Agricultural Practice (GAP) for irrigated rice production. Positive reports by the farmers involved directly in the study resulted in the provincial government formally requesting IRRI for support in providing a platform for adaptive technology diffusion in 11 districts. The technologies for outreach had minor modifications developed by the participating farmer communities. The An Giang provincial government provided funds for the project. In February 2008, the Vice Minister from MARD endorsed An Giang to be established as a model province for GAP for the Mekong delta. Training of trainers was conducted with the assistance of IRRI; most trainers were NARES counterparts of IRRI scientists, trained under the IRRC. They came from 4 different NARES institutions in the Mekong Delta. This project demonstrates how farmer participatory adaptive research with close linkages to national, provincial and district extension systems, can lead to an effective model for outreach that is led by local NARES partners but has strong policy links with provincial governments. (Supporting documentation: official letter, Vice Director An Giang Foreign Affairs Department, Jan 25, 2008)

IRRI Outcomes - 2008

SC Assessment

Score: 7.50

SC Comments:

Outcome case	Score	Comments
New rice breeding lines with improved yield under drought	8.7	Output is clear for breeding of important traits (reference to MTP is not accurate), but outcome (testing, plan to release variety in one country) is early. Clear IPG
User community adopts oryza2000 simulation model for rice	6.5	Output seems to be incremental improvements to a model but what was added is vague. Linkage of outcome to the recent improvements is not clear; reference is to the original version. Incremental improvement, but of IPG nature.
Aerobic rice production systems	9.5	The outcome has derived partly from earlier activities than those identified. Outcome pathway is very comprehensively presented (evidence) and outcome linkage to recent research is clear by association. IPG .
Empowering grain quality analysis in NARES through the international network for quality rice (INGER)	4.7	Output is capacity building through development of networks which also provide the dissemination pathway. Outcome is not described (membership in networks is not an outcome), although some outcome is plausible from the network. No evidence.
Upland rice varieties for the hills of Nepal	6.4	MTP link not given but apparent although upland rice breeding has produced results before 2004. Description is largely about the process (including seed distribution) but cultivar adoption seems to have occurred also outside the projects. Poor evidence, some in local languages. Local importance.

Germplasm exchange under the international treaty on plant genetic resources for food and agriculture (ITPGRFA)	8.9	Output is clear and verified; case of potentially broad use of practical best practice established at the Center. Outcome is still at recommendation stage but there are indications of use.

Outcome 1

TITLE: NEW RICE BREEDING LINES WITH IMPROVED YIELD UNDER DROUGHT

OUTCOME STATEMENT:

Six breeding lines with yield advantages of 0.8-1.0 t ha^{-1} under severe drought conditions over current varieties are used by breeding programs in South Asia.

OUTPUTS THAT RESULTED IN THE OUTCOME:

The outputs are the 6 breeding lines with much improved performance under drought stress. They are the product of a 2007 output target (IRRI MTP 2007-2009).

ACHIEVEMENT OF THE OUTPUT DOCUMENTED:

On-station breeding trials and on-farm participatory varietal selection trials of the India drought breeding network (IDBN) demonstrated that the breeding lines IR 72667-16-1-1, IR 55419-04, IR 74371-70-1-1, IR 74371-54-1-1, IR 70215-70-CPA-3, and IR 70844-10-SRN-43-1-B had yield advantage of at least 0.8 to 1.0 t ha^{-1} under drought situations over IR 64 and IR 36, the two prominent varieties grown in these regions, whilst maintaining at least the same yield as IR64 and IR 36 under irrigated conditions. Variety testing in Bangladesh and Nepal has confirmed their good performance under rainfed conditions. This is documented in the annual progress reports (2008) of the Rockefeller Foundation-GCP supported project " Developing and disseminating resilient and productive rice varieties for drought - prone environments in India" and in the first report of the BMGF supported project "Stress Tolerant Rice for Poor Farmers in Africa and South Asia (STRASA)".

Further evidence is the crop variety release proposal submitted by the Central Rainfed Upland Rice Research Station (CRURRS, Hazaribag) to the Central Sub Committee on Crop Standards, Notification and Release Varieties of Govt. of India, for the IRRI breeding line "IR74371-70-1-1" as variety "Sahbhagi Dhan" for the Indian states of Jharkhand, Chhattisgarh, Orissa and Tamil Nadu, documented in the report of the Directorate of Rice Research (DRR, Hyderabad) for the varietal trials, kharif 2007.

The 2008 report of the All India Coordinated Rice Improvement Program (AICRIP) showed that the breeding line IR74371-70-1-1 had yield advantages of 29.2% and 19.1% over the national and regional check varieties under drought conditions, and a yield advantage of 22.8% and 31.4% over national and regional check varieties under non-stressed conditions. Check varieties were also out-yielded under drought stress at Bhubaneshwar, Cuttack, and Rewa.

USERS/ADOPTERS OF THE OUTPUTS:

Next Users:

NARES breeders in the rainfed drought prone regions of eastern India, the Terai region of Nepal, and northwestern Bangladesh.

Final Users:

Final users after variety release will be farmers of the rainfed regions of eastern Indian provinces, the Terai region of Nepal, and northwestern Bangladesh.

USE/ADOPTION OF OUTPUTS:

Next Users:

The adoption of the drought tolerant breeding lines by NARES partners has been facilitated through the IDBN collaborative efforts. NARES adopters in India are: CRURRS (Hazaribag, Jharkhand); Birsa Agricultural University (Ranchi, Jharkhand); Central Rice Research Institute (Cuttack, Orissa); Orissa University of Agriculture and Technology (Bhubaneshwar, Orissa); Indira Gandhi Krishi Vishwa Vidyalaya (Raipur, Chhattisgarh); Narendra Dev University of Agriculture and Technology (Faizabad, U.P.); Jawaharlal Nehru Krishi VishwaVidyalaya (Jabalpur, Madhya Pradesh); Tamil Nadu Agricultural University (Coimbatore, Tamil Nadu); University of Agricultural Sciences (Bangalore, Karnataka); Directorate of Rice Research (Hyderabad, Andhra Pradesh); Barwale Foundation (Hyderabad, Andhra Pradesh). In Nepal: National Rice Research Program, Hardinath; Regional Research Station, Nepalganj. In Bangladesh: Bangladesh Rice Research Institute (BRRI).

Final Users:
Selected farmers in India, Nepal, and Bangladesh cultivated the drought tolerant breeding lines in their fields as part of Participatory Variety Selection trials. The drought tolerant breeding lines were highly preferred by farmers.

MAGNITUDE OF THE OUTCOME RELATIVE TO THE INTENDED RECOMMENDATION DOMAIN

Next Users:

NARES on-station and on-farm experiments proved yield advantage of 0.8- 1.0 t ha^{-1} over the presently grown best varieties under drought stress.

Final Users:

Average yield advantages of 0.8 to 1.0 t ha^{-1} under drought stress over presently grown varieties have also been achieved by selected farmers in the drought prone rainfed areas in India, Nepal, and Bangladesh. After variety release and dissemination, this superior germplasm will be available to farmers in all adjoining rainfed areas.

EVIDENCE THAT THE OUTCOME IS DERIVED FROM THE OUTPUT AND FOR THE OUTCOME:
Direct e vidence is the use of the breeding lines in breeding programs of NARES in India, Nepal, and Bangladesh, and the crop variety release proposal submitted by CRURRS for the breeding line “IR74371-70-1-1” as variety “Sahbhagi Dhan”. Further evidence is given in the reports of the DRR on the varietal trials kharif 2007, in the reports of the Rockefeller Foundation-GCP supported project “ Developing and disseminating resilient and productive rice varieties for drought - prone environments in India”, and in the first report of the BMGF supported STRASA project.

Evidence: IRRI Outcome 1 drought.zip

Outcome 2

TITLE: USER COMMUNITY ADOPTS ORYZA2000 SIMULATION MODEL FOR RICE

OUTCOME STATEMENT:
In 2008, a network of research institutes adopted the use of the ORYZA2000 crop growth simulation model for teaching, research, and development of rice technologies to improve resource-use efficiency (radiation, water, nitrogen) and increase yields in an environmentally-sustainable way.

OUTPUTS THAT RESULTED IN THE OUTCOME:
ORYZA2000 is a process-based, eco-physiological model to simulate the growth and development of rice. The first version was released by IRRI in 2001 but reported in IRRI’s MTP 2004-2006 output 5.1. The model was subsequently tested, improved, and used by IRRI and its partners, as reported in MTP 5.1 through MTP 2.2 over the years. In 2008, a unique data set was put together that contains calibrated crop files and data sets for more than rice 10 varieties (inbreds, hybrids) tested under different experimental conditions across multiple sites in China, Philippines, Indonesia, Japan, Thailand. In 2008 a network of users was established that adopted ORYZA2000 as main platform for modeling rice at the Rice Modeling Workshop held at IRRI, November 2008.

ACHIEVEMENT OF THE OUTPUT DOCUMENTED:
Key publications and student theses document the chain of results and outputs of ORYZA2000 since 2001 that led to the outcome in 2008. Other outputs in 2008 are

documented by the notes of the 2008 Rice Model Workshop, the progress reports on APSIM-ORYZA2000 integration, and by the large collection of calibrated crop data files and environmental characterization files.

USERS/ADOPTERS OF THE OUTPUTS:

Next Users :

China Agricultural University, Wuhan University , Ubon Ratchathani Rice Research Center, University of the Philippines Los Banos, Wageningen University, Nanjing Agricultural University , Punjab Agricultural University, Ferdowsi University of Mashhad, Institute of Atmospheric Physics - Chinese Academy of Sciences, Agricultural Production Systems Research Unit – Toowoomba, Gyeonggi Agricultural Research and Extension Services, Central Rice Research Institute, Institut de Radioprotection et de Sûreté Nucléaire, Austral University of Chile, Mitsubishi Research Institute – Tokyo.

Final Users:

The ORYZA2000 model is targeted at scientists and scholars at universities and research institutes who are both next and final users. Ultimately, however, the use of ORYZA2000 by them should contribute to the development and delivery of improved crop management recommendations and target domains to rice farmers.

USE/ADOPTION OF OUTPUTS:

Next Users: ORYZA2000 was used to:

- quantify crop by environment interactions for different rice varieties;
- disentangle effects of different climatic factors;
- develop crop establishment recommendations in salt-affected areas in the Mekong Delta;
- analyze yield decline in aerobic rice and identify causal factors in the Philippines;
- quantify yield and irrigation water requirements to derive irrigation management recommendations in China, India and the Philippines;
- calculate the global and national water footprints of rice; determine optimum fertilizer-nitrogen strategies in irrigated rice in China and Korea;
- assess attainable yields, quantify yield gaps, and identify management practices that would reduce the yield gap in rainfed rice in Indonesia and Thailand;
- analyze effects of climate change, especially temperature, on yield of rice in China and the Philippines; and
- explore potential impacts of combined changes in temperature and CO2 levels and N fertilization.

ORYZA2000 is incorporated into curricula for students at ChinaAgriculturalUniversity, and is used as research tool by students at University of the Philippines Los Baños, WageningenUniversity, NanjingAgriculturalUniversity, WuhanUniversity, UbonUniversity , Austral University of Chile . The APSRU model team in Australia worked with IRRI staff to further integrate ORYZA2000 into APSIM by developing specific routine to handle the flooded rice – nonflooded upland crop interface and soil-nutrient and SOM balances during saturated soil conditions.

Final Users:

Generated knowledge by the use of ORYZA2000 will contribute to the development of rice cropping practices to be disseminated and adopted by rice farmers.

MAGNITUDE OF THE OUTCOME RELATIVE TO THE INTENDED RECOMMENDATION DOMAIN

Next Users:

ORYZA2000 is valid for rice crops grown in any part of the world and can be used anywhere to support research and development of rice varieties and rice management practices. Current use of ORYZA2000 by NARES and ARIs is found in Asia (Vietnam, Thailand, China, India, Philippines, Korea, Japan), Australia, Europe (Netherlands, Germany, France), South America (Chile), Middle East (Iran).

Final Users:

Rice farmers all over the world can potentially benefit from improved management recommendations derived with inputs from studies with ORYZA2000.

EVIDENCE THAT THE OUTCOME IS DERIVED FROM THE OUTPUT AND FOR THE OUTCOME:
The evidence is found in the scientific papers, student theses, workshop reports, and activity reports that report on the use of ORYZA2000.

Evidence: ORYZA2000.zip

Outcome 3
TITLE: AEROBIC RICE PRODUCTION SYSTEMS

OUTCOME STATEMENT:
In 2008, a large number of NARES in Asia used aerobic rice germplasm developed in IRRI-led projects and networks, and adopted research, development, and dissemination activities on the IRRI-developed aerobic rice production system, while "aerobic rice" as proposed by IRRI has become an accepted term and research topic by many ARIs.

OUTPUTS THAT RESULTED IN THE OUTCOME:
"Aerobic rice" was conceptualized by IRRI in 2001 and subsequently included in its MTPs. Outputs were originally documented in MTP outcomes 5.1 and 5.2 in 2004, while recent outputs are documented under MTP outputs 1.1 and 2.2. Key outputs in 2008 include pre-breeding germplasm and released aerobic rice varieties, and a range of crop-soil-water management technologies on irrigation, nutrient management, crop establishment (direct seeding), and mechanization (machine seeding and harvesting). A list of aerobic rice germplasm is provided in the evidence. Four scholars obtained a PhD degree on aerobic rice in 2008.

ACHIEVEMENT OF THE OUTPUT DOCUMENTED:
Aerobic rice achievements culminated in 2008 with the conclusion of three major projects: the water workgroup of the Irrigated Rice Research Consortium III, "Systems of tropical Aerobic Rice", and "Development and Dissemination of Water-Saving Rice Technologies in South Asia". An overview is presented in the report "Developing a System of Temperate and Tropical Aerobic Rice in Asia" (http://cpwf-theme1.irri.org/compreports.htm) and in annual project reports. Key publications and student theses (see annex) since 2005 document the chain of results and outputs that led to the outcome. See also http://www.irri.org/Aerobic_Rice/.

USERS/ADOPTERS OF THE OUTPUTS:
Next Users:
The NARES users are China Agricultural University (CAU, China), Huazhong University (China), Huibei Research Station – Kaifeng (China), a large number of local townships and agricultural bureaus in China, Indian Agricultural Research Institute-Water Technology Centre (Delhi, India), Central Rice Research Institute (Cuttack, India), Directorate of Rice Research (Hyderabad, India), Central Soil and Water Conservation Research & Training Institute (Chhalesar, Agra, India), Regional Agricultural Research Station (Tarhara , Nepal), National Rice Research Program (Hardinath, Nepal), Rice Research Institute (Pakistan), Kala Shah Kaku

Rice Research Institute (Dokri, Pakistan), National Irrigation Administration Tarlac (NIA, Philippines), Philippine Rice Research Institute (PhilRice), Central Luzon State University (Philippines), Bulacan Agricultural State College (Philippines), National Soil and Water Resources Research and Development Center - Bureau of Soil and Water Management (Philippines), Ubon Ratchathani Rice Research Center (URRC, Thailand), National Agriculture and Forestry Research Institute (NAFRI, Laos), Bangladesh Rice Research Institute (Gazipur, Bangladesh), Rural Development Academy (RDA, Bogra, Bangladesh),

Final Users:
The ultimate users of aerobic rice are farmers. Early adoption is documented in China, India, Philippines.

USE/ADOPTION OF OUTPUTS:
Next Users:
The aerobic rice production system is included in many research programs and in extension and training programs by the NARES for dissemination to rice farmers in Asia. In China, India, Philippines, Bangladesh, and Pakistan, pilot sites for technology demonstrations have been set up in farm communities and farmer field days and demonstrations have been organized. A large number of trainings was also targeted at national scientists and extension workers. Breeding trials and field and greenhouse experiments for further technology development have been established by the NARES in China, India, Thailand, Laos, Philippines, Bangladesh, and Pakistan.

Final Users:
Early adoption of aerobic rice by farmers is documented in China, India, Philippines.

MAGNITUDE OF THE OUTCOME RELATIVE TO THE INTENDED RECOMMENDATION DOMAIN
Next Users:
Many NARES and ARIs are picking up research and development of aerobic rice systems beyond the partners directly affected by our outputs as listed above, as evidenced by literature reports and requests for collaboration received.

Final Users:
Potential extrapolation domain areas for aerobic rice were calculated using homolog and weights of evidence modeling that look for agroecological and socioeconomic conditions similar to those found at project pilot sites (Rubiano et al., 2007). The analysis shows that the highest probability areas are all in Asia. In India, the extrapolation domain is largely concentrated in the rice-wheat systems in the Indo-Gangetic basin. In Thailand and Myanmar, the areas are concentrated in rainfed lowland areas. Large potential recommendation domains are found in North China in the YellowRiver Basin (not part of extrapolation domain study). The analysis also found large areas that are suitable climatically in Africa in Zimbabwe, Mozambique, Madagascar, Burkina Faso, and Nigeria, and in Latin America in Brazil, Bolivia, and Venezuela.

EVIDENCE THAT THE OUTCOME IS DERIVED FROM THE OUTPUT AND FOR THE OUTCOME:
The evidence is found in the scientific papers, proceedings, student theses, project and activity reports, popular dissemination material partners, and documented experiment protocols.

Evidence: IRRI Outcome 3 aerobic rice.zip

Outcome 4
TITLE: EMPOWERING GRAIN QUALITY ANALYSIS IN NARES THROUGH THE INTERNATIONAL NETWORK FOR QUALITY RICE (INQR)

OUTCOME STATEMENT:
Investment in research on grain quality at IRRI has led to new capacity for screening and evaluating grain quality in NARES breeding programs. Genetic and biological understanding of several quality traits has provided the necessary tools for implementing new ways to evaluate grain quality, and the formation of the International Network for Quality Rice provides the conduit for dissemination of the methodologies. This has long-term implications for (a) enhanced selection capacity in breeding programs; (b) adoption of varieties by farmers; and (c) raising income through better market value of rice varieties.

OUTPUTS THAT RESULTED IN THE OUTCOME:

1. **Formation of International Network for Quality Rice (INQR)** (Project 6 Output 1 2007, MTP 2006-08). The INQR was formally launched in 2007. It currently has 80 members from almost every quality evaluation program associated with a rice improvement program, advanced institutes whose research directly relates to traits of quality, and instrument makers whose

products can be used for better analysis of quality.

2. **Amylose evaluation** (Project 3 Output 1, MTP 2006-08). We have identified the sources of variability caused by using at least 7 different methods of measuring amylose around the rice world. Our effort in analyzing the contribution of each source to variability has resulted in the development of a new method for measuring amylose, which takes advantage of new technology and linkages that exist between developers and users of technology within the INQR. Another test is being carried out to assess the variability between labs for this method (46 quality labs). The new method has been agreed to by all the laboratories.
3. **Aroma evaluation** (Project 2 Output 2 2008, MTP 2006-08). Traditional aromatic varieties of jasmine and basmati types were collected within the INQR and key metabolomic differences were found for the first time, between jasmine types and basmati types. Huge variability in the amount of the aromatic chemical in rice led to the hypothesis of allelic variability at the locus. So far, 10 different alleles of the aroma gene were found. These findings were made possible by collaborative linkages between developers and users of technology within the INQR. A workshop was held in Laos for the rice suppliers and the metabolite identifiers in 2008 which resulted in a publication.
4. **Grain Dimensions** (Project 3 Output 1 2008 MTP 2006-8). A survey where 22 quality evaluation groups classified 450 images of rice showed that different definitions are being applied to the physical characteristics of rice around the world, especially to chalk. Structural differences in starch from chalky areas are known. We have standardized the definitions and are in the process of a second test to assess compliance with definitions.

ACHIEVEMENT OF THE OUTPUT DOCUMENTED:

1. Scientific publications:

- Hall RD et al. 2008. Plant metabolomics and its potential application for human nutrition. *Physiologia Plantarum* 132, 162-175
- Fitzgerald MA, Hall RD. 2008. Illuminating the gap. *Rice Today* 7, 38
- Fitzgerald MA et al. 2009. More than just a grain of rice, the global quest for quality. *Trends in Plant Science* (in press)
- Kovach MJ et al. 2009. The origin and evolution of fragrance in rice (*Oryza sativa* L.) submitted to *PLOS Genetics.*
- Fitzgerald M et al. 2009. The dilemmas of amylose in rice. In preparation for submission to *Cereal Chemistry.*

2. Databases and data online (www.irri.org/inqr):

- Genotype information for genes of quality for 5000 varieties published on the INQR website. Database of publications on rice quality posted.

3. Methodology

- New amylose method submitted to three standards organizations, harmonizing the method across these: IUPAC, ISO and AACC, and to the members of the INQR.

USERS/ADOPTERS OF THE OUTPUTS:

Next Users :
Quality evaluation laboratories in NARES

Final Users:
Breeders

USE/ADOPTION OF OUTPUTS:

Next Users:
Farmers

Final Users:
Millers, marketers and consumers

MAGNITUDE OF THE OUTCOME RELATIVE TO THE INTENDED RECOMMENDATION DOMAIN
Due to increasing emphasis on quality rice in the market, the enhanced activities related to quality were as expected in breeding programs. The number of interested parties participating in the International Network for Quality Rice is greater than expected.

EVIDENCE THAT THE OUTCOME IS DERIVED FROM THE OUTPUT AND FOR THE OUTCOME

- Active participation of all 77 members in the International Network for Quality Rice projects.
- The INQR website is password protected and passwords have been issued to the members on the INQR only. Use of the databases and information on the website is evidenced by 32,235 logins to the INQR website over the past 18 months.

Evidence: Outcome 4 Grain quality.pdf

Outcome 5
TITLE: UPLAND RICE VARIETIES FOR THE HILLS OF NEPAL

OUTCOME STATEMENT:
In 2008, three farmer-preferred improved upland rice lines/varieties, namely, Radha-32 (IRRI breeding line IR-44595-70), IR-55435-5, and Ghaiya-2 became increasingly becoming popular in the Nepalese upland rice production environments. IRRI-NARS partners distributed about 1.4 tons of seeds of these varieties in 2008 alone, and about 3.4 tons between 2006 and 2008 to extension agencies and farmers for promotion and dissemination of varieties through formal and informal processes.

Farmers jointly operated village-based field research sites already produce seeds of these varieties. In 2008 individual farmers and farmer groups produced more than nine tons of seeds of the three varieties under joint technical supervision. The farmers were trained in scientific seed production. Furthermore this collaboration facilitated formation and registration of two farmer-group-based commercial enterprises to produce and market rice seeds.

Radha-32 has performed well in the upland rice environments of Nepal. The Nepalese National Rice Research Program has submitted a proposal to the National Variety Release Committee to release Radha-32 as a nationally recommended upland rice variety. Another IRRI breeding line IR-55435-5 is a potential candidate for national release.

OUTPUTS THAT RESULTED IN THE OUTCOME:
Four years of farmer participatory research since 2005 in collaboration with the National Rice Research Program (NRRP) and Institute of Agriculture and Animal Science (IAAS) have identified eight suitable improved upland rice lines/variety (B6144F-MR-6, B6149F-MR-7, Ghaiya2, IR-55435-5, NR1824 , Radha32, RR166-645, and WAB272-B-B1-H2) for upland rice environments.

ACHIEVEMENT OF THE OUTPUT DOCUMENTED:
1. IFAD TAG706 Annual Reports 2005, 2006, 2007 and 2008 (inprep.)
2. National Rice Research Program's IFAD TAG706 Annual Reports 2005, 2006, 2007 and 2008 (inprep.)
3. Institute of Agriculture and Animal Science's IFAD TAG706 Annual Reports 2005, 2006, 2007 and 2008 (inprep.))
4. Validated Technologies for Rice-based Systems of the Churia and Middle Hills,

Nepal (IFAD TAG706). A joint publication of NARC, IAAS, IFAD, and IRRI.
5. DVD, IFAD TAG706 Newsletter Volume 1, Issue 1 and 2
6. Proceedings 25th Summer Crop Workshop 2007, Nepal Agricultural Research Council (forthcoming). Online news: http://www.narc.org.np/narc/summer_crop_workshop.php

USERS/ADOPTERS OF THE OUTPUTS:
Next Users :
National Rice Research Program; Institute of Agriculture and Animal Science; IFAD-funded Western Uplands Poverty Alleviation Project; non-governmental organizations; district agriculture development offices; private seed entrepreneurs; and farmer seed groups.

Final Users:
The upland rice farmers in the hills of Nepal.

USE/ADOPTION OF OUTPUTS:
Next Users:
National Rice Research Program; Institute of Agriculture and Animal Science; IFAD-funded Western Uplands Poverty Alleviation Project; non-governmental organizations; district agriculture development offices; private seed entrepreneurs; and farmer seed groups.

Final Users:
The upland rice farmers in the hills of Nepal.

MAGNITUDE OF THE OUTCOME RELATIVE TO THE INTENDED RECOMMENDATION DOMAIN
Next Users:
The national agricultural research system; various rural and agricultural development projects; district agricultural development offices; non-governmental organizations; private seed entrepreneurs; and farmer seed groups.

Final Users:
The upland rice ecosystem in Nepal is diverse. Upland rice is grown from 200 meters in the *Terai* and inner-*Terai* region to 2,800 meters above sea level in the hills. Although fifteen districts are the major upland rice producers, rice is grown in most districts at some scale except a few high mountain and low-lying ***Terai*** districts. (Gauchan *et al.* 2008)

Upland rice is typically a subsistence crop. Some 233,000 resource-poor marginal farm households grow upland rice in some 68,000 ha of land (Central Bureau of Statistics 2002). Upland rice growing households account for 8.4% of total rice growing households and its area accounts for 4.4% of total rice area (Gauchan *et al.* 2008).

EVIDENCE THAT THE OUTCOME IS DERIVED FROM THE OUTPUT AND FOR THE OUTCOME:
1. IFAD TAG 706 Annual Reports 2005, 2006, 2007 and 2008 (inprep.))
2. National Rice Research Program's IFAD TAG706 Annual Reports 2005, 2006, 2007 and 2008 (inprep.)
3. Institute of Agriculture and Animal Science's IFAD TAG706 Annual Reports 2005, 2006, 2007 and 2008 (inprep.)
4. Validated Technologies for Rice-based Systems of the Churia and Middle Hills, Nepal (IFAD TAG706). Joint publication of NARC, IAAS, IFAD, and IRRI.
5. DVD, IFAD TAG706 Newsletter Volume 1 (2008), Issue 1 and 2 http://www.irri.org/IFAD_Upland_NewsletterV1N1.pdf , and http://www.irri.org/IFAD_Upland_NewsletterV1N2.pdf
6. Flyers on upland rice "Radha-32" and "Rice varieties for uplands and its cultivation practice" by NRRP and on "IR-55435-5" by IAAS in Nepali language
7. Proceedings 25th Summer Crop Workshop 2007, Nepal Agricultural Research Council (forthcoming). Online news:

http://www.narc.org.np/narc/summer_crop_workshop.php
8. Shrestha et al (2008) *Adoption of Rice based Technologies in Marginal Uplands in Siwalik*. Paper read at the 2nd Convention of Society of Agricultural Scientists, Nepal, 27-29 August 2008, Kathmandu, Nepal (proceedings forthcoming in 2009).
9. Radha-32 Variety Release Proposal submitted by NRRP to National Variety Release Committee, Kathmandu, Nepal.

Evidence: Upland rices in Nepal.zip

Outcome 6

TITLE: GERMPLASM EXCHANGE UNDER THE INTERNATIONAL TREATY ON PLANT GENETIC RESOURCES FOR FOOD AND AGRICULTURE (ITPGRFA)

OUTCOME STATEMENT:

Following implementation of the Standard Material Transfer Agreement of the ITPGRFA in 2007, NARES are exchanging more germplasm with IRRI than with any other CGIAR centre. IRRI NARES partners are sending more rice germplasm to IRRI than they did before. CIMMYT is in the process of adopting IRRI's approach. The Secretariat of the ITPGRFA has published IRRI's system on their web site, described it as the gold standard, recommended other holders of germplasm to adopt IRRI's system, and invited IRRI to contribute expert technical advice on the implementation of the Treaty through consultancies and through participation in a range of expert meetings, for example on legal issues and on information processing for germplasm exchange.

OUTPUTS THAT RESULTED IN THE OUTCOME:

- Rice genetic resource conserved and characterized (Project 1, Output 1 2004, MTP 2004-2006)
- Establishing global network of NARES, CGIAR, and ARIs holding rice genetic resources (Program 5, Output 4 2007, MTP 2007-2009)
- A consolidated rice germplasm information system for genetic resources, genomics and crop improvement (Program 6, Output 1 2007, MTP 2007-2009)

Through Outputs from 2004-8, we have improved characterization of the germplasm collection and upgraded information retrieval in the International Rice Genebank. We eliminated backlogs and improved processing of incoming rice samples, safety backup and taxonomic authentication. We combined data on all germplasm held in IRRI into a single database regardless of the group responsible for managing the germplasm. These improvements have laid the foundation for increased usage and exchange.

In 2006 there was period of intensive collaborative activity involving several organizational units (Seed Health, Plant Breeding, GeneticResourcesCenter, and Crop Research Informatics Laboratory, Intellectual Property Management Unit) to develop a new database, software and workflows. This resulted in the launch, in 2007, of a new system for germplasm exchange under the Standard Material Transfer Agreement of the Multilateral System of Access and Benefit Sharing of the ITPGRFA .

ACHIEVEMENT OF THE OUTPUT DOCUMENTED:

- Design issues for documented online at http://cropwiki.irri.org/icis/index.php/ICIS_ddd_002
- Technical documentation for maintenance of the SMTA website available online at http://cropwiki.irri.org/icis/index.php/Updating_the_SMTA_website
- Technical documentation for reporting on germplasm exchange available online at http://cropwiki.irri.org/icis/index.php/ICIS_ddd_002#SUMMARIES_.2F_REPORTING
- External user's guide for germplasm exchange procedures documented online at http://www.irri.org/grc/requests/requests.htm
- Internal procedures for germplasm exchange documented for IRRI scientists at http://shareportal/sites/sh/default.aspx

USERS/ADOPTERS OF THE OUTPUTS:
Next Users:
- National institutes, NGOs, private companies and individuals in 71 countries around the world
- CIMMYT
- Secretariat of the ITPGRFA

Final Users:
- Global rice researchers and breeders

USE/ADOPTION OF OUTPUTS:
Next Users:
- National institutes, NGOs, private companies and individuals in 22 countries sending germplasm to IRRI in one year
- National institutes, NGOs, private companies and individuals in 67 countries receiving germplasm from IRRI in one year
- CIMMYT: adopting the computing technology and workflows for germplasm exchange
- Secretariat of the Treaty: adoption of IRRI's standards as a global gold standard; formal involvement of IRRI in further planning of Treaty implementation.

Final Users:
- Global rice researchers and breeders

MAGNITUDE OF THE OUTCOME RELATIVE TO THE INTENDED RECOMMENDATION DOMAIN
Next Users:
- High, increased in germplasm exchange, as an element of implementing the Treaty, was the primary intended outcome.
- Adoption by CIMMYT was considered as a likely outcome given the sharing of informatics expertise and technologies between the two institutes.
- Adoption and promotion of IRRI's protocol by the Treaty Secretariat as the gold standard recommend for use by others, was an unexpected additional outcome
- Raising the status of IRRI, to be a formal provider of technical advice to the Treaty Secretariat on implementing the Treaty, was an unexpected additional outcome.

Final Users:
- Global rice researchers and breeders

EVIDENCE THAT THE OUTCOME IS DERIVED FROM THE OUTPUT AND FOR THE OUTCOME:
- Seed exchange: Database of incoming and outgoing shipments managed by the Seed Health Unit
- Historical changes in germplasm receipts by INGER: Reports of INGER to INGER, CORRA, IRRI BoT, IRRI.
- Adoption of ICIS by CIMMYT: documentation of ICIS development: https://cropforge.org/ http://cropwiki.irri.org/icis/index.php/ICISWiki (links to meetings reports and to the International Wheat Information System IWIS3, the International Maize Information System IMIS, and the Genetic Resources Information Management System for Wheat Genebank
- Recommendation by the Treaty Secretariat: Treaty website www.planttreaty.org and links to SMTAs (the SMTA web page http://www.planttreaty.org/smta_en.htm features IRRI SMTAs - the only provider featured) and meeting reports (http://www.planttreaty.org/meetings/tcit2_en.htm shows IRRI's contribution to Technical consultation meeting: http://intranet.sgrp.cgiar.org/ICWG-

GR2008/Summary_reports/ITPGRFA_CGIAR_S.Bhatti.pdf shows Treaty Secretariat describing IRRI as "defining best practice").

Evidence: Outcome 6 germplasm exchnage.pdf

IRRI Impact Culture - 2008

Criterion 1. EpIA studies/Advancement of epIA methods (45%)

SC Assessment

Score: 36.50

SC Comments:

Criterion 1. Overall score = 36.5 (max. 45)

Criterion 1a (# epIAs) = 20 (max. 20)

nine studies submitted, only Studies #1, #3 and #9 were accepted as epIAs;

minimum benchmark reqt [1] = 1.7

Criterion 1b (average quality of epIAs) = 11.5 (max. 20)

Study #1 (Templeton; Jamora 2008) = 9.3

Study #9 (Kajisa; Palanichamy 2008) = 13.6

Criterion 1c (budget/staff commitment) = 5 (max. 5)

based on 8.33 FTE

[1] based on 1epIA per $20 million of center budget.

1.A. Please provide the full citation of all ex post IA studies published in 2008 that attempt to assess major impacts attributed to your Center's work and provide summary information describing the scale of adoption (# farmers, # of hectares) and the main impacts or effects resulting from the adoption in economic or social or environmental terms. [20 points maximum if submitting one or more ex post IA study per every $20 million of Center budget]

1. Full Citation: Templeton DJ, Jamora N. 2008. Economic Assessment of IRRI's Policy-orientated Research into the Private Health Costs of Pesticide Use in Rice Farming in the Philippines. IRRI Impact Assessment Report No. 1. International Rice Research Institute (IRRI): Los Baños, Laguna, the Philippines. Also in http://www.sciencecouncil.cgiar.org/fileadmin/user_upload/sciencecouncil/Impact_Assessment/PORIA2008_pr_4_F_I-r_3_.pdf

Clearly state the research related output being assessed and the role of the center in realizing that output. Indicate the geographic scale/size of the assessment, the time period covered, and the method used. Present main result/indicators of impact reported by the study, i.e., estimates of adoption or uptake, estimates of income and other effects (on poverty, environment) both positive and negative – max of 100 words for each study:

IRRI's policy-orientated research on farmers' health and pesticide use in 1989-92 contributed in changing the country's 1992-96 pesticide policy package (PPP)—banning of hazardous chemicals and improving awareness of and adherence to their safe use. Farm surveys in 2006-07 showed decreases in insecticide use by 50% from 1990-91 levels and in farmer's health cost by 26%. Moreover, 85% of farmers adopted safe use practices such as wearing long sleeves and long pants compared to 2% in 1988-89. Assuming 75% attribution and 10% contribution to PPP benefits, the net present value of IRRI's research were US$248 million computed over 30 years.

1.B. For each ex-post IA study listed in 1.A above, please provide the relevant information under each component by checking the appropriate item 1 [20 points maximum for ex post IA studies' quality score of 100]

1. Publication venue (select one only)

[ ] Refereed journal
[ ] Book chapter
[ ] Conference paper (includes proceedings)
[x] In-house publication (reviewed externally)
[ ] In-house publication (not reviewed externally)

2. (Co-) authorship (additive up to max 5)
[ ] With other CG Center scientists
[ ] With NARS scientists
[ ] With ARI scientists
[x] Center only scientists

3. EpIA coverage (primary type of research assessed) (select one only)
[ ] Commodity improvement
[ ] NRM related
[x] Policy related
[ ] Biodiversity related
[ ] Training/Capacity building related
[ ] Other challenging area (specify)

4. Distance down the impact pathway covered by the study (points based on the highest-point indicator marked)
[x] Uptake/adoption (only for policy-related research)
[ ] Uptake/adoption plus direct impacts at the adopter-level (Stage 1): improved yield/quality, higher incomes, lower risk, improved health, etc.
[ ] Uptake/adoption plus intermediate impacts that go beyond the direct impacts at the adopter-level (conserve resources, increased market access/efficiency, developed human capacity, increased productivity)
[ ] Uptake/adoption plus ultimate societal impacts on poverty, food security, environment (Stage II)

5. Geographical breadth or scale of documented uptake/adoption on which the impacts assessed by the study are based (points based on the highest-point indicator marked)
[x] Single location (region) within a single country
[ ] Multi-locations (regions) within a single country
[ ] Multiple locations (regions) within several countries (~ 2-5)
[ ] Global coverage across the center's mandated political region (e.g., the whole region of West Africa, Latin America, Asia , Sub - Saharan Africa, All developing countries, etc.)

6. Advances in new methods/models & use of novel indicators (additive, up to a max.of 25 pts)
[ ] Addresses non-economic impact indicators
[ ] Addresses negative effects
[ ] Addresses differential effects (different target groups)
[ ] Addresses multiplier effects (other sectors)
[x] Employs novel methods (combines quantitative & qualitative, etc.)
[ ] Other methodological advances (specify)

2. Full Citation: Huelgas Z, Templeton D, Castanar P. 2008. Three Reductions, Three Gains (3R3G) technology in South Vietnam: searching for evidence of economic impact. Paper presented at the 52nd Annual Conference of the Australian Agricultural Economics Society, Canberra, 5-8 February 2008. Available at http://purl.umn.edu/6014

Clearly state the research related output being assessed and the role of the center in realizing that output. Indicate the geographic scale/size of the assessment, the time period covered, and the method used. Present main result/indicators of impact reported by the study, i.e., estimates of adoption or uptake, estimates of income and other effects (on poverty, environment) both positive and negative – max of 100 words for each study:

The uptake and economic impacts of "Three Reductions, Three Gains," a crop management technology that IRRI pilot tested in CanTho province and scaled out to the Mekong Region by the Vietnamese government in 2002, were studied. Data from two (out of three) provinces surveyed in CY2006-07 showed about 80% awareness and 40% adoption. Seed rates were consistently lower among adopters. Results showing lower pesticide use, fertilizer applications, and production costs and higher incomes higher were inconclusive. To obtain stronger conclusions more work will be done in data cleaning, model specification, measuring returns-to-research, and addressing attribution issues.

1.B. For each ex-post IA study listed in 1.A above, please provide the relevant information under each component by checking the appropriate item 1 [20 points maximum for ex post IA studies' quality score of 100]

1. Publication venue (select one only)

[ ] Refereed journal
[ ] Book chapter
[x] Conference paper (includes proceedings)
[ ] In-house publication (reviewed externally)
[ ] In-house publication (not reviewed externally)

2. (Co-) authorship (additive up to max 5)

[ ] With other CG Center scientists
[ ] With NARS scientists
[ ] With ARI scientists
[x] Center only scientists

3. EpIA coverage (primary type of research assessed) (select one only)

[ ] Commodity improvement
[x] NRM related
[ ] Policy related
[ ] Biodiversity related
[ ] Training/Capacity building related
[ ] Other challenging area (specify)

4. Distance down the impact pathway covered by the study (points based on the highest-point indicator marked)

[ ] Uptake/adoption (only for policy-related research)
[x] Uptake/adoption plus direct impacts at the adopter-level (Stage 1): improved yield/quality, higher incomes, lower risk, improved health, etc.
[ ] Uptake/adoption plus intermediate impacts that go beyond the direct impacts at the adopter-level (conserve resources, increased market access/efficiency, developed human capacity, increased productivity)
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[ ] Addresses multiplier effects (other sectors)
[ ] Employs novel methods (combines quantitative & qualitative, etc.)
[ ] Other methodological advances (specify)

3. Full Citation: Huelgas ZM, Templeton DJ. 2008. Adoption of crop management technology and cost efficiency impacts: The case of Three Reductions, Three Gains. Paper presented at the IRRC Workshop on Research to Impact: Case Studies for Natural Resources Management of Irrigated Rice in Asia, 23-24 Sept 2008, Philippine Rice Research Institute, Muñoz, Nueva Ecija, Philippines.

Clearly state the research related output being assessed and the role of the center in realizing that output. Indicate the geographic scale/size of the assessment, the time period covered, and the method used. Present main result/indicators of impact reported by the study, i.e., estimates of adoption or uptake, estimates of income and other effects (on poverty, environment) both positive and negative – max of 100 words for each study:

IRRI introduced "Three Reductions, Three Gains" in South Vietnam to optimize the rates of seeds, fertilizer, and pesticides and thereby reduce production costs, improve farmers' health, and protect the environment. The technology targeted 3.8 M ha of rice area. Survey data collected in three provinces for CY 2006-07 revealed 89% awareness and 48% adoption. Mass media promoted awareness, but, probit model estimates indicated extension as the main determinant of adoption. Adopters used significantly lower rates of seeds, nitrogenous fertilizers, and pesticides; were more cost-efficient (based on stochastic frontier model estimates); and had higher net incomes (by US$44/ha/yr) than the non-adopters.

1.B. For each ex-post IA study listed in 1.A above, please provide the relevant information under each component by checking the appropriate item 1 [20 points maximum for ex post IA studies' quality score of 100]

1. Publication venue (select one only)

[ ] Refereed journal
[ ] Book chapter
[ ] Conference paper (includes proceedings)
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[x] In-house publication (not reviewed externally)

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3. EpIA coverage (primary type of research assessed) (select one only)

[ ] Commodity improvement
[x] NRM related
[ ] Policy related
[ ] Biodiversity related
[ ] Training/Capacity building related
[ ] Other challenging area (specify)

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[ ] Addresses multiplier effects (other sectors)
[ ] Employs novel methods (combines quantitative & qualitative, etc.)
[ ] Other methodological advances (specify)

4. Full Citation: Moya P, Valencia SD, Kajisa K, Lampayan R, Bouman B. Outcomes of the transfer of water saving technology in a deepwell pump system in Canarem Tarlac, Philippines. Paper presented in a Workshop on Adoption and Impact of water Savings in Rice in the Philippines. 26-28 March 2008, IRRI, Los Baños, Laguna, Philippines

Clearly state the research related output being assessed and the role of the center in realizing that output. Indicate the geographic scale/size of the assessment, the time period covered, and the method used. Present main result/indicators of impact reported by the study, i.e., estimates of adoption or uptake, estimates of income and other effects (on poverty, environment) both positive and negative – max of 100 words for each study:

Adoption and impact of Alternate Wetting and Drying (AWD) irrigation technology in a 61-hectare pump irrigation system (P-38) in Tarlac, Philippines were assessed in DS-2005 after introduction in DS-2002. Using before-and-after analysis, AWD scores did not improve and the expected outcome—significant reduction in the amount of water use—was not attained. Impact on net income was ambiguous because the higher income was more attributable to the global rise in paddy price than the AWD. Despite the training and support activities, farmers revert back to the old when left on their own.

1.B. For each ex-post IA study listed in 1.A above, please provide the relevant information under each component by checking the appropriate item 1 [20 points maximum for ex post IA studies' quality score of 100]

1. Publication venue (select one only)

[ ] Refereed journal
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[x] NRM related
[ ] Policy related
[ ] Biodiversity related
[ ] Training/Capacity building related
[ ] Other challenging area (specify)

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[ ] Employs novel methods (combines quantitative & qualitative, etc.)
[ ] Other methodological advances (specify)

5. Full Citation: Huan NH, Chien HV, Quynh PV, Tan PS, Du PV, Escalada MM, Heong KL. 2008. Motivating rice farmers in the Mekong Delta to modify pest management and related practices through mass media. Int. Jour. of Pest Management 54:4,339-346.

Clearly state the research related output being assessed and the role of the center in realizing that output. Indicate the geographic scale/size of the assessment, the time period covered, and the method used. Present main result/indicators of impact reported by the study, i.e., estimates of adoption or uptake, estimates of income and other effects (on poverty, environment) both positive and negative – max of 100 words for each study:

Utilizing a participatory planning process, IRRI steered development of media materials that targeted 714,100 ha rice area in TienGiang and CanTho, Vietnam, in a campaign to reduce input rates and costs and increase incomes. Posters, leaflets, charts, and radio/TV drama records were distributed in 2003. Surveys revealed 56-81% of farmers heard of the campaign. Belief scores computed pre- and post-exposure to media materials indicated a significant change in perception favoring reductions in their rates of seeds, fertilizer, and pesticides to achieve lower input costs and higher incomes. These belief changes following a media campaign precede actual reductions in input use.

1.B. For each ex-post IA study listed in 1.A above, please provide the relevant information under each component by checking the appropriate item 1 [20 points maximum for ex post IA studies' quality score of 100]

1. Publication venue (select one only)

[x] Refereed journal
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3. EpIA coverage (primary type of research assessed) (select one only)

[ ] Commodity improvement
[x] NRM related
[ ] Policy related
[ ] Biodiversity related
[ ] Training/Capacity building related
[ ] Other challenging area (specify)

4. Distance down the impact pathway covered by the study (points based on the highest-point indicator marked)

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[ ] Other methodological advances (specify)

6. Full Citation: Heong KL, Escalada MM, Huan NH, Ky Ba VH, Quynh PV, Thiet LV, Chien HV. 2008. Entertainment– education and rice pest management: A radio soap opera in Vietnam. Crop Prot 27:1392-1397.

Clearly state the research related output being assessed and the role of the center in realizing that output. Indicate the geographic scale/size of the assessment, the time period covered, and the method used. Present main result/indicators of impact reported by the study, i.e., estimates of adoption or uptake, estimates of income and other effects (on poverty, environment) both positive and negative – max of 100 words for each study:

With IRRI providing conceptual leadership in using an entertainment–education (E–E) approach, 104 episodes of radio soap opera on pest management were broadcasted in Vinh Long province. Pre- and post-launch surveys showed that farmers dropped insecticide sprays by 31% (from 1.9 to 1.3 sprays per season), nitrogen 7%, and seed use 9%. Corresponding attitudinal changes were observed; farmers who had listened had higher reductions in insecticide sprays (60%), nitrogen (9%) and seeds (33%) compared to those who had not listened to the soap. There were also similar changes in belief attitudes favoring judicious use of pesticides, fertilizers, and seeds.

1.B. For each ex-post IA study listed in 1.A above, please provide the relevant information under each component by checking the appropriate item 1 [20 points maximum for ex post IA studies' quality score of 100]

1. Publication venue (select one only)

[x] Refereed journal
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[x] NRM related
[ ] Policy related
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[ ] Addresses differential effects (different target groups)
[ ] Addresses multiplier effects (other sectors)
[x] Employs novel methods (combines quantitative & qualitative, etc.)
[ ] Other methodological advances (specify)

7. Full Citation: Paris TR, Singh A, Cueno AD, Singh VN. 2008. Assessing the impact of participatory research in rice breeding on women farmers: A case study in eastern Uttar Pradesh, India. Experimental Agriculture. 44:97-112.

Clearly state the research related output being assessed and the role of the center in realizing that output. Indicate the geographic scale/size of the assessment, the time period covered, and the method used. Present main result/indicators of impact reported by the study, i.e., estimates of adoption or uptake, estimates of income and other effects (on poverty, environment) both positive and negative – max of 100 words for each study:

The expected outcomes of a participatory varietal selection (PVS) conducted in 2002 in eastern Uttar Pradesh (India) were the adoption of rice varieties most suitable to submergence/drought prone areas, higher yields and, incomes. This study looked at an indirect outcome—women empowerment. A woman empowerment index (WEI) assigned scores of 1 to 5 depending upon the contribution to farm decisions. Analysis of 2004 survey using mean comparison and multivariate regression of WEI showed that PVS significantly empowered women in making farm decisions. Qualitative data suggested strategies to empower and enhance women roles for an accelerated adoption of new varieties.

1.B. For each ex-post IA study listed in 1.A above, please provide the relevant information under each component by checking the appropriate item 1 [20 points maximum for ex post IA studies' quality score of 100]

1. Publication venue (select one only)

[x] Refereed journal
[ ] Book chapter
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3. EpIA coverage (primary type of research assessed) (select one only)

[ ] Commodity improvement
[ ] NRM related
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[ ] Biodiversity related
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[ ] Other challenging area (specify)

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[ ] Addresses differential effects (different target groups)

[ ] Addresses multiplier effects (other sectors)
[x] Employs novel methods (combines quantitative & qualitative, etc.)
[ ] Other methodological advances (specify)

8. Full Citation: Revilla-Molina IM, Bastiaans L, Van Keulen H, Mew TW, Zhu YY, and Villano RA. 2008. Improvement of technical efficiency in rice farming through interplanting: a stochastic frontier analysis in Yunnan, China. Paper presented at the Plenary Session of Dynamics, Economic Growth, and International Trade - XIII Conference, Manila, Philippines, 18-19 November 2008. (http://www.degit.ifw-kiel.de/papers/degit_13/c013_015.pdf)

Clearly state the research related output being assessed and the role of the center in realizing that output. Indicate the geographic scale/size of the assessment, the time period covered, and the method used. Present main result/indicators of impact reported by the study, i.e., estimates of adoption or uptake, estimates of income and other effects (on poverty, environment) both positive and negative – max of 100 words for each study:

Deployment of genetic diversity through interplanting of glutinous and hybrid rice varieties to manage blast disease was introduced in Yunnan, China in 1997. Production efficiency impacts were analyzed using survey data of adopters and nonadopters collected in 2000. Stochastic frontier production function estimates showed that adopters of interplanting were more technically efficient. With significant reduction in blast disease severity as a result of interplanting, output responsiveness to inputs such as labor, seeds, and fertilizer increased. Yields of glutinous rice on interplanted farms were about 110 kg mu–1 higher than farms with pure stands of glutinous rice.

1.B. For each ex-post IA study listed in 1.A above, please provide the relevant information under each component by checking the appropriate item 1 [20 points maximum for ex post IA studies' quality score of 100]

1. Publication venue (select one only)

[ ] Refereed journal
[ ] Book chapter
[x] Conference paper (includes proceedings)
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2. (Co-) authorship (additive up to max 5)

[ ] With other CG Center scientists
[x] With NARS scientists
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3. EpIA coverage (primary type of research assessed) (select one only)

[ ] Commodity improvement
[ ] NRM related
[ ] Policy related
[x] Biodiversity related
[ ] Training/Capacity building related
[ ] Other challenging area (specify)

4. Distance down the impact pathway covered by the study (points based on the highest-point indicator marked)

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[x] Uptake/adoption plus direct impacts at the adopter-level (Stage 1): improved yield/quality, higher incomes, lower risk, improved health, etc.
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6. Advances in new methods/models & use of novel indicators (additive, up to a max.of 25 pts)

[ ] Addresses non-economic impact indicators
[ ] Addresses negative effects
[ ] Addresses differential effects (different target groups)
[ ] Addresses multiplier effects (other sectors)
[ ] Employs novel methods (combines quantitative & qualitative, etc.)
[ ] Other methodological advances (specify)

9. Full Citation: Kajisa K, Palanichamy NV. 2008. Income dynamics and schooling investments in Tamil Nadu, India from 1971 to 2003: Changing roles of land and human capital. In: Otsuka K., Estudillo JP, Sawada Y, editors. Rural Poverty and Income Dynamics in Asia and Africa, Abingdon (UK): Routledge. p 118-144.

Clearly state the research related output being assessed and the role of the center in realizing that output. Indicate the geographic scale/size of the assessment, the time period covered, and the method used. Present main result/indicators of impact reported by the study, i.e., estimates of adoption or uptake, estimates of income and other effects (on poverty, environment) both positive and negative – max of 100 words for each study:

The rice green revolution has contributed to poverty alleviation directly by increasing the farm income of rural households and indirectly by increasing the schooling investments in their children which resulted in an income increase among the children's generation through the encouragement of their participation in non-farm job opportunities.

1.B. For each ex-post IA study listed in 1.A above, please provide the relevant information under each component by checking the appropriate item 1 [20 points maximum for ex post IA studies' quality score of 100]

1. Publication venue (select one only)

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Rice Green Revolution

4. Distance down the impact pathway covered by the study (points based on the highest-point indicator marked)

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   [ ] Other methodological advances (specify)

1.C. Please provide an estimate of the number of full time equivalent staff 2 devoted to epIA work in your Center in 2008 [5% for IA investment relative to Center budget]: 8.33

Criterion 2: Building an IA culture at the Center and enhancing the capacity of IA (including communication/dissemination) (20%)

SC Assessment

Score: 17.20

SC Comments:

Criterion 2. Overall score = 17.2 (max. 20)

A = 5;

B = 2.5;

C = 2.5;

D = 2.2;

E = 2.5;

F = 2.5.

A) IA conferences and workshops: List those held for both external and internal audiences, e.g., showing results of impact studies of a particular research theme; assessing the expected impacts of planned and ongoing research of the Center. Describe theme and number of participants for each. [5%]

List: Indicator 4 Criterion 2.pdf

B) Utilization of epIA results: Describe using specific examples how empirical epIA findings have been applied as a basis for ex-ante impact projections that contribute to the Center's priority-setting procedures, or have been used to validate earlier ex-ante work. (< than 100 words) [5%]

epIA findings on water savings, aerobic rice, direct seeding, nutrient management, rodent management and post harvest were the basis for developing priorities for a new Phase IV of the Irrigated Rice Research Consortium (2009-2012). Funding (USD3.9 million) from the Swiss Agency for Development & Cooperation was approved in October 2008. These led to IRRI strengthening its commitment to outputs 2.5 and 7.5 in our 2008-2010 mid term plan.

C) Baseline surveys/studies: Provide specific examples of establishment (or updating) of baseline studies conducted in the reporting year to provide counterfactuals for future epIA (< than 100 words) [2.5%]

Surveys of farms in the following Asian and African countries were conducted to construct or update baseline data for forthcoming or anticipated ex-post impact studies using structured questionnaires. Standard to the questionnaire are input-output and price data by season. Data on knowledge, attitudes, and perceptions of farmers on rice technologies and practices were added on-demand. Sampling of farms and timing of surveys aimed at capturing adopters and nonadopters of and/or before and after the intervention.

1. Saline-prone rice areas of India to study impact of salt-tolerant varieties;

2. Submergence-prone rice areas of Cambodia, Laos, Indonesia, Philippines and Thailand to study impact of sub varieties;
3. UPRIIS command area to study impact of Alternate Wetting and Drying, a water-saving technology;
4. Central Luzon and Laguna in the Philippines to update the Loop Survey data; a panel data of varied uses for long term studies;
5. Mozambique , Africa;
6. Sulawesi , Indonesia to study impact of yet-to-be-identified rice technology;
7. Cambodia to study impact of post-harvest technology; and
8. Bangladesh to study impact of direct seeding rice

In addition, an electronic survey of IRRI scholars who graduated between 1996 through 2006 was initiated in 2008 and to continue onto 2009 to assess if IRRI training had increased the capacities of NARES.

D) EpIA briefs, popular media: List epIA briefs produced and other forms of communication of epIA study results. [2.5%]

List: Indicator 4 Criterion 2 D.pdf

E) Training materials: List IA related training materials developed. [2.5%]

List: Inidcator 4 Criterion 2 E.pdf

F) MS or PhD theses completed: List MSc and PhD dissertations completed (published) during 2008. [2.5%]

List: Indicator 4 Criterion 2F.pdf

Criterion 3. One epIA published study that effectively demonstrates the impact of the Center on the poor or food insecure people and to the environment, rated for quality and rigor (35%)

SC Assessment

Score: 25.25
SC Comments:

"An impact assessment of policy-oriented research into the private health costs of pesticide use in rice farming in the Philippines "

Summary of External Peer Reviewers' Comments:

General:
The study documents the contributions made by IRRI on health and environmental impacts of pesticides use and policy advocacy to reduce use of pesticides. The associated research costs are also documented. This study is a good example of the impact of policy research on human health.

Specific:
- The area covered is large but the sample survey to estimate unit benefits is rather small (152 farmers).
- Two important assumptions are made in the study (a) compliance rate of policy recommendations and (b) attribution of the benefits to IRRI. These are reasonable but more information would have improved their acceptability.
- A well organized cross-section data for estimation of health cost function but a larger sample size would have improved confidence in the results.
- Reduction in pesticide use and toxicity because of other factors like rice price are discussed but possible reduction attributed to these factors is wanted.
- Assumption of attributing 10% benefits to IRRI research needs further of information to justify this number.
- It seems as though the authors may have understated the degree to which pesticide use might have declined absent any IRRI research, given that the impacts of IPM

research were felt worldwide.

- Sensitivity analysis is done for realized and potential benefits, compliance rate of policy recommendation and attribution of pesticide reduction to policy change.

Impact Study: Templeton et al PORIA.pdf

Results for the CGIAR Performance Measurement

IRRI Institutional Health - 2008

5A: Summary Score on Governance Checklist 87.50**%**

Focus on Purpose and Outcomes/Ensure Accountability 10.50

5A.1) Has the full board been engaged in developing or updating the Center's strategic plan in the past two years?

[x] Yes - Fully [ ] Yes – Partially [ ] No

5A.2) In 2008, did the board assess the Center's performance based on the targets and strategic goals approved in the Medium Term Plan and/or the strategic plan, and act on significant deviations from projected results?

Assessed results:

[x] Yes [ ] No

Acted on significant deviations:

[ ] Yes – Fully [ ] Yes – Partially [ ] No [x] No deviations

5A.3) Does the board have an approved schedule for CCERs on program matters?

[x] Yes [ ] No

5A.4) In 2008, did the board monitor actions taken in response to CCERs and EPMRs?

[ ] Yes – both [ ] Yes – only EPMRs [x] Yes – only CCERs [ ] No – both

5A.5) How often does the full board receive information on key financial indicators?

[x] At least quarterly [ ] Annually

5A.6) In 2008, did the board act on any significant deviations (10% +/--) from the approved budget?

[ ] Yes [ ] No [x] No deviations

5A.7) Did the full board participate in the annual performance appraisal of the DG, including decisions on compensation?

[x] Yes [ ] No

5A.8) Does the board review annual trends in Center staffing, including gender, diversity, and turnover?

[x] Yes [ ] No

5A.9) Is there a board-approved policy on delegation of authority, particularly with respect to financial transactions, that makes clear the decision-making responsibilities reserved to board?

[x] Yes [ ] No

5A.10) Has the board reviewed the adequacy of the Center's risk management and internal control mechanisms as an explicit agenda item in the past two years?

[x] Yes [ ] No

Understand Stakeholder Perspectives 3.00

5A.11) As part of planning, program evaluation or ongoing board development, did the board take the opportunity to engage directly with partners, stakeholders and beneficiaries?

[x] Yes [ ] No

5A.12) Is the role of board members in serving as ambassadors and advocates for the Center included in the terms of reference describing board member responsibilities?

[x] Yes [ ] No

5A.13) Does the board have a formal mechanism for regular, independent communication with staff through meetings with staff councils or other representative staff groups?

[x] Yes [ ] No

Ensure transparency and timely disclosure 1.00

5A.14) Is the following information publicly available on the Center's website?

[x] Mission, vision and strategic goals
[x] Annual report (including full presentation of financials and performance indicators)
[ ] Staff compensation schedule (salary scales)
[x] List of current board members with biographical information
[ ] Schedule of board and executive committee meetings
[ ] Archive of board meeting agendas and summaries (recommended 2 year minimum)
[x] Contact information that allows for independent communication with the chair of the board
[x] Medium term plan
[x] Latest EPMR (including Center's response)

Commit to effective governance 7.50

5A.15) Has the board undertaken a thorough assessment of its own performance in the past two years and implemented improvements based on the assessment?

Assessed:

[x] Yes [ ] No

Implemented improvements:

[x] Yes [ ] No

5A.16) Does the full board perform an annual evaluation of the board chair?

[x] Yes [ ] No

5A.17) Are committee chairs evaluated by the respective committee members annually?

[ ] Yes [x] No

5A.18) Was a formal evaluation of board members conducted before reappointment?

[ ] Yes [ ] No [x] No board members renewed in 2008

5A.19) Does the board have at least two members with professional qualifications in financial management?

[ ] Less than 2 [x] 2 [ ] More than 2

5A.20) Does the board have at least one member with professional expertise in corporate, nonprofit or public governance?

[ ] None [ ] 1-2 [x] More than 2

5A.21) Have all new board members (who started their terms in 2007 or earlier):

attended a CGIAR board orientation program?

[ ] Yes [x] No

attended a comprehensive Centerspecific orientation program?

[x] Yes [ ] No

5A.22) When did the board commission the last CCER on Center governance?

[x] Less than 3 years ago [ ] More than 3 years ago

Policy checklist 0.25

5A.23) In the last two years, has the board approved or reviewed the following policies:

[ ] External audit
[x] Investment
[ ] Procurement
[x] HR policy (including grievance procedures)
[x] Whistle blower
[x] Conflict of interest/code of conduct

Assessment by External Panel

Assessment of Board Statements: 2.75

This action supports the board's legal role, helping to ensure that policies/procedures are aligned with the charter. While this action is important and clearly described, its impact on improving board performance is considered somewhat limited. This action is largely an operational activity that was triggered by concerns about the clarity of the Center's core governance arrangements in view of the upcoming CGIAR change process.

5B: Board Statements

In its April 2008 meeting, the Board discussed the emerging change process in the CGIAR and the need for the IRRI BoT to ensure the clarity of its core governance arrangements, in preparation for possible future changes in CGIAR governance. To progress this process, the BoT requested a review of the Board's policies and procedures contained in the Board Handbook to ascertain their consistency with the Charter, for the next Board meeting.

IRRI's original charter, consisting of the Articles of Incorporation and By-Laws, was approved by the Philippine Securities and Exchange Commission in 1960. On April 19, 1979, the Philippine Government through Presidential Decree No. 1620, granted IRRI the status, immunities and privileges of an international organization.

On May 19, 1995, an international agreement recognizing the status of IRRI as an international organization ("International Agreement") was executed which, to date, has been signed, acceded to, and/or ratified by 20 countries, including the Philippines. The International Agreement remains open for accession by other countries.

Appended to the International Agreement is a new IRRI Charter (1995). While the International Agreement provides that IRRI *"shall . . . operate in accordance with its Charter, as appended hereto . . ."*, the Charter itself provides that it *"may be amended or modified by the affirmative vote of a majority of all the members of the Board of Trustees . . . inclusive of the ex-officio members."*

In 1996, the Board approved amendments to the IRRI Charter, consolidating previous and then-existing Board policies into the Charter. After 1996, the Board approved other resolutions to further amend the Charter.

However, the review of the pertinent documents determined that the amendments to the Charter in 1996 and thereafter were ineffective because the International Agreement came into force only in 2005. The Board discussed this at its September 2008 Board meeting, noting, however, that all of the Board actions and policies that had been taken after 1995 were consistent with the 1995 Charter. These included the creation of new offices and appointment of officers, the creation of new committees, re-election of trustees, and fixing the date of the annual meeting.

With this enlightened perspective, three issues were resolved by the Board that had Charter-related implications and were likely to be operational when any changes occurred in the CGIAR. These were the separation of the Finance and Audit Committee into 2 separate committees, the selection of vice chairpersons of the standing committees, and the term of the Director General. All were resolved by the Members with the confidence that their actions were consistent with the Charter.

In addition, the Board clarified that the 1996 amendments to the Charter never took force; the Board is operating under the 1995 Charter. All major Board decisions that are consistent with the Charter will be recognized as Board policies and no amendment of the Charter was needed at that time.

Evidence material: IRRI Board statement evidence.pdf

5C: Summary Score on Culture of Learning and Change Checklist 51.83%

Staff satisfaction 2.00

5C.1) a. Has the Center conducted a staff satisfaction and/or attitude survey of ALL staff in 2007 or 2008, where the results were shared with staff?

[x] Yes [ ] No

5C.1) b. If yes, did the survey result in specific action plans to improve staff satisfaction and /or attitudes?

[x] Yes [ ] No

Leadership development program 0.50

5C.2) a. Does the Center have an active leadership development program covering current and prospective staff in managerial positions?

[ ] Yes, for current AND prospective staff [x] Yes, for current staff [ ] Yes, for prospective staff [ ] No

Continuous learning opportunities for the staff 1.00

5C.3) a. Does the staff appraisal system include the development and follow-up of annual individual learning plans?

[x] Yes [ ] No

5C.3) b. Does the Center have a mentoring program for young scientists?

[ ] Yes [x] No

Staff development activities 1.65

5C.4) a. What percentage of the overall 2008 budget was spent for attendance at international conferences or professional society meetings or for a short sabbatical at a university, etc?

[ ] 0- 0.5% [ ] 0.51-1.0% [ ] 1.1%-2.0% [ ] 2.1%-3% [x] More than 3%

5C.4) b. What percentage of the overall 2008 budget was spent on staff training (e.g. computer, language, project management, leadership training etc.)?

[ ] 0-0.5% [x] 0.51-1.0% [ ] 1.1%-2.0% [ ] 2.1%-3% [ ] More than 3%

5C.4) c. Considering staff training only (b), what is the total number of training days in 2008 for all IRS staff, divided by the total number of IRS staff?

[ ] Less than 1 [x] 1-2.5 [ ] 2.6-4.5 [ ] 4.6-6.5 [ ] 6.6-8 [ ] More than 8

5C.4) d. Considering staff training only, what is the total number of training days in 2008 for all NRS staff, divided by the total number of NRS staff?

[ ] Less than 1 [x] 1-2.5 [ ] 2.6-4.5 [ ] 4.6-6.5 [ ] 6.6-8 [ ] More than 8

Planning and review of programs 1.25

5C.5) a. On average, how many days did an IRS staff spend in 2008 on program planning and review?

[ ] 0-2.0 [ ] 2.1-3.0 [ ] 3.1-4.0 [ ] 4.1-5.0 [x] More than 5

5C.5) b. What is the percentage of your program budget (average for 2006-2008) that has been covered by CCERs completed in 2006-08?

[ ] 0%-30% [x] 31%-50% [ ] 51%-70% [ ] 71%-90% [ ] 90% +

Data management 0.50

5C.6) Do you systematically preserve research project data (primary and secondary data sets), including documentation on the data and project?

[ ] YES, we have a comprehensive (meta) database for primary and secondary research data that is fully available for internal use

[x] YES, we have some (meta) database, but not all, of the research project data preserved and these are internally available

[ ] NO, we do not have at all a (meta) database preserving research data systematically

5D, 5E: Diversity

5D) Percentage of women in management (Percent of management positions, either research or non-research, occupied by women as of 31. December 2008). 16.67%

List of staff members in management positions, including names, titles and gender: IRRI Women in Management.pdf

5E) IRS Nationality concentration:
Percentage of internationally-recruited staff that comes from the top two countries represented in the IRS staff nationality list for the Center (as of December 31, 2008). Please also indicate the Nationality.

First nationality: 12.60% - Nationality: Philippines
Second nationality: 12.60% - Nationality: USA

List of IRS staff names and country of nationality: Indicator 5E IRS nationality concentration.xls

IRRI Financial Health - 2008

6A) Long-term financial stability (adequacy of reserves): 260

6B) Cash Management on Restricted Operations: 0.11

CGIAR

Report on the Verification of Selected 2008 CGIAR Performance Measurement System Indicators

CGIAR

July 1, 2009

Ren Wang, CGIAR Director
Rudy Rabbinge, Chair, CGIAR Science Council

Report on the CGIAR Performance Measurement System – 2008 Data Verification

Dear Ren and Rudy,

Please find attached the report on the results of the 2008 independent verification of selected CGIAR Performance Measurement (PM) System indicators.

The results for each center have been provided to the CGIAR Secretariat to support adjustments made in the 2008 PM System. When there were differences between a center's assessment and the verification results, the adjustments were conveyed and discussed with the center focal point prior to the finalization of the verification exercise. In addition, individual center reports were sent to the respective Center DGs.

This report contains the findings and a number of recommendations to improve the PM System, assuming the same indicators are retained in future.

Please do not hesitate to contact me if you require further information.

Yours sincerely,

Antonio del Monaco

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Contents

Acknowledgements

I would like to thank all the GGIAR Centers for their prompt responses and collaboration with this data verification exercise so important for the CGIAR Performance Measurement System.

I also would like to thank Erwin Lopez and John Fitzsimon who assisted in the verification of the institutional health indicators. Finally, my gratitude also goes to Maria Eugenia Lara and Maria Iskandarani for their prompt responses to questions about the indicators and overall assistance.

REPORT ON THE CGIAR PERFORMANCE MEASUREMENT SYSTEM –

2008 DATA VERIFICATION

INTRODUCTION

We have completed a verification exercise on selected 2008 CGIAR Performance Measurement (PM) System indicators submitted earlier this year by each of the Centers. This year, we verified the following indicators:

- **Indicators of Results**:
  - Outputs Indicator 1: Measure 1A[1] and 1B[2] for all centers;
  - Outputs Indicator 2[3] for all centers
  - Impact Culture Indicator 4: Criteria 1: section 1A[4] and 1B[5] for one epIA[6] for seven randomly selected centers.
- **Indicators of Potential to Perform: Institutional Health**
  - Indicator 5A, 5C: A sample of questions from the Governance Checklist and from the Culture of Learning and Change Checklist for all centers.
  - Indicator 5D: Assessment of the percentage of women in management for all centers

The CGIAR Internal Auditing Unit assisted with the verification process, providing advice and assistance with the methodology in relation to the Institutional Health indicators. Mr. Erwin Lopez was seconded by the Unit to assist me with this verification.

I corresponded with Center PM Focal Points during the verification process to request the necessary evidence materials for each indicator verified. If the evidence supplied was insufficient to support the indicator values this was discussed with the PM focal points. In some cases further information supplied by the Center resulted in acceptance of the Center's self assessment, while in other cases the indicators were adjusted. In all cases, a summary of indicator results was prepared for each Center, sharing them first in draft with the Center PM Focal Points for their comments and to determine if there were any

[1] Number of externally peer-reviewed publications per scientist in 2008 that were published in journals listed in Thomson Scientific/ISI. This was formerly indicator 4B.

[2] Number of externally peer-reviewed publications per scientist in 2008, excluding articles published in journals listed in the Thomson Scientific / ISI. This was formerly indicator 4A.

[3] Percentage of scientific papers that were published with developing country partners in refereed journals, conference and workshop proceedings in 2008. This was formerly indicator 4C.

[4] Full epIA citation and summary

[5] For the epIA study: publication venue, authorship, primary type of research assessed, distance down the impact pathway covered, geographical breath of adoption, and advances of new methods

[6] An epIA or ex-post Impact Assessment refers to a published journal article, conference paper, book chapter (but not entire edited book), report or any other publication that has entered the public domain, which is not a revised version of an earlier submission.

factual errors, before sending a final report to the Center Director General. All of the verification results were finalized with Centers by the beginning of June 2009.

The following sections discuss the verification results, some observations on selected indicators as well as some recommendations to address the issues found.

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INDICATORS OF RESULTS:

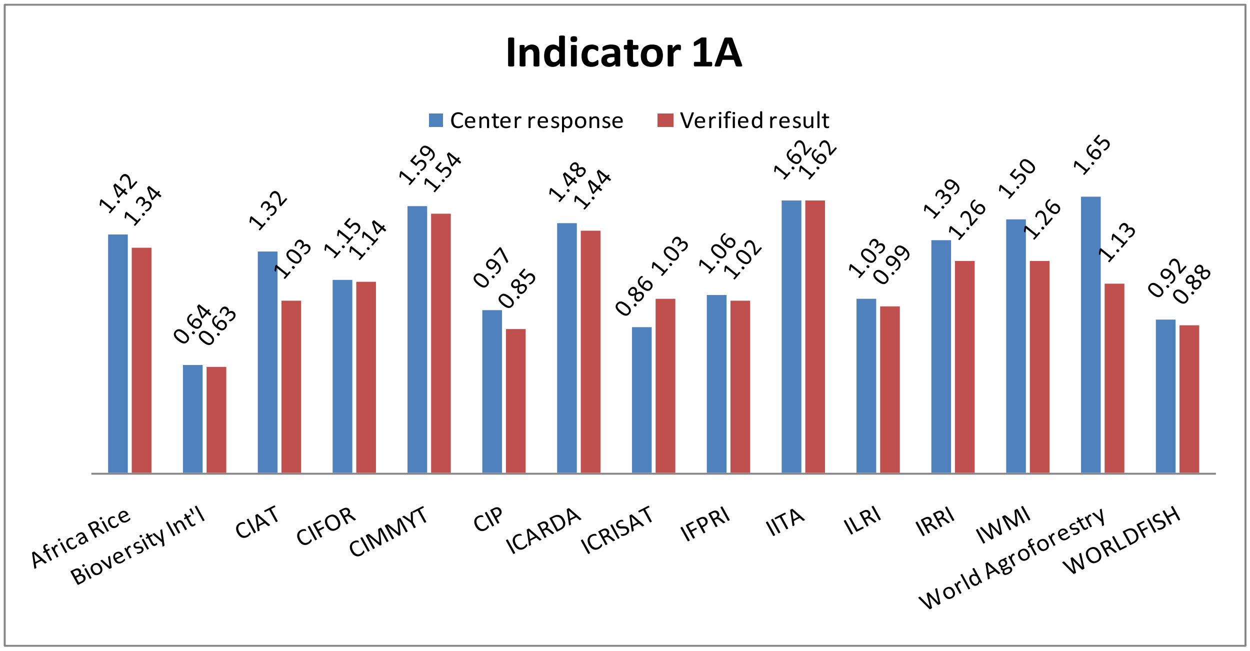
Findings on output indicators 1 and 2 (publications)

This year, publications became center outputs under the PM system. Former indicator 4B became Measure 1A, former indicator 4A became Measure 1B, and former indicator 4C became Indicator 2.

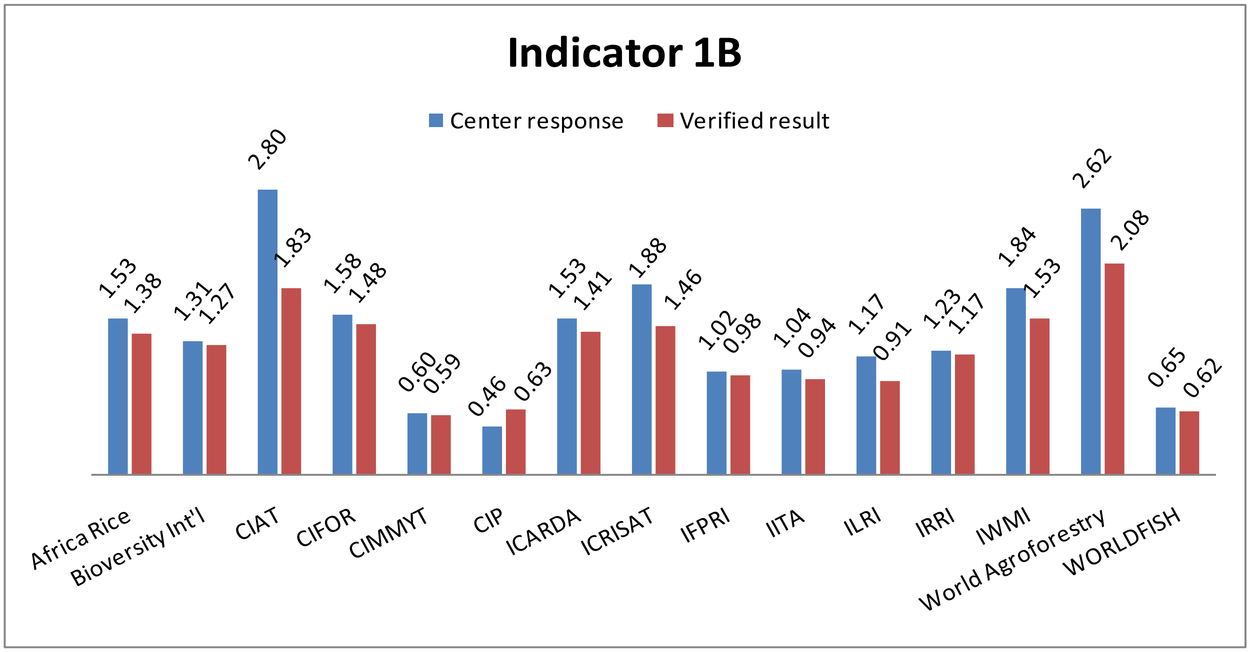
All Centers provided the scientist list information in excel as requested in the guidelines (specifically, name and last name, title or position, day/month/year of hire and departure, and the FTE) which facilitated the verification. However, issues found during previous years regarding publications continued to be a problem this year. Many if not all of these issues could be avoided if the centers provided the publications information in a more structured way such as in the tables under the recommendations as has been suggested in previous years.

One issue found was that not all centers identified the developing country partners under indicator 2. Some centers included under indicator 2 only the list of publications with developing country authors which complicated verifying the calculation of this indicator since the total number of publications, the denominator, was difficult to assess.

The following tables provide a comparison between the values of indicators 1A, 1B and 2 provided by the centers and the verified values.



After the verification the values of indicator 1A for 13 centers decreased mainly due to increases in the scientists' full time equivalent (FTE[7]) and the removal of a few publications for each center for reasons such as not being in Thomson, not having any center authors, not being relevant to the center's mission or counted already in previous PM exercises. The center's with the largest adjustments under 1A included ICRISAT, CIAT and World Agroforestry. ICRISAT experienced an increase in 1A because 23 Thomson publications had been mistakenly counted under indicator 1B rather than 1A. CIAT and World Agroforestry experienced the largest decrease. CIAT had 24 scientists authors added which increased its FTE by over 26% while World Agroforestry had 9 scientist authors added to the FTE calculation and 22 publications eliminated.

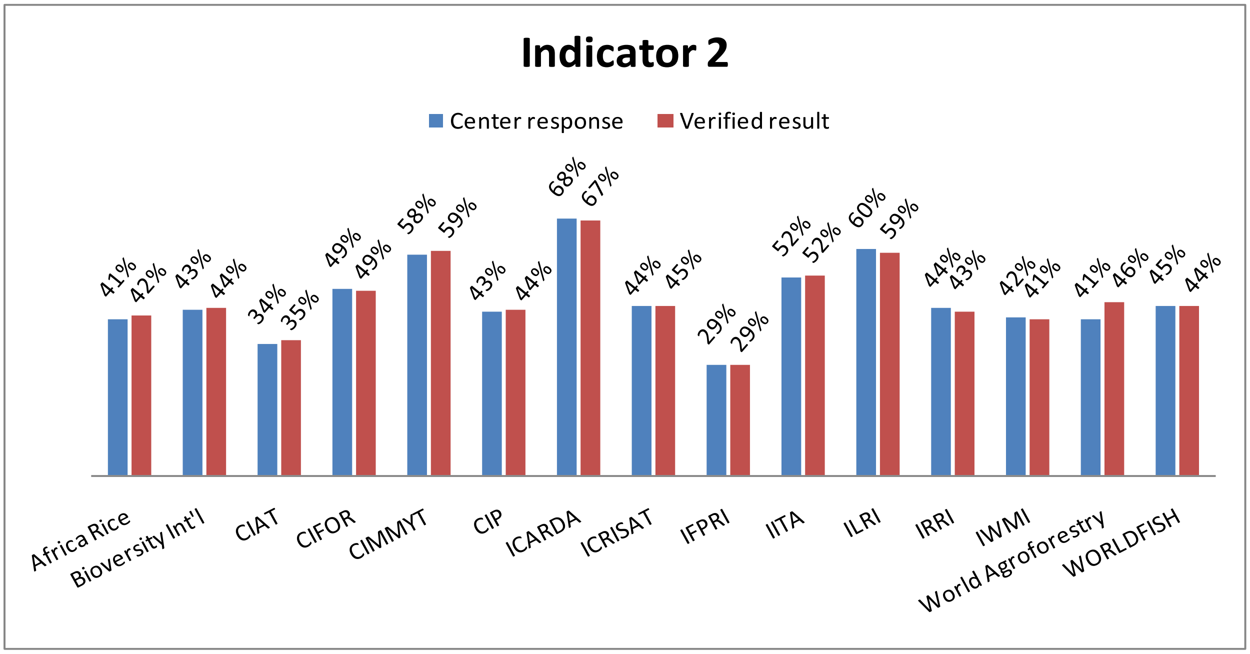


Similarly, the value of indicator 1B decreased for 14 centers after the verification. In the case of CIP, 15 publications that had been counted under indicator 2 only also qualified under indicator 1B which increased its 1B value. For the remaining centers, the FTE increased for 12 centers which decreased the values of both indicators 1A and 1B, and publications under 1B were disallowed. The main reasons for disallowing 1B publications were: not having any center authors, not been formally published in full and externally peer reviewed, or counted already in previous year's PM verifications. The centers with the largest decreases were CIAT, ICRISAT and World Agroforestry. ICRISAT had 23 of the 41 publications moved to 1A as indicated before, while CIAT had 35 papers presented in conferences which were moved to be counted only under indicator 2 and World Agroforestry had 37 publications disallowed.

Since indicator 2 is the ratio between scientific papers published with developing country partners (DCPs) and total publications expressed as a percentage, the publications disallowed affected both the

[7] FTE: Full Time Equivalent is the percentage of time of the year a staff scientist works.

numerator and denominator resulting in five centers decreasing their value, seven centers increasing and three remaining unchanged. That said there were still publications listed only under indicator 2 that were disallowed. The main reasons were: papers presented at conferences but not published yet (not even the abstracts), publications counted in previous PM verifications, double entries, publications with no center authors, and internal working papers and reports.



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Recommendations on output indicators 1 and 2 (publications)

Presenting the publications information in a tabulated format (e.g. in Excel) AND including the criteria indicated in the tables below will improve the quality of the information provided in the future, resulting in fewer adjustments of the indicator values and more reliable publications information from the centers.

Individual reports that we prepared for each center this year requested that they submit the lists for indicators 1A, 1B and 2, and the list of scientists tabulated in an Excel sheet under separate tabs. This format will also facilitate submission as only one Excel file will be uploaded to the CGIAR website. Since publications with developing country partners would be clearly identified in the 1A and 1B lists, then list 2 can include only those additional publications not submitted under 1A and 1B (but must clearly identify those new publications with DCPs), rather than including the entire list of publications or just a partial list with only those publications with DCPs as some center did. This format will also allow centers to verify that all authors are accounted in the FTE calculation. Below is an example of the tables that can be used to submit the publications data in Excel.

Table of 1A publications

Full journal title	Publication title	Publication year	Center authors or co-authors names	Developing Country Partners (NARS based) names if any	Volume number and page numbers (range)	ISSN number

Table of 1B publications

Title of publication journal, book or other.	Publication title	Publication year	Center authors or co-authors names	Developing Country Partners (NARS based) names if any	Page numbers (range)	External peer reviewers	Center published or externally published

Table of indicator 2 publications

Title of publication journal, book, proceedings or other	Publication title	Publication year	Center authors or co-authors names	Developing Country Partners (NARS based) names if any	Page numbers (range)

Last year, the General Verification Report indicated that “Another issue was that some centers disagreed last year [2006] with providing the publications information on a tabulated format using a template provided in the “Report on the CGIAR Performance Measurement System – 2006 Data Verification” to streamline the verification process. Therefore the 2007 “Guidelines for the Reporting of Performance Indicators for CGIAR Centers” requested centers to provide the information contained in the tables even if they did not use the tables. However, some centers did not provide all the information as requested, delaying the verification process. For example, some ISSN numbers for 1A publications were missing, and in some cases it was unclear from the lists provided which were the publications with developing country partners for the verification of indicator 2."

A case can be made to present the information tabulated as described below based on this year's good results for the centers that abided by this recommendation: they had the lowest number of issues. For example, CIMMYT was the only center that provided both the information exactly as requested in the tables and in a tabulated format in excel setting a good practice standard for the other centers. We accepted 349 out of 350 total publications submitted and only two authors were left out of the FTE count. Similarly, CIFOR presented the information in a tabulated format but some of the requested criteria were missing from the table headings. Nevertheless only two authors had to be added to the FTE count and only 4 publications disallowed out of 218.

To emphasize the importance of including all the criteria listed in the tables, ILRI presented the information tabulated in excel but a column for the page ranges was missing for 1B publications. 18 publications that were only abstracts were disallowed under that indicator. The rest of the centers presented the lists in word and most of them had greater adjustments in the value of their publication indicators than the three centers that presented the information tabulated. Given the clear benefits for all of presenting the information in this form, reconsider adding a recommendation to the guidelines, for future PM exercises, requiring centers to present the publications information tabulated in excel and include the criteria detailed in the tables above.

To further simplify the guidelines for next year, consider revising the definition of scientists as follows:

The number of scientists should be counted in terms of **Full Time Equivalents** (based on the staff list as of December, 31 2009) and should include the time of

- All research staff employed at the center as of 31st December 2009
- All research staff who left during 2009
- All research staff who left in 2008 and have publications included the 2009
- part-time or joint positions counted as 50% for FTE computations

Other considerations are:

- Exclude research staff that left two or more years prior to this assessment (i.e. all staff that left in 2007 or earlier should not be added to the 2009 FTE calculation).
- Exclude from the 2009 publication lists those where a scientist who left in 2007 is the sole author. Since the author is being excluded from the FTE calculation, the publication itself needs to be excluded as well.
- Exclude also all publications that are two or more years old (i.e. published in 2007 or before)
- Exclude managerial/administrative staff (DG, DDG, Director Finance, Director HR, Head of Training, Head of information technology and other wholly administrative regional representatives). EXCEPTION: if a managerial/administrative staff member published in 2008

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and his/her publication is included in the calculation of indicator 1a/b or 2, then the staff member must be included in the scientist count as well.

This definition would substantially reduce the number of conditions against which the publications list must be checked reducing the center's time demand to prepare the requested information. While these changes may increase the number of scientists in the FTE calculation it will apply to all Centers.

A few additional recommendations for the centers to improve the reporting of publications include:

- Ensure all center publication authors are counted in the FTE calculation following the guidelines.
- All scientists should be included in the scientist list even if they had no publications.
- Published abstracts of papers presented at conferences and publications not externally peer-reviewed should be included only under indicator 2.
- Publications that have been translated into another language can only be counted once.

Findings on Impact Culture indicator 4 (Ex-post Impact Assessments)

To assess the centers' commitment to documenting impacts from past research in a credible way and building an impact assessment culture, this year's review included an assessment of an "ex-post Impact Assessment (epIA) study" for seven randomly selected centers. The Science Council provided a preliminary list of epIA studies (from the list that each center submitted) for the seven randomly selected centers and we randomly selected one of those studies for verification.

The centers that were randomly selected for this year's verification of indicator 4 were:

- CIAT
- CIFOR
- CIP
- ICARDA
- WORLD AGROFORESTRY
- ICRISAT
- IWMI

We verified the center's self assessment under sections 1A and 1B and completed these sections with the relevant information to support our ratings and compared them with those implied by the self assessment. Section 1A was the full citation and summary. For each epIA study published in 2008 that attempted to assess major impacts attributed to a Center's work, the following components under 1B were verified based on the information contained in the study report:

- Publications Venue
- Co-(Authorship)
- EpIA coverage;
- Distance down the impact pathway covered by the study;
- Geographical breadth of impacts assessed by the study; and
- Advances in new methods/models for epIA embodied in the study.

All the centers that were subject to the impacts verification submitted the required documents promptly. The epIA reports submitted were comprehensive enough to respond to all the questions in the verification.

There were no significant differences between the centers' self assessment of their epIAs and the verified results. The table below provides a comparison between the center responses and the verified values in those cases where there were adjustments after the verification.

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Adjustments to center responses on the Impact Culture indicator 4

INDICATORS	Center's response	Agreed final response
(Co-) authorship	World Agroforestry: with NARS scientists only. (Co-)authorship score: 1.67 ICARDA: with ARI scientists, NARS scientists and scientists from other CG centers (Co-)authorship score: 5	World Agroforestry: with NARS scientists **and** with scientists from other CG centers (Co-) authorship score: 3.34 ICARDA: with NARS scientists **only** (Co-)authorship score: 1.67
Geographical breadth or scale of documented uptake/adoption on which the impacts assessed by the study are based	CIFOR: Multiple locations (regions) within several countries (~ 2-5) Geographical breath score: 20	CIFOR: multi-locations (regions) within **single** country assessment Geographical breath score: 15

INDICATORS OF POTENTIAL TO PERFORM: INSTITUTIONAL HEALTH

Findings on Institutional Health Indicators 5A, 5C and 5D

This year included the verification of a sample of questions from the Governance Checklist (indicator 5A) and from the Culture of Learning and Change Checklist (indicator 5C) for all centers. In addition, the percentage of women in management (indicator 5D) was also assessed.

This section discusses the findings and some issues observed during the verification process regarding institutional health that will lead to some specific recommendations later in this report. For 2008, 21 indicators were verified. Like in past verification exercises, some centers continue to express concerns about the value or relevance of some indicators being verified, particularly in the area of institutional health.

Four unique indicators not previously verified in past verification exercises were included in the 2008 verification process. Below are the indicators verified for 2008 and the issues observed in the verification process for each indicator:

- Regarding question 5A-2: *(a) In 2008, did the board assess the Center's performance based on the targets and strategic goals approved in the Medium Term Plan and/or the strategic plan?* - This year was the first time that this indicator was selected for verification and the results were very encouraging, i.e. 14 out of 15 centers' boards assessed their respective centers' performances based on targets and strategic goals. Centers submitted, as evidence, board documents such as agenda, minutes and resolutions and copies of management presentations on the results of previous year's performance.

  (b) Did the board act on significant deviations from projected results? – The PM guidelines did not provide a clear definition of what the term "deviation" means, and when a deviation can be considered significant. The non-definition of "deviation" also made responding to the indicator difficult as centers were confused on how they will distinguish between options of "Yes-Fully" and "Yes- Partially" as a response to the indicator. Consequently, centers raised questions on the subjectivity of this indicator.

  One center also argued that it is not within the realm of center board's responsibilities to monitor output targets at that level because doing so could get into micro-management. The center noted that monitoring targets is the role of the DDG-Research, program leaders etc, and the board should operate only at a strategic level. Management's role is to bring to the board's attention those issues that need board action.

- Regarding question 5A-8: *Does the board review annual trends in Center staffing, including gender, diversity, and turnover?* - In past PM verification exercises, the indicator verified was the center's board-approved gender and diversity policy. The PM now takes the verification a step further by checking the board oversight of the staff activities and the implementation of the board-approved gender and diversity policies. The results were very encouraging as 14 of 15 centers' boards performed annual review of trends and center staffing. The evidence submitted by centers were in the form of copies of 2008 board meetings agenda, minutes or resolutions, or copies of management presentations to the board.

- Regarding question 5A-13: *Does the board have a formal mechanism for regular, independent communication with staff through meetings with staff councils or other representative staff groups?* - This year was the first time that this indicator was selected for verification and the results were also encouraging. Except for two (2) centers, all centers positively responded to this indicator and the evidence was accepted by the verification team. The two other centers have no staff council or staff representative groups who meet with their board members although one had been instructed by their center board to encourage the center staff to organize a staff council.

  When such formal policy and mechanism is lacking, alternative evidence for informal meetings of the Board with staff groups was accepted for the time being (e.g. Board minutes describing the practice of informal luncheons with staff groups as some Centers have been providing) . A statement by the Board about how they approach this issue would have also been acceptable.

  The two centers which did not respond positively on the indicator submitted as evidence, for this indicator, records of board members and staff attendance in board program committee meetings. The centers argued that this is also an opportunity for the board and the staff to meet. However, the verification team did not accept the evidences as the agenda of program committee meetings are specific to the center's research agenda, and the indicator was intended to cover meetings of board members with staff where the latter had the opportunity to discuss anything about the staff employment with the center. In addition, management may always restrict attendance of staff in board program committee meetings thereby defeating the purpose of the indicator.

- Regarding question 5A-14: *(a) Is the center's information i.e. mission, vision and strategic goals publicly available (e.g. on the Center website)?* - This year was the first time that this indicator was selected for verification and all 15 centers responded positively on this indicator and the evidence was accepted by the verification team.

(b) Annual report (including full presentation of financials and performance indicator)? – This year was the first time that this indicator was selected for verification. The indicator requires several items before a "Yes" response can be accepted, namely: 1) whether the center's annual report was publicly available; 2) whether the annual report included the full presentation of financial performance; and 3) whether the annual report included the results of previous year's performance measurement. However, the PM guidelines did not provide a clear definition of the phrase "full presentation of financials and performance indicator".

All centers have their annual reports available publicly in their websites. However, only IRRI presented the full audited financial statements (including opinion of the external auditors and notes to the financial statements) in the annual report. Other centers only showed some financial highlights of the previous year's financial operations. Centers expressed concerns that including the full audited financial statements in the annual report will make the report too long.

In lieu of the publication of the full audited financial statements (including the notes to the financial statements) in the annual report, the verification team accepted the publication in the center's website of the copy of its audited financial statements if at least some financial highlights were shown in their annual report.

Centers did not likewise include in their annual reports the results of previous year's performance measurement verification. The 15 centers showed only selected performance measurement indicators (usually publications) in the annual report.

The verification team also accepted partial publication in the annual report of previous year's performance measurement verification results owing to the fact that the CGIAR website had already published the results of the previous year's performance verification results for all centers. In the end, eight (8) of the 15 centers were able to respond positively on this indicator.

(c) staff compensation structure (i.e. salary scales for different grades of staff)? – Seven (7) of 15 centers have this information publicly available on their center's public websites. Some centers continue to be reluctant about making their salary structure available to the public either because of security in the host countries or that the salary structure does not provide a complete picture of the compensation package being offered by the center and could therefore be misleading. As pointed out in the previous years, other international organizations such as the United Nations have their salary and compensation structures available on their websites for public access, to which we may add this year the seven (7) centers that have also done this.

(d) list of current board members with biographical information? - This year was the first time that this indicator was selected for verification. All 15 centers responded positively on this indicator and the evidence was accepted by the verification team.

(e) schedule of board and executive committee meetings publicly available? - This year was the first time that this indicator was selected for verification and the result was encouraging i.e. twelve (12) out of 15 centers responded positively on this indicator. Some centers do not have a separate Executive Committee and as such, only the schedules of board meetings were made publicly available.

(f) archive of board meeting agendas and summaries (recommended 2 year minimum)? – Ten (10) of 15 centers have this information publicly available on their Center's public websites.

Some centers continue to treat the whole board minutes as confidential. Consequently, no part of the board minutes of meetings was made available to the public.

(g) contact information that allows for independent communication with the chair of the board? - This year was the first time that this indicator was selected for verification and the result was encouraging i.e. thirteen (13) out of 15 centers responded positively on this indicator and the evidence was accepted by the verification team.

- Regarding question 5A-15: *(a) Has the board undertaken a thorough assessment of its own performance in the past two years?* - This year was the first time that this indicator was selected for verification and the results were very encouraging i.e. all 15 centers responded positively on this indicator and the evidence was accepted by the verification team.

  (b) Has the board implemented improvements based on the assessment? – Thirteen of the 15 centers responded positively on this indicator and the evidence was accepted by the verification team. There were cases reported by Centers where the board, after the self-assessment, did not deem it necessary to make any improvement. In these cases, the centers did not submit further evidence other than the assessment made by the board and the verification team accepted it as a "Yes" response.

- Regarding question 5A-16: *Does the full board perform an annual evaluation of the board chair?* – This year was the first time that this indicator was selected for verification and all 15 centers responded positively on this indicator and the evidence for such was accepted by the verification team. The Board Chairs' evaluation is usually a component of the full board evaluation.

- Regarding question 5A-19: *Does the board have at least two members with professional qualifications in financial management* – In the past, this question was worded as "How many Board members have professional qualification in financial management?" Centers continue to respond positively on this indicator. For 2008, the answers to this indicator were limited to only three choices namely (1) Less than 2 board members; (2) 2 board members; and (3) more than 2 board members. In 2007 and 2006, the answer to this indicator was a choice among four answers i.e. (1) None; (2) 1 board member; (3) 2 board members; and (4) more than 2 board members. The rationale for the change was not clearly explained in the 2009 PM Guidelines but the clear intention was to encourage the centers to have at least two board members with professional qualifications in financial management.

  As in previous years, criticism on the definition of "professional qualification in financial management" persisted. Centers continue to insist that their board members who head organizations with large financial budgets have the experience to be considered professionally qualified in financial management.

In another case, the center-nominated board members were noted to be strong audit committee chairs or members and as such, the centers insisted on their acceptance under this indicator.

The verification team considered that, in these cases, they did not meet in spirit with the criteria in the PM guidelines. Being chief executives of organizations does not necessarily confer the kind of specialized ability promoted in the criteria. The verification team also considered that accepting others on the basis of their track record of effective financial oversight, notwithstanding that they didn't meet the criteria, would introduce an element of subjectivity impossible to audit, as well as being unfair to other Centers who may then want to propose such members.

- Regarding question 5A-20: *Does the board have at least one member with professional expertise in corporate, nonprofit or public governance?* – The last time this indicator was verified was in 2005. Then, the question was framed as "How many Board members have professional qualification in corporate, nonprofit or public governance?" On both verification years, all 15 centers reported that they have more than 2 board members with professional expertise in corporate, nonprofit or public governance, and the evidence was accepted by the verification team.

- Regarding question 5A-23: *(a)* In the last two years, has the board approved or reviewed the investment policies*?* – In 2005 to 2006, the PM system encouraged the centers to have board approved investment policies. This year, the PM system verified whether the board reviewed the investment policy that centers developed in 2005 and 2006. As of 2008, 14 of 15 centers have board-approved investment policies that were regularly reviewed.

  (b) HR policies (including grievance procedures)? – This is the second straight year that this indicator was verified. Results were encouraging as 14 out of 15 centers responded positively to this indicator and the evidence was accepted by the verification team.

Culture of Learning and Change (Indicator 5C)

Regarding question 5C (b): *What is the percentage of your program budget (average for 2006-2008) that has been covered by CCERs completed in 2006-08?* - This indicator was likewise verified in 2005 and 2006 PM verification exercise. The persistent question of centers under this indicator is whether corporate-related CCERs and CCERs related to research support should be included in the computation. The centers argued that the CCER of corporate services should be included in the computation because a good corporate services team is a major component of effective program management. The PM guidelines did not provide a clear guideline on this. But the verification team excluded the non-program related CCERs in the computation as this would render the computations of the indicator meaningless.

However, one center (CIFOR) initially included 100% coverage on the basis of a CCER on research partnership management, arguing that research partnership is an important theme that cuts across all research programs of the center. The PM system did not provide clear guideline on how to treat this in the computation. Fortunately, the verification team noted that the CCER in question was performed outside the cut-off period. As such, the appropriate treatment regarding the CCER on research partnership did not become an issue in 2008. Recommendations on how to calculate the percentage of the program budget covered by CCERs is presented further below.

Regarding question on 5C Data Management: *Do you systematically preserve research project data (primary and secondary data sets), including documentation on the data and project?* - This is the second year that this indicator was verified (the first was in 2006). In 2008, three (3) of 15 centers reported that they have a comprehensive databases for research data, and the 12 centers reported to have only some databases.

The usual question of centers on this indicator is the criteria of the phrase "comprehensive meta databases". The PM guidelines did not provide clear criteria on this.

Gender and Diversity Indicators (Indicator 5D)

The following excerpts from last year's report are still relevant in the 2008 PM verification exercise of this indicator:

- At least two centers continue to express their concern about the definition of "women in management" for indicator 5E. Currently the definition requires that for women to be counted for this indicator, they must report directly to the center's DG as a means to standardize the indicator and to only include senior management level and not third tier managers for instance. This was the same definition used in the previous year. The two centers insist that it would be unfair not to consider women in other key management positions within their organizations such as Regional Directors and other Group Directors position where these were currently occupied by women but in their organizational structure did not report to the DG directly.

- One center expressed the view that in the computation of the percentage of women in management, the management position should be limited to the members of management committee or executive management of the center regardless of whether the members of the management committee or executive management report directly to the DG. The center argued that it is the members of the management committee or executive management who can actually and directly influence the management decisions of each center.

- Some centers inquired whether the Director General (DG) should be included in the computation of the percentage of women in management. The answer is yes as the PM guidelines clearly point out that "Management position" includes Director General, Deputy

Directors General, Directors of major programs/divisions and senior heads of administration if they report directly to the DG."

- Another issue that appeared to require further clarification was whether a management position that reports directly to the DG and is vacant as of the cut-off date of verification be included as part of the denominator in the computation of this indicator. The verification process did not include in the computation the management position that is vacant as of the cut-off date as it would skew the computation of the percentage.

The table below summarizes the findings for the verified institutional health indicators, and provides a comparison between the center responses and the verified values in those cases where there were adjustments after the verification.

Verification findings and adjustments to center responses on the Institutional Health Indicators

	INDICATORS VERIFIED	Centers' original response	VERIFICATION FINDINGS
5A	**GOVERNANCE CHECKLIST**		
	Focus on Purpose and Outcomes Ensure Accountability		
5A-2	In 2008, did the board assess the Center's performance based on the targets and strategic goals approved in the Medium Term Plan and/or the strategic plan, and act on significant deviations from projected results? Assessed results: Yes/No	**IITA** – No **Other centers** – Yes	**OK**
	Acted on significant deviations: Yes – Fully Yes – Partially No No deviations	**CIFOR, CIMMYT, ICRISAT and World Agroforestry** – Fully **IITA** – No **Other centers** – No deviation	**OK**
5A-8	Does the board review annual trends in Center staffing, including gender, diversity, and turnover? Yes or No	**All 15 centers** – Yes	**Worldfish** – NO **Other centers** – Yes
	Understanding Stakeholder Perspectives		
5A-13	Does the board have a formal mechanism for regular, independent communication with staff through meetings with staff councils or other representative staff groups?	**All 15 centers** – Yes	**ICARDA and IWMI** – No **Other centers** – Yes

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	Yes or No		
5A-14	Is the following Center information publicly available (e.g. on the Center website)?	**All 15 centers** – Yes	**Africa Rice –** No **CIAT –** No **CIP –** No **IFPRI –** No **IWMI –** No **World Agroforestry –** No **WorldFish –** No **Other centers** – Yes
	a) Mission, vision and strategic goals	**All 15 centers** – Yes	**OK**
	b) Annual report (including full presentation of financials and performance indicators)	**Bioversity, CIFOR, CIMMYT, ICARDA, ICRISAT, IITA, ILRI and IRRI** – Yes **Other centers** - No	**OK**
	c) Staff compensation structure (i.e. salary scales for different grades of staff)?	**Africa Rice, Bioversity, CIFOR, CIMMYT, ICRISAT, ILRI, WorldFish** – Yes **Other centers** – No	**OK**
	d) List of current board members with biographical information	**All 15 centers** – Yes	**OK**
	e) Schedule of board and executive committee meetings.	**CIAT, CIP and CIMMYT** – No **Other centers (including IRRI)**– Yes	**CIAT, CIP and IRRI** – No **Other centers (including CIMMYT)** – Yes
	f) Archive of board meeting agendas and summaries (recommended 2 year minimum)	**CIP, ICARDA, ICRISAT, IFPRI and IRRI** – No **Other centers** – Yes	**OK**
	g) Contact information that allows for independent communication with the chair of the board	**CIAT, CIP and CIMMYT** – No **Other centers** – Yes	**CIAT and CIP** – No **Other centers (including CIMMYT)** – Yes
5A-15	Has the board undertaken a thorough assessment of its own performance in the past two years and implemented improvements based on the assessment?		
	a) assessed?	**All 15 centers** – Yes	**OK**
	b) implemented improvements?	**CIAT and CIFOR** - No **Other centers** – Yes	**OK**
5A-16	Does the full board perform an annual evaluation of the board chair?	**All 15 centers** – Yes	**OK**
5A-19	Does the board have at least two members with professional qualifications in financial	**IFPRI and IRRI** – more than 2 **Bioversity, CIAT, CIFOR, ICRISAT, and World**	**IFPRI** – more than 2 **Bioversity, CIAT, ICRISAT, IRRI and World**

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	management	**Agroforestry** – 2 **Africa Rice, CIMMYT, CIP, ICARDA, IITA, ILRI, IWMI and WorldFish** – less than 2 (all have at least one)	**Agroforestry** – 2 **Africa Rice, CIFOR, CIMMYT, CIP, ICARDA, IITA, ILRI, IWMI and WorldFish** – less than 2 (all have at least one)
5A-20	Does the board have at least one member with professional expertise in corporate, nonprofit or public governance?	**Bioversity and ILRI** – 1 to 2 **Other centers** – More than 2	**All 15 centers** – More than 2
	Policy checklist		
5A-23	In the last two years, has the board approved or reviewed the following policies:		
	b) Investments	**ICARDA** - No **Other centers** – Yes	**OK**
	d) HR policy (including grievance procedures)	**CIFOR** - No **Other centers** – Yes	**OK**
5C	**CULTURE OF LEARNING AND CHANGE CHECKLIST**		
	Planning & Review of Program		
	b. What is the percentage of your program budget (average for 2006-2008) that has been covered by CCERs completed in 2006-08? 0-30% 31 - 50% 51-70% 71-90% 90% +	**CIMMYT, ICARDA, IITA, IWMI, and World Agroforestry**– 0% - 30% **CIP, IFPRI, WorldFish and IRRI** - 31% - 50% **ILRI**– 51% - 70% **Bioversity**– 71% - 90% **Africa Rice, CIAT, CIFOR and ICRISAT** – 90%+	**CIMMYT, ICARDA, IITA, IWMI, World Agroforestry and WorldFish** – 0% - 30% **CIP, IFPRI and IRRI** - 31% - 50% **CIFOR** – 51% - 70% **Bioversity and ILRI** – 71% - 90% **Africa Rice, CIAT and ICRISAT** – 90%+
	Data Management		
	Do you systematically preserve research project data (primary and secondary data sets), including documentation on the data and project? YES, we have a comprehensive (meta) database for primary and secondary research data that is fully available for internal use	**Africa Rice, CIAT and IFPRI** – YES, we have a comprehensive (meta) database for primary and secondary research data that is fully available for internal use **Other centers** - YES, we have some (meta) database, but not all of the research project data is preserved or internally	**OK**

	YES, we have some (meta) database, but not all of the research project data is preserved or internally available NO, we do not have at all a (meta) database preserving research data systematically	available	
5D	**Percentage of women in management (Percent of management positions, either research or non-research, occupied by women as of 31 December 2008)**	**Africa Rice** – 20% **Bioversity** – 28% **CIAT** – 50% **CIP** – 33% **ICARDA** – 18.20% **IFPRI** – 30% **ILRI** – 50% **CIFOR** – 28.57% **CIMMYT:** 14.29% **ICRISAT**: 8% **IITA**: 50% **IRRI**: 17% **IWMI**: 37.5% **World Agroforestry**: 33% **WorldFish**: 12.5%	**Africa Rice** – 25% **Bioversity** – 11.11% **CIAT** – 40% **CIP** – 50% **ICARDA** – 16.67% **IFPRI** – 28.57% **ILRI** - Nil **Other Centers** – OK

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Recommendations on Institutional Health Indicators 5A, 5C and 5D

- We recommend that the PM system should avoid, in the next PM verification exercise, compounding several requirement or questions under one indicator. Instead, a separate letter or numbers should be assigned to different requirement or expectation from centers. This would prevent the situation where the centers' response cannot clearly be determined as a "yes" or a "no" because of partial compliance or submission such as the following indicators:

    - Indicator 5A-14(a) on Mission, vision and strategic goals – should be separate for mission, vision and strategic goals
    - Indicator 5A-14(b) on Annual report (including full presentation of financials and performance indicators) – should be separate for the annual report, audited financial statements and performance indicator
    - Indicator 5A-14(e) on Schedule of board and executive committee meetings – should be separate for the full board, and for the executive committee

- Regarding Indicator 5A-2 on "board action on significant deviation from projected results, we recommend that the PM system should, in the next PM verification, include in the guidelines a clear definition of the term "deviation" and the criteria to be considered before a "deviation" may be considered "significant". For example:

    "Deviation" – means any of the following:
    a) When the achievement of any target or output set was less than 100%
    b) When the achievement of any target or output was deferred or cancelled
    c) When the center has not done anything to meet the target or output set

    A deviation is considered significant when:
    a) at least 30% of the total targets were not achieved.
    b) At least 50% of the total target were cancelled or deferred for another year

- Regarding Indicator 5A-13 on "formal mechanism for regular, independent communication with staff through meetings with staff councils or other representative staff groups, **we recommend** that this indicator be covered under different but related questions as follows:

    - Whether the center has a staff council or other representative staff group?
    - Whether the board meets with the staff council or other representative staff group at least on an annual basis.

    These questions would no longer necessitate the requirement for a formal mechanism by the board for regular communication.

    We also recommend that the indicator clearly provide the purpose for the meeting between the members of the board and the staff councils. For example, the agenda or purpose of the board members meeting with staff council is to provide an opportunity for the parties to discuss common concerns of staff (not a specific grievance case) and to seek the staff representatives' views on any center related issue. Other meetings or forum where the attendance of staff and board members are only incidental (e.g. program committee meetings, Board Chair or DG updates) and not primarily for the board members to seek the views of staff representatives are not the ones contemplated on this indicator.

- Regarding Indicator 5A-14b on "Annual report (including full presentation of financials and performance indicator)"– ***We recommend*** that this indicator be covered under different but related questions as follows:

    - Whether center's annual report is publicly available?
    - Whether the center's annual report includes the full audited financial statements (including report or opinion of external auditors and the notes to the financial statements)? or whether the center's audited financial statements are publicly available?
    - Whether the center's annual report includes the full results of the previous year's performance measurement verification exercise.

- Regarding Indicator 5A-14c on "staff compensation structure, ***we recommend*** that the PM system should consider expanding the coverage of the phrase "staff compensation structure" to require the inclusion and public availability of information about the other monetary and non-monetary benefits offered by centers in order to show the public the complete picture of staff compensation structure.

- Regarding Indicator 5A-14e on "schedule of board and executive committee meetings publicly available, ***we recommend*** that this indicator be covered under different but related questions as follows:

    - Whether the schedule of full board meetings is publicly available?
    - Whether the schedule of executive committee meetings is publicly available?

- Regarding Indicator 5A-14f on "archive of board meeting agendas and summaries (recommended 2 year minimum)" ***we recommend*** that the PM system consider including another bullet on this indicator on "non-confidential decisions on board meetings".

- Regarding Indicator 5A-15 on "board implemented improvements based on the assessment", we recommend that the PM guideline should include among the responses an option where the center board did not deem it necessary to make improvements after its own self-assessment.

- Regarding indicator 5A-19 on "professional qualifications in financial management", ***we recommend*** that the PM guideline revisit the criteria for considering board members as professionally qualified in financial management." Consider the following revision:

"Professional qualification in financial management" means that a Board member should have one of the following qualifications:

(1) a recognized accounting or financial qualification provided by a member of the International Federation of Accountants (in particular a national professional accounting body) such as a CPA, CA or equivalent and/or
(2) have substantial experience (at least 10 years) as a Chief Financial Officer or equivalent in a public or private sector organization, or in other senior positions responsible for the analysis of financial statements or financial management of such organizations., or as a faculty member of a higher education institute with responsibilities to teach on such analysis

Board members who have qualifications or professional/academic experience in public finance or macroeconomics without meeting one of the above requirements will not be considered "professionally qualified in financial management" as the focus of the qualification is on members who have substantial experience at organizational level. Persons with Masters of Business Administration or Public Administration would be accepted provided they meet criteria (2) above."

- Regarding Indicator 5C on "percentage of your program budget (average for 2006-2008) that has been covered by CCERs, ***we recommend*** that the PM guideline should include the following:

  - a clear definition or coverage of the phrase "program budget". For example, program budget – means strictly research budget i.e. total center budget less budget for corporate services and research support units.

  - an explanation why corporate services and research support services CCER are not to be included in the computation, such as for example, that including corporate services and research support services CCER would defeat the purpose of the indicator.

  - guidance on how to treat, in the computation of coverage, thematic CCERs (such as research partnerships) that cut across several research programs. One way of doing this would be to include a separate indicator for partnership CCERs and other thematic CCER affecting all research programs.

  - a formula that can be used by the centers in computing for this indicator. For example:

  = (Total Budget of Program(s) covered by CCER ÷ Total Program Budget) x 100%

- Regarding Indicator 5C on "data management", ***we recommend*** that the PM system should include a clear definition and criteria of the phrase "comprehensive meta databases", and consider the following definition and criteria: "comprehensive (meta) database should allow for primary and secondary research data that is fully available for internal use and includes research

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data generated by the Center or partners undertaking sub-contracted research for research projects managed from headquarters and from center regional, country and project offices."

- Regarding Indicator 5E on "Women in management", ***we recommend*** that the PM system should revisit the definition of "women in management" and clarify the functions that should be included in "management" and consider the definition provided below:

  "Management position" includes Director General, Deputy Directors General, Directors of major programs/divisions and senior heads of administration such as Directors of Corporate Services, Finance or Human Resources if they are part of a management committee which has been established as a collective management decision making body for the Center."

  This recommendation should be taken together with the 2007 recommendation related to this indicator i.e. "Consider adding a new indicator under 5E that measures the percentage of women in management positions that are heads of some departments but that may not be part of the management committee or report directly to the Center's DG. These management positions would have to be strictly defined to keep this new indicator meaningful, and could include Regional and Group Directors, and Unit Heads. As mentioned above, the current definition under 5E was arrived at to keep the indicator simple and consistently measured. Given this, consider leaving the existing indicator 5E as it is to continue measuring women in senior management positions that report to the DG."

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STATUS OF PREVIOUS PENDING RECOMMENDATIONS

A) Recommendations for the CGIAR performance measurement system

PUBLICATIONS		
Recommendation	**Status as of 2008 PM Verification**	**Comments**
1) Consider including in the guidelines the following text: "Publications from the previous year, whether online or hard copy, will be accepted only if they were not included in the list of publications from the previous year. Publications can only be counted once, either online or in hard copy. Please ensure that publications from the previous year that were not counted in that PM verification are listed separately".	Implemented	
1) Consider computerizing the verification of publications by creating an interface using the existing online PM verification system where centers can upload the publications information for 1A, 1B and indicator 2 in a tabulated format. The system would verify that all publications comply with the guidelines, calculate the FTEs, ensure that all center authors are indeed counted in the scientist list, ensure that publications are only counted once within a year's list and also compared to the previous year's list (in case of publications dated as of the previous year), verify that 1A publications are in Thomson, prepare a list of disallowed publications and scientists, and calculate 1A, 1B and indicator 2. This will be sent to the centers for their feedback as it is currently done.	Not implemented	Structural changes within the PM verification system taking place during 2008 gave greater weight to the verification of publications, putting this recommendation on hold.
2) Consider eliminating from the CGIAR PM website the link to upload the list of scientists for calculating 4B since it is redundant as it is the same as the list of scientists used for 4A.	Implemented	

EPIA VERIFICATION (IMPACTS)		
Recommendation	**Status as of 2008 PM Verification**	**Comments**
1) Consider informing the verification team what are the SC preselected epIAs by the time the evidence documents are requested to the centers.	Implemented	
INSTITUTIONAL HEALTH: GOVERNANCE CHECKLIST (INDICATOR 5A), CULTURE OF LEARNING AND CHANGE CHECKLIST, AND GENDER AND DIVERSITY INDICATORS		
2007 Recommendation	**Status as of 2008 PM Verification**	**Comments**
1) We reiterate our previous year's recommendation to consider including a brief description of the rationale for each category of indicators in the online Performance Measurement System based on frequently asked questions (FAQs) made by the centers during the verification exercise. We believe this will serve to support the "Guidelines for the Reporting of Indicators for CGIAR Centers".	Implemented.	
2) We recommend that the PM guideline clarify the formula for computing the percentage of women in management, specifically pointing out the treatment in case of vacancy in the management position and the inclusion of the DG in the computation.	Not implemented.	
3) Consider including a brief description of the rationale for each category of indicators in the online Performance Measurement System based on frequently asked questions (FAQs) made by the centers during the verification exercise. This will serve to support the "Guidelines for the Reporting of Indicators for CGIAR Centers"	Partially implemented	The rationale was included when possible. The CGIAR Secretariat indicated that this will be discussed further as the PM System's structure will change.
4) Consider adding a new indicator under 5E that measures the percentage of women	Not implemented	The CGIAR Secretariat will decide

in management positions that are heads of some departments but that may not report directly to the Center's DG. These management positions would have to be strictly defined to keep this new indicator meaningful, and could include Regional and Group Directors, and Unit Heads. As mentioned above, the current definition under 5E was arrived at to keep the indicator simple and consistently measured. Given this, consider leaving the existing indicator 5E as it is to continue measuring women in senior management positions that report to the DG.		on this for next year's exercise.

B) Recommendations for the centers

PUBLICATIONS		
Recommendation	**Status as of 2008 PM Verification**	**Comments**
1) The collection of publications data is an effort that can be done through the year to avoid last minute crunches that could lead to leaving out some publications that may not get counted. The requirement to provide publications indicators is now well established in the PM process and Centers should be maintaining databases for this purpose to ease the reporting effort for the PM System as well for other Center purposes. Centers are dependent on scientists to help keep such databases up to date and complete. Centers should consider including publications in scientist performance evaluation processes to provide an incentive for the timely submission of information. This recommendation for the centers was also made in last year's report.	Implemented	All centers provided the publications information in a timely manner
INSTITUTIONAL HEALTH		
2007 Recommendations	**Status as of 2008 PM Verification**	**Comments**
1) Indicator 5C-7: Centers should have MoU or other written agreements to support the number of new partnerships established in a given year.	Not verified in 2009	To be determined in future PM exercises.

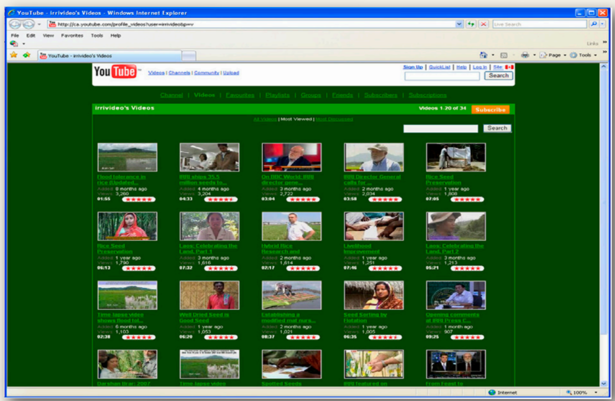
Selected Acronyms

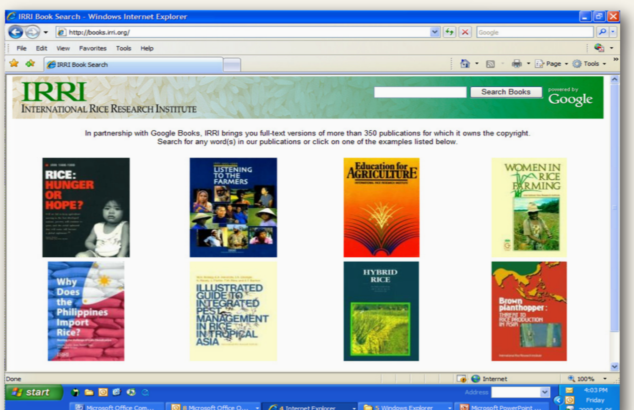
ACIAR	Australian Centre for International Agricultural Research
ADB	Asian Development Bank
ARRRI	All-Russia Rice Research Institute
ARI	advanced research institute
ASEAN	Association of Southeast Asian Nations
ASL	Analytical Service Laboratories
AWD	alternate wetting-and-drying (technology)
BADC	Bangladesh Agricultural Development Corporation
BMGF	Bill & Melinda Gates Foundation
BOT	Board of Trustees
BPH	brown planthopper
BRRI	Bangladesh Rice Research Institute
CESD	Crop and Environmental Sciences Division
CGI	Clinton Global Initiative
CGIAR	Consultative Group on International Agricultural Research
CIMMYT	Centro Internacional de Mejoramiento de Maíz y Trigo (International Maize and Wheat Improvement Center) (Mexico)
CORRA	Council for Partnerships on Rice Research in Asia
CPS	Communication and Publications Services
CRIL	Crop Research Informatics Laboratory
CRRI	Central Rice Research Institute (India)
CSISA	Cereal Systems Initiative for South Asia
CURE	Consortium for Unfavorable Rice Environ-ments
DDG-OSS	Deputy Director General for Operations and Support Services
DDG-R	Deputy Director General for Research
EPMR	external program and management review
ES	Experiment Station
ESA	East and Southern Africa
EVO	Events and Visitors' Office
FAO	Food and Agriculture Organization
FoSHoL	Food Security for Sustainable Household Livelihoods
GCP	Generation Challenge Program
GHG	greenhouse gas
GLH	green leafhopper

Selected Acronyms

GQNPC	Grain Quality, Nutrition, and Postharvest Center
GR	Golden Rice
GRC	Genetic Resources Center
GWP	global warming potential
HRDC	Hybrid Rice Research and Development Consortium
IAARD	Indonesian Agency for Agricultural Research and Development
IARC	international agricultural research center
ICAR	Indian Council of Agricultural Research
ICIS	International Crop Information System
ICRAF	World Agroforestry Center
IFAD	International Fund for Agricultural Development
IMIS	International Maize Information System
INGER	International Network for Genetic Evaluation of Rice
INQR	International Network for Quality Rice
IP	intellectual property
IRGSP	International Rice Genome Sequencing Project
IRIS	International Rice Information System
IRRC	Irrigated Rice Research Consortium
IRRN	International Rice Research Notes
ITS	Information Technology Services
ITPGRFA	International Treaty on Plant Genetic Resources for Food and Agriculture
JICA	Japan International Cooperation Agency
JIRCAS	Japan International Research Center for Agricultural Sciences
LDS	Library and Documentation Services
MAS	marker-assisted selection
META–PHOR	Metabolomic Technology Applications for Plants, Health, and Outreach
MOA	memoranda of agreement
NARES	national agricultural research and extension systems
NIAS	National Institute for Agrobiological Sciences (Japan)
NIL	near-isogenic line
PBGB	Plant Breeding, Genetics, and Biotech-nology (Division)
PhilRice	Philippine Rice Research Institute
QTLs	quantitative trait loci
RDA	Rural Development Administration (Korea)
RIL	recombinant inbred line
RKB	Rice Knowledge Bank
RTBV	rice tungro bacilliform virus
RTD	rice tungro disease
RTSV	rice tungro spherical virus
SDC	Swiss Agency for Development and Cooperation
SHU	Seed Health Unit
SMTA	Standard Material Transfer Agreement
SNP	single nucleotide polymorphism
SSD	Social Sciences Division
SSNM	site-specific nutrient management
STRASA	Stress-Tolerant Rice for Poor Farmers in Africa and South Asia
STS	sequence tagged site (marker)
TC	Training Center
TRRC	Temperate Rice Research Consortium
TRT	The Rice Trader
UC	University of California
UPLB	University of the Philippines Los Baños
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
WARDA	Africa Rice Center
WHO	World Health Organization

Useful Resources at a Glance





Rice research Thursday seminars 2008

Dr. John Bennett, 10 January, Audio and powerpoint.

Dr. Peter Jennings, 17 January, Video.

Dr. Cezar Mamaril, 24 January, Audio and powerpoint.

Dr. Philippe Hervé, 7 February, Audio and powerpoint.

Dr. Deborah Templeton, 28 February, Audio and powerpoint.

Mr. Gene Hettel, Seed preparation for Svalbard Vault, video

Dr. Randolph Barker, 24 April, Audio and powerpoint.

IRRI's response to the rice crisis, Panel of IRRI staff, 29 April, Audio.

Dr. Kenneth McNally, 8 May, Audio and powerpoint.

Dr. Hei Leung, 22 May, Audio and powerpoint.

Dr. Darshan Brar, 29 May, Audio and powerpoint.

Dr. Robert Hijmans, 12 June, Audio and powerpoint.

Dr. Gary Jahn, 26 June, Audio and powerpoint.

Dr. K.S. Lee, 27 June, Audio and powerpoint.

Dr. Uma Shankar Singh, 14 August, Audio and powerpoint.

Dr. Sushil Pandey, 14 August, Audio and powerpoint.

Dr. Reiner Wassmann, 28 August, Audio and powerpoint.

Dr. Grant Singleton, 4 September, Audio and powerpoint.

Dr. K.L. Heong, 11 September, Audio and powerpoint.

Dr. R.K. Singh, 25 September, Audio and powerpoint.

Mr. Matthieu Conte, 20 October, Audio and powerpoint.

Panel of IRRI and WARDA staff, 7 October, Powerpoint.

Mr. Adam Barclay, 16 October, Audio and powerpoint.

Ms. Jacqueline Dionora, 23 October, Audio and powerpoint.

Dr. Yin Xinyou, 6 November.

Dr. David Johnson, 18 November, Audio and powerpoint.

Dr. Achim Dobermann, 20 November, Audio and powerpoint.

Dr. Stephan Haefele, 27 November, Audio and powerpoint.

Mr. Gene Hettel, 4 December, IRRI on YouTube

Dr. Robert Zeigler, 11 December, Audio and powerpoint.

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The responsibility for this publication rests solely with the International Rice Research Institute.

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