Global Rice Science Partnership

CGIAR

Research Program on Rice

Global Rice Science Partnership

GRiSP in motion

The Global Rice Science Partnership (GRiSP), which is the CGIAR Research Program on Rice, represents for the first time ever a single strategic and work plan for global rice research. GRiSP brings together hundreds of scientists to embark on the most comprehensive attempt ever to harness the power of science to solve the pressing development challenges of the 21st century. Cutting-edge science is deployed to develop new rice varieties with high yield potential and tolerance of a variety of stresses such as flooding, salinity, drought, soil problems, pests, weeds, and diseases. Improved natural resource management practices will allow farmers to fully realize the benefits of such new varieties on a sustainable basis while protecting the environment. Future rice production systems are designed to adapt to climate change and to mitigate the impacts of global warming. Policies conducive to the adoption of new varieties and cropping systems will be designed to facilitate the realization of development outcomes. GRiSP will train future rice scientists and strengthen the capacity of advisory systems to reach millions of farmers. For impact at scale, GRiSP scientists collaborate with hundreds of development partners from the public and private sector across the globe.

GRiSP was launched in 2010 and is coordinated by three members of the CGIAR Consortium—the International Rice Research Institute (IRRI, the lead institute), Africa Rice Center (AfricaRice), the International Center for Tropical Agriculture (CIAT)—and three other leading agricultural agencies with an international mandate and with a large portfolio on rice: Centre de Cooperation Internationale en Recherche Agronomique pour le Développement (Cirad), L'Institut de Recherche pour le Développement (IRD), and the Japan International Research Center for Agricultural Sciences (JIRCAS). Together, they align and bring to the table consortia, networks, platforms, programs, and collaborative projects with over 900 partners from the government, nongovernment, public, private, and civil society sectors.

The responsibility for this publication rests solely with the Global Rice Science Partnership.
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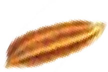

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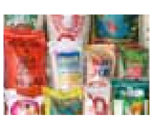

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C. Quintana, IRRI

GRiSP in motion

The year 2012 was the second year of implementation of the CGIAR Research Program for Rice, known as the Global Rice Science Partnership (GRiSP). Since its launch in December 2010, we have considerably strengthened our partnership foundation for mobilizing science to increase food security, alleviate poverty, and increase the sustainability of rice production. Both the collaboration among GRiSP's six coordinating institutes and that between those institutes and more than 900 other partners from the public and private sector worldwide have intensified considerably.

GRiSP aims to develop science-based solutions to today's and tomorrow's agricultural development problems. It mobilizes partners that operate on the cutting edge of science at one end of the globe and connects them with grass-roots partners at other ends. In this report, we present a snapshot of such activities that illustrates the tremendous gains that well-chosen partnerships can deliver. You'll read about partnerships that discover new genes and deploy those genes to produce new rice varieties that increase tolerance of phosphorus deficiency, confer resistance to insect pests and virus diseases, or will lead to a completely new type of rice, called C_4 rice, which could potentially increase yields by up to 50%. But, you'll also read how GRiSP partners team up with indigenous people and local farmer groups in remote areas to preserve and improve age-old rice varieties and make sure they are retained for generations to come.

GRiSP partners from Latin America, Africa, and Asia discuss the workings of each other's rice sectors and policies and cross-fertilize each other with new ideas. New concepts for forging local partnerships are piloted in South Asia and across Africa in an attempt to fast-track the development and delivery of locally adapted technologies. And, finally, GRiSP invests in capacity building of the next generation of rice scientists and helps them prepare to become leaders in their own right when it's their turn to take over from the current generation.

I hope you enjoy reading these snapshots and can share in the exhilaration we all feel in being part of GRiSP and combining our knowledge to help make our world a more food-secure, richer, and environmentally friendly place to live in.

Bas Bouman
Director, GRiSP

Transplanting Uruguay's rice experience into Asia's rice fields

Uruguay has achieved a 25% increase in rice productivity in recent years—much higher than many other nations—which has set it on track to contribute to meeting the global demand for an estimated 116 million additional tons of rice by 2035. Representatives from around 20 countries brought together by GRiSP went to Uruguay to learn about its success in rice production and study whether, and how, Uruguay's model can be used in Asia.

From relative obscurity 50 years ago, Uruguay, a small South American country, now has the third-highest rice productivity in the world—an average of 8 tons per hectare of dry paddy rice over the last 5 years. Although it has only 580 rice farmers cultivating some 180,000 hectares of irrigated rice, Uruguay's unique system has triggered 25% gains in productivity in recent years.

N. Palmer, CIAT

The Uruguayan way

The features of the rice sector are vertical integration and transparency among farmers, millers, researchers, and the government. This structure integrates complete and up-to-date information on rice exports, well-defined rules on rice quality standards, active participation of farmers and millers in research goals, and the farmer-miller relationship duly signed in a production contract every year, including agreement on the price farmers will receive for their rice.

Organized through the Rice Growers Association (ACA in Spanish), farmers sell their rice directly to local mills, which process it for export. The mills work closely with international traders and feed information to rice breeders at Uruguay's National Agricultural Research Institution (INIA by its Spanish acronym) on the type of rice they need. This ensures that INIA's breeding and research priorities are in line with market demand.

An integrated rice chain

Uruguay has no publicly funded extension system. Instead, rice millers employ their own agronomists, who have close contact with researchers at INIA, to provide farmers with crop management advice. The mills also supply farmers with clean, certified rice seed to help guarantee the best possible harvest, which assures millers of a reliable source of high-quality paddy.

As co-founders of the Latin American Fund for Irrigated Rice (FLAR by its Spanish acronym) in 1995, INIA, ACA, and rice millers helped ensure that rice producers are able to get the latest technologies as soon as they are delivered by international centers.

"The integration of the rice chain has been the driving force for the impressive competitiveness achieved in the past four decades in Uruguay," explained Gonzalo Zorrilla, FLAR executive officer and GRiSP theme leader.

The agronomy revolution

Uruguay's impressive yield gains were accomplished partly by using improved varieties, but mainly through improved crop management practices such as timely crop establishment, water and nutrient management, and proper weed control. The quick adoption of these simple but effective agronomic improvements was achieved through close interaction among scientists, agronomists, and farmer groups who make frequent field visits together and pragmatically discuss "what works and what doesn't."

Vietnam's vision

Can Uruguay's success be duplicated in Asia, where 120 million rice farmers have an average area of 0.5–2 hectares and very limited access to inputs?

"I think elements of the Uruguayan system really could work well in parts of the Mekong Delta," said Bas Bouman, director of GRiSP. "In Vietnam's An Giang Province, for example, the government has a vision to develop a high-quality rice sector to supply international markets. Here, I could see one or more large mills joining together with large groups of farmers to produce high-value rice in a system based on trust and transparency."

Pham Van Du, deputy director general of the Department of Crop Production of the Vietnamese Ministry of Agriculture and Rural Development, who joined the GRiSP meeting in Uruguay, saw valuable lessons for a new Vietnamese program called "Small Farmers, Large Rice Field." Under the program, millers, farmers, and the public and private sector work together to produce high-quality rice.

Later in 2012, Dr. Du continued the discussion with Raúl Uraga Berrutti, agronomist and technical advisor at one of Uruguay's large rice mills, during GRiSP's Global Forum in the Philippines.

A lesson for Asia

"While most of the rice in Asia is consumed by the very poor, there is a rapidly growing middle class buying high-quality branded rice from supermarkets," Dr. Bouman said. "Introducing something like the Uruguayan system at a smaller level could help farmers and local rice sectors take advantage of this.

"This is relevant not only for Vietnam but also for other rice-producing countries in Asia that are undergoing rapid structural transformation," he concluded.

A model country. Researchers are looking at Uruguay's highly successful rice production model in building high-value rice sectors in Asia to supply global markets.

N. Palmer, CIAT

Stopping rice enemy number one

With new planthopper outbreaks occurring at an unprecedented scale, researchers from across different GRiSP organizations came together as never before to improve implementation of holistic strategies at "ground zero" and to share the growing arsenal that is becoming available to better know and fight this enemy.

Brown planthoppers (BPH) are efficient rice killers when they occur in large numbers. They pierce the stem and suck out the sap, causing rice plants to dry out and die. They can also transmit viruses that cause severe rice diseases.

BPH are regarded as the number-one insect pest of rice in Asia because of the severe damage they cause, estimated at 2 to 3 million tons annually, across regions where outbreaks occur. In 2012, BPH outbreaks in Thailand affected 17 provinces in the Central Plains. In China, the worst outbreak in 20 years affected more than 5 million hectares in the southern provinces of Hunan, Guizhou, and Sichuan.

Multinational line of defense

The war against BPH reached a watershed in 2012. Two international events, organized under GRiSP, focused on building a stronger multinational network to fight this pest that does not recognize international borders.

More than 160 participants from Australia, Cambodia, China, Indonesia, Myanmar, the Philippines, Thailand, IRRI, and FAO attended the International Conference on Rice Planthoppers in China, where new findings from sequencing the planthopper genome were presented. This opens the door to understanding the genetic diversity and adaptability of BPH and leads to new ways to manage the pest.

Second, partners of the Rice Planthopper Project from China, Thailand, Vietnam, and the Philippines came together in China and reported that ecological engineering has been adopted in seven provinces of the Mekong Delta in Vietnam, three provinces in Thailand, and three counties in China. Ecological engineering is a management strategy to build ecological diversity to strengthen the rice field's natural capacity to cope with pests. It is being promoted by the project, which is supported by the Asian Development Bank and the International Rice Research Institute (IRRI).

Friendly fire

The link between how pesticides are supplied, marketed, and sold and the worsening BPH problem was also presented at the conference. Weak marketing regulations, in which pesticides are sold as "fast-moving consumer goods," can lead to excessive pesticide misuse that contributes to BPH outbreaks. Thus, there is a need for rice-producing countries to reform pesticide marketing regulations.

"When there is more ecological diversity in a rice field, the biological control of BPH provided by ecosystem service providers, such as spiders, wasps, parasitoids, and other predators, is enhanced," IRRI insect ecologist K.L. Heong

Tiny troublemaker. Despite its minute size, BPH inflict catastrophic losses in rice production across Asia by their sheer numbers.

S. Villareal, IRRI

Battlefield scars. The burned-looking rice plants in the foreground are a tell-tale sign of damage caused by the pest. BPH outbreaks are linked to excessive and improper use of pesticides.

S. Villareal, IRRI

said. "If this is combined with careful insecticide use, then the occurrence of planthopper outbreaks can be markedly reduced."

Philippines

Under GRiSP, the Bureau of Agricultural Research of the Philippine Department of Agriculture started a project in 2012 with IRRI and Regional Agricultural Research Centers to restore and conserve ecosystem service providers that support effective pest management in rice through ecological engineering. This will build on the work of the Rice Planthopper Project to apply ecological engineering concepts across selected sites in the Philippines.

A cavalry of genes

Alongside more ecologically diverse and naturally pest-resilient rice fields, rice varieties that can resist BPH can reduce the pest's damage. But, as BPH constantly and rapidly evolve, they can overcome any resistance genes introduced into rice varieties. Scientists continue to search for genes that can withstand BPH.

Kshirod Jena, a rice breeder at IRRI, and his team recently identified new BPH resistance genes (*Bph18, Bph20,* and *Bph21*) that provide broad resistance to BPH populations in Asia. Dr. Jena and his team have developed a BPH-resistant version of rice variety IR24, making it easier to transfer the gene into other varieties.

Several GRiSP research partners in other countries are also incorporating these BPH resistance genes into their elite rice cultivars. Already, the Cuu Long Delta Rice Research Institute in Vietnam has developed several BPH-resistant breeding lines with the *Bph18* gene, and nominated them for varietal release in 2012.

IRRI is continuously developing new generations of BPH-resistant rice varieties as well as effective deployment strategies to delay hopper adaptation, and increase genetic resistance for stable rice production. GRiSP speeds up the sharing of the latest weapons and tactics in the war against BPH among researchers worldwide. Eventually, farmers will have all the tools and tactics they need to overtake the enemy.

A breeding offensive. Using newly discovered genes, BPH-resistant rice varieties will soon be part of an overall breeding strategy to counter Asia's most devastating insect pest. At the Cuu Long Delta Rice Research Institute in Vietnam, researchers have already developed resistant breeding lines with the *Bph18* gene.

S. Clayton, IRRI

Modern arks for ancient rice

In two remote areas in the Philippines, native rice varieties—cultivated in traditional ways—are sources of food and income but also have strong cultural currency. GRiSP, through the International Rice Research Institute (IRRI), is helping farmers manage these valuable assets by using modern agricultural practices. When farmers continue to grow heirloom rice, they are conserving irreplaceable genetic resources, too.

GRiSP contributes to the long-term conservation of rice biodiversity thanks to the support of donors to the International Rice Genebank at IRRI. The genebank holds more than 117,000 types of modern and traditional rice varieties and wild relatives of rice from all over the world. However, farmers can also take an active part in rice conservation locally, particularly of "heirloom" varieties that they have been growing for generations.

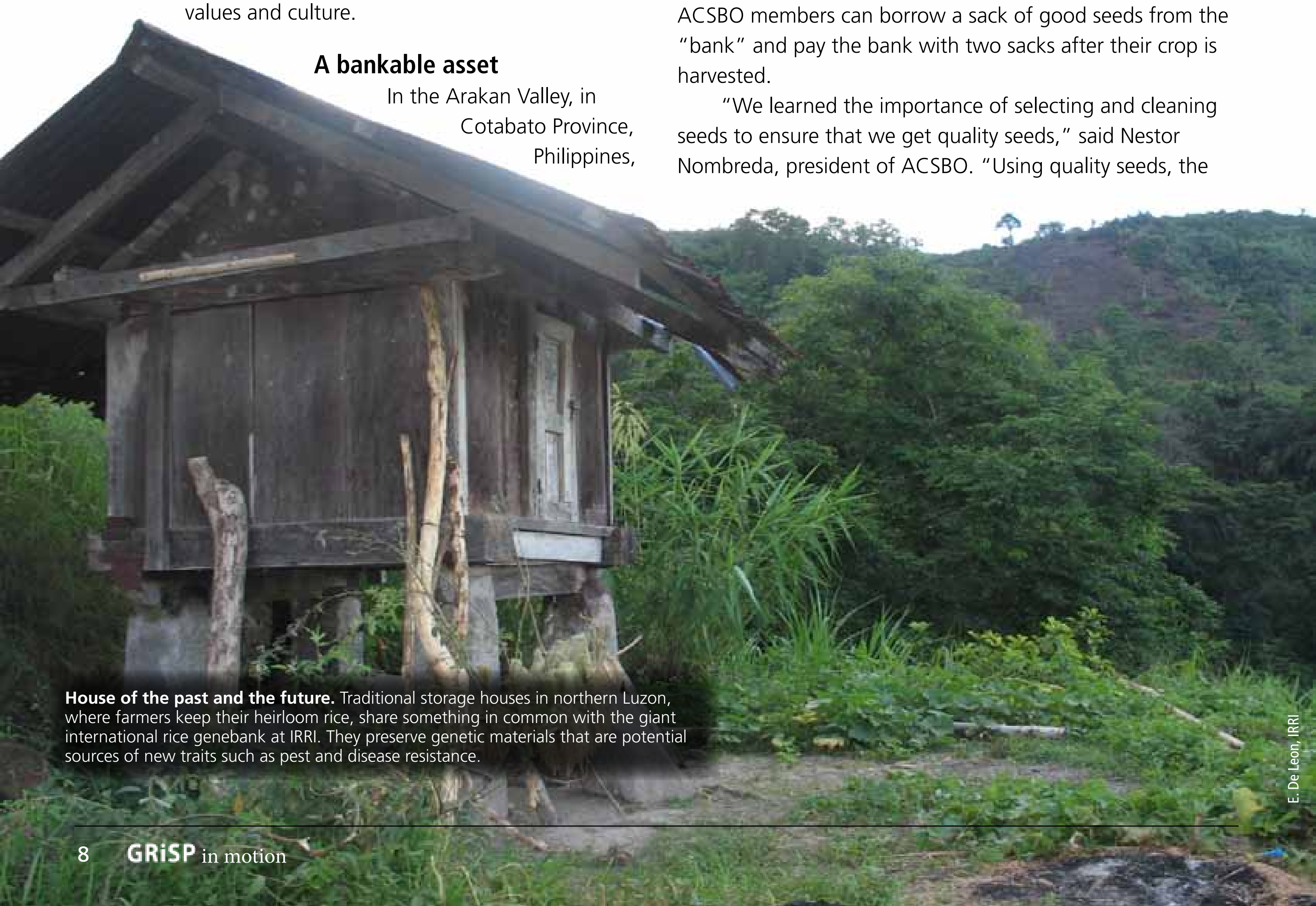
The Consortium for Unfavorable Rice Environments (CURE), a partnership among research and extension institutions from South and Southeast Asia and coordinated by IRRI, assists remote farmers not only in safeguarding ancient rice varieties but also in maintaining traditional values and culture.

A bankable asset

In the Arakan Valley, in Cotabato Province, Philippines, rice variety Dinorado is more than a crop that commands a premium price. It is part of the pride and social identity of the people. But, its quality and commercial value have deteriorated as the genetic purity of its seed stocks has declined over time because the farmers did not have the skills to maintain seed quality.

IRRI scientists joined forces with the University of Southern Mindanao, the Philippine Rice Research Institute, the Municipal Agricultural Office of Arakan, and the Department of Agriculture to train selected farmers in high-quality seed production, and to introduce modern and other traditional rice varieties. After the training, the farmers set up the Arakan Community Seed Bank Organization (ACSBO). ACSBO members can borrow a sack of good seeds from the "bank" and pay the bank with two sacks after their crop is harvested.

"We learned the importance of selecting and cleaning seeds to ensure that we get quality seeds," said Nestor Nombreda, president of ACSBO. "Using quality seeds, the



House of the past and the future. Traditional storage houses in northern Luzon, where farmers keep their heirloom rice, share something in common with the giant international rice genebank at IRRI. They preserve genetic materials that are potential sources of new traits such as pest and disease resistance.

E. De Leon, IRRI

Their heritage rice. Women farmers in Kalinga in the northern part of the Philippines sort Unoy, an aromatic indigenous variety of rice that is cultivated using production practices of their forefathers.

plants have a good appearance, good tillers, and large round grains while low-quality seeds acquire many diseases and perform poorly."

ACSBO member Russel Samillano said, "Before, we did not have seeds to plant in our fields; we had nowhere to buy seeds from. Now, we use good seeds from the seed bank. Because of this, our family will not go hungry."

ACSBO members also made extra money selling high-quality seeds to other farmers.

Teaming up the old with the new

Meanwhile, at the opposite end of the Philippine archipelago, farmers in remote areas of the Cordillera region of Luzon are facing similar problems: their age-old rice terraces are eroding, and the yield of the traditional rice varieties that their ancestors have cultivated for hundreds of years is low and unstable. Farmers worry about a lack of interest in rice farming among the younger generation and that no one will preserve their ancient traditions.

CURE teamed up with the Second Cordillera Highland Agricultural Resource Management Project, funded by the International Fund for Agricultural Development, to train farmers in the region on rural community-improvement opportunities. Specifically, CURE introduced new rice management technologies and varieties that could help farmers increase productivity and their livelihoods while maintaining their traditional rice varieties. Technologies such as community-based rodent control and modern varieties have merged with traditional systems such as organic agriculture and the use of heirloom rice.

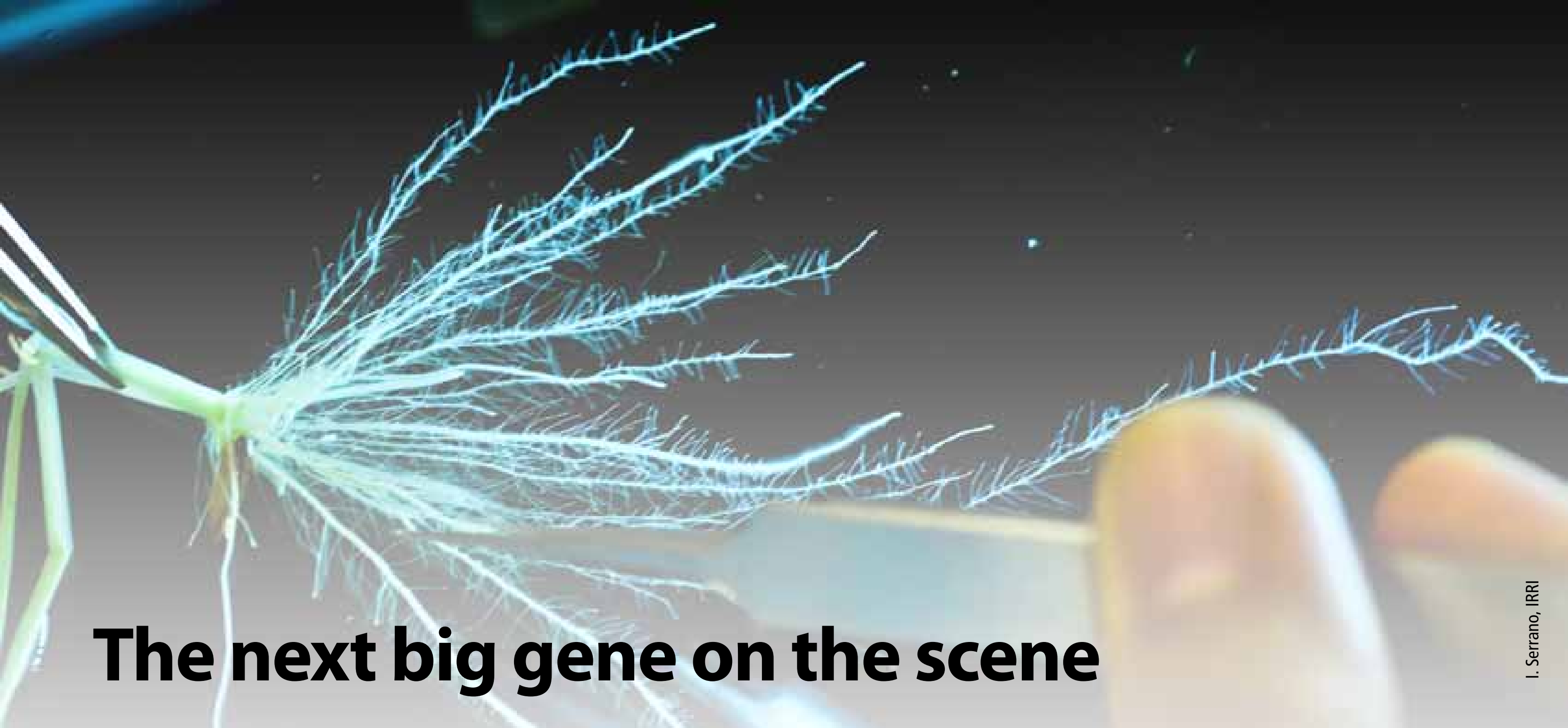
"The conservation of traditional varieties is important to plant breeding," said Dr. Casiana Vera Cruz, a scientist at IRRI. "They are untapped genetic resources and potential sources of new traits such as pest and disease resistances as well as tolerance of the changing climatic conditions."

Global S.O.S.: save old seeds

Scientists are developing ways to work with farmers to safeguard rice biodiversity by blending modern seed production technologies and crop management with traditional practices and heirloom rice varieties. Strengthening national partnerships under GRiSP allows the work to thrive and be extended to other communities worldwide.

Ultimately, this enriches the world's rice gene pool that provides GRiSP organizations across the globe with genetic knowledge and tools needed to produce varieties to solve the increasing production and environmental challenges in the future.

Management course. Farmers in Arakan inspect traditional and hybrid rice varieties growing in experimental plots. Management for crop diversity, in which traditional and hybrid rice varieties are intercropped, has been proven to promote on-farm conservation of rice.



I. Serrano, IRRI

The next big gene on the scene

Scientists at the International Rice Research Institute (IRRI) and Japan International Research Center for Agricultural Sciences (JIRCAS)—two strategic partners leading GRiSP—have pinpointed the PSTOL1 *gene that enables rice plants to grow bigger and better roots to absorb more phosphorus, an important but limited nutrient. This gene discovery unlocks the potential of rice to produce around 20% more grain while reducing the need for expensive phosphorus fertilizer.*

Phosphorus is an important plant nutrient, but, when phosphorus levels in the soil are low, rice plants can suffer from lower yield. Because almost 60% of rice is cultivated on flooded or irrigated land that is deficient in phosphorus, phosphorus fertilizer is needed to achieve optimal yield. But, phosphorus fertilizer is often too expensive for poor farmers. On problem soils, farmers can apply phosphorus fertilizer but the nutrient can rapidly attach to soil minerals and no longer be available to plants.

Adding to the problem is that phosphorus is a nonrenewable natural resource and rock phosphate reserves—the source of most phosphorus fertilizer—are running out. But, with global demand for phosphate fertilizer projected to increase from 41.7 million tons in 2011 to 45 million tons in 2015, according to the Food and Agriculture Organization, prices are also expected to rise further and thus put poor farmers at an additional disadvantage.

Genetic jackpot

The *PSTOL1* (*phosphorus starvation tolerance 1*) gene could help ease the pressure on phosphorus. It helps rice grow larger, better root systems that can access more phosphorus.

PSTOL1 was discovered by scientists at IRRI and JIRCAS, in collaboration with the University of Milano in Italy, the University of the Philippines Los Baños, and the Institute for Agricultural Biotechnology and Genetic Resources Research and Development in Indonesia. The main financial support was provided by the CGIAR Generation Challenge Program, with supplementary funding from other donors. This collaboration is an outstanding example of how GRiSP brings together partners from across the world to solve problems in rice science.

"For several years, we have known a major gene enhancing root growth and phosphorus uptake existed," said Matthias Wissuwa of JIRCAS. The superior performance under phosphorus deficiency of rice variety Kasalath, which was where the *PSTOL1* gene was found, was initially discovered by Dr. Wissuwa, who then collaborated with IRRI and shared the DNA information.

Sigrid Heuer, a scientist at IRRI and leader of the team that published the discovery in *Nature*,[1] added, "We have finally hit the jackpot and found the major gene responsible for improved phosphorus uptake and we understand how it works."

A gene of promise

In pot experiments on soils that are very low in phosphorus, yield increases due to *PSTOL1* can exceed 60%, suggesting the gene would be very effective in upland rice fields that

[1]Gamuyao R et al. 2012. The protein kinase Pstol1 from traditional rice confers tolerance of phosphorus deficiency. Nature 488 (7412):535-539.

are not irrigated and where farmers are often too poor to improve their poor soils by applying fertilizer. Field tests in Indonesia and the Philippines showed that rice with the *PSTOL1* gene produced about 20% more grain than rice without the gene.

The *PSTOL1* gene is also being tested in rice varieties for the more productive irrigated rice-growing areas and initial results show that the plants grow a better root system and have higher production, too. "This means it could help farmers in these areas reduce their fertilizer use and expenditure without compromising productivity," Dr. Heuer stressed.

New tool for breeding

The discovery of *PSTOL1* means that breeders will be able to develop new rice varieties faster and more easily, and with 100% certainty their new rice will have the gene.

According to Dr. Wricha Tyagi of the School of Crop Improvement at the Central Agricultural University in the Indian state of Meghalaya, knowledge of the exact gene will be critical for future breeding programs suited to eastern and northeastern parts of India, where rice productivity is less than 40% of the national average due to acidic soil and poor phosphorus availability.

New rice varieties with the enhanced capacity to take up phosphorus may be available to farmers within a few years.


C. Quintana, IRRI

The team of scientists who discovered the *PSTOL1* gene: (left to right) Rico Gamuyao, J.H. Chin, and Sigrid Heuer from IRRI, and Matthias Wissuwa from JIRCAS.

I. Serrano, IRRI

A milestone gene. Researchers will be able to make new rice varieties that can produce high yields even in phosphorus-deficient soils from the PSTOL1 breeding lines developed at IRRI.

Banking on the rice of the future

With a significant boost in funding received in 2012, scientists from various GRiSP partner institutions have moved closer to developing a prototype of a new super rice, known as C_4 rice. It has the potential to produce 50% more grain—with less water and nutrients. If successful, C_4 rice could catapult efforts to meet the anticipated global demand for rice and significantly contribute to global food security.

E. Panisales, IRRI

There are classes of plants known as "C_3" and "C_4"—referring to how they convert (photosynthesize) carbon dioxide and water, in the presence of sunlight and chlorophyll, into sugar. C_3 photosynthesis is less efficient at converting inputs to grain than C_4 photosynthesis, which processes resources more effectively for higher grain production. Rice is a C_3 plant, so re-engineering rice photosynthesis into C_4 could be the key to breaking through that "yield barrier."

IRRI and its network of partners across GRiSP are working to install the C_4 photosynthetic pathway in rice. Researchers have already successfully introduced 10 out of the 13 genes needed to develop C_4 rice. In the second phase of the project, the team aims to produce prototypes of C_4 rice.

Dream team

Modifying rice photosynthesis is a complex undertaking that involves different experts, organizations, and skills. "We're thrilled to be working with the world's elite in photosynthesis research to uncover genetic secrets and understand biochemical processes to bring rice to a new yield frontier," says IRRI's Dr. Paul Quick, coordinator of the C_4 rice project that brings together 17 research institutes worldwide.

Creating ways to design new genes, which is required to make C_4 rice, is what Dr. Julian Hibberd and his colleagues at the University of Cambridge are doing. This work is complemented by project partners in China led by Dr. Xinguang Zhu of the Institute for Computational Biology. Dr. Zhu is developing mathematical models of the leaf anatomy of C_4 rice. Finding novel genes by sifting through genetic codes at different stages of leaf development is also an essential part of this ambitious project. Dr. Tom Brutnell and Dr. Jane Langdale of the Donald Danforth Plant Science Center and Oxford University, respectively, are on top of this task.

Once all the necessary elements are in place, Dr. Bob Furbank at the Commonwealth Scientific and Industrial Research Organisation will test the C_4 prototypes at the High-Resolution Plant Phenomics Centre in Australia and select those that show promise.

The making of a super rice

The C_4 project was initially funded by the Bill & Melinda Gates Foundation (BMGF) and IRRI in 2009. For the second phase of the project that commenced in 2012, BMGF, the UK government, and IRRI have put $14 million behind it.

"This is exactly the sort of innovative scientific research that the Prime Minister was calling for at the Hunger Summit at Downing Street earlier this year," said the UK Parliamentary Under-Secretary of State for International Development Lynne Featherstone. "Rice is the staple food for millions across the developing world, so finding a way to double the amount each plant produces would help to feed many more of the very poorest. This could prove a critical breakthrough in feeding an ever-growing number of hungry mouths."

Other donors are the European Union's "3to4" project and the CGIAR Canada Linkage Fund through a collaboration between IRRI and the University of Toronto.

Other members of the C_4 Rice Consortium are Heinrich Heine University of Düsseldorf, Washington State University, University of Sheffield, Academia Sinica Taiwan, University of Minnesota-Minneapolis Campus, University of Nottingham, Cornell University, Kyung Hee University, James Cook University, and Australian National University.

Genetic bridges between Africa and Asia

Achieving food security in Africa largely depends on growing high-yielding crops, such as rice, that are also well adapted to the continent's harsh environment. GRiSP, through the Institut de Recherche pour le Développement (IRD), International Center for Tropical Agriculture (CIAT), and Africa Rice Center (AfricaRice), is building genetic bridges between African and Asian rice to accelerate the development of new robust and high-yielding rice varieties suitable for Africa.

Cross-breeding between different species of rice can produce new plants that stand up better to drought, salty soil, diseases, and insect pests. Since the 1990s, AfricaRice has been crossing African rice (*Oryza glaberrima*), which is particularly resistant to drought and diseases, with *O. sativa*, the high-yielding Asian rice species most widely grown in the world, to create the New Rice for Africa (NERICA) varieties.

NERICA rice has been hailed as a major advancement for Africa and could help Africa achieve much higher rice productivity. Currently, 78 NERICA varieties are available to rice farmers in sub-Saharan Africa, and, by 2011, adoption had reached more than 700,000 hectares.

The right gene mix

The initial problem in developing NERICA was that the two different rice species produced sterile offspring that could not be used to grow crops. Scientists at AfricaRice overcame this by repeatedly backcrossing into Asian rice to restore fertility. Although the early NERICA crosses exhibited low susceptibility to disease and insect attacks, the backcrossing process reduced the proportion of the African rice genome in the final NERICA varieties, consequently reducing the desired tolerance of pests.

"If we were to increase the proportion of *O. glaberrima* genes, would we get better varieties?" Dr. Mandé Semon, an upland rice breeder at AfricaRice, wondered. He proposed reversing the gene route and bringing the desirable genes from Asian rice into African rice instead. However, sterility was still going to be a problem.

The bridge from sterility to fertility

To solve this problem, the iBridges (interspecific Bridges) project was launched in 2005 as a close cooperation among IRD, CIAT, AfricaRice, the Philippine Rice Research Institute, and African national agronomic research bodies such as the Institute of Rural Economy in Mali and the Institute of Environment and Agricultural Research in Burkina Faso. Originally supported by the CGIAR Generation Challenge Program, the second phase of iBridges is now being advanced under GRiSP.

Cutting-edge research under Mathias Lorieux, IRD director of research and plant geneticist at CIAT, led to the fine mapping of the *S1* gene, previously identified as a key factor in interspecific sterility. Using the rice genome maps developed by the Oryza Map Alignment Project, the researchers identified the portion of the chromosome responsible for sterility.

"This resulted in the design of a genetic model that explains the sterility of interbred descendants, and opens the way to further research into the genetic control of sterility," said Dr. Lorieux, who is also the iBridges co-project leader along with Dr. Alain Ghesquiere of IRD.

"Being able to identify the few and rare fertile individuals from interspecific crosses early in the breeding process eliminates many stages previously required for interspecific breeding and accelerates the development of new and improved African-Asian varieties that fully embrace the rich diversity of African rice alongside that of Asian rice."

Open pool

Thanks to the partnerships that are being fostered by GRiSP, plant breeders now have access to the complete genetic diversity available in African rice. Under GRiSP, the iBridges project aims to develop new and fertile rice varieties derived from crosses between elite *O. sativa* and *O. glaberrima* rice varieties.

"We hope that the iBridges will make a significant breakthrough in improving African rice varieties," said Dr. Lorieux. "It is the African rice farmers who will directly benefit from this technology, and this will certainly contribute to Africa's food security."

Domesticating West Africa's rice market

Although a substantial increase in rice production has been observed since the 2008 food price spike, the local rice sector in sub-Saharan Africa continues to struggle against cheap imports. GRiSP partner Africa Rice Center (AfricaRice) is working with regional partners to promote economic policies that will protect and ensure a sustainable increase in local rice production.

Rice consumption in West Africa has been growing at 6% annually since 1973 as the staple diet in the region continues to shift from traditional coarse grains, roots, and tubers. More than a third of cereal calorie intake in West Africa is provided by rice and consumption is expected to continue to rise. Rice has become a strategic commodity in the region, according to the Economic Community of West African States (ECOWAS), a consortium of West African countries, which has allocated resources for the development of rice farms and to double total production by 2017.

Outside pressure

But, in addition to its own production limitations, West Africa's rice industry confronts the availability of imported rice.

"A major challenge for the development of the rice sector in sub-Saharan Africa is the volume of rice imports," explains AfricaRice policy economist Jeanne Coulibaly. "One contributory factor to the continuing increase in imports is the low tariff on imported rice."

Compared to other major grains, rice trading is widely subject to protectionist policies enforced by different countries based on national policies on food security, support for domestic producers, and price stability. But it is least protected in Africa, particularly West Africa. Although East African tariffs are about 75%, ECOWAS has recommended a Common External Tariff (CET) of only 10% for rice since 2006. Some countries and stakeholders in West Africa consider this protection too liberal to contribute to achieving the regional objective of self-sufficiency in rice. In fact, from 2010 to 2012, rice imports into the region increased by 21%, despite domestic production increases since 2008.

"Along with other players in the rice sector, we believe that an increase in import tariff would provide an incentive

R. Raman, AfricaRice

for local farmers to increase rice production," says Dr. Coulibaly.

In September, the Network of Farmers' and Agricultural Producers' Organizations of West Africa (ROPPA) and AfricaRice organized a reflection and consultation workshop on the reclassification of the rice CET in ECOWAS countries. Participants agreed that an increase in the CET of rice to 35% was appropriate to control imports and support the development of the rice sector.

However, ECOWAS has so far failed to raise the rice CET. ROPPA is lobbying national governments and ECOWAS on the agreements reached at the workshop. Meanwhile, AfricaRice has begun a study on the likely impacts of the proposed change in tariff on local rice production and households' welfare.

Regional rice offensive

"Many organizations are working toward the goal of rice self-sufficiency," says Dr. Coulibaly. "But, these initiatives are not well coordinated and harmonized. Since the 2008 food crisis, many African countries have prepared national rice development strategies with support from AfricaRice as part of the Coalition for African Rice Development, but these say very little about 'regionality.'"

AfricaRice therefore supports the idea of a "regional offensive," led by ECOWAS, to support all rice-sector initiatives in the region, with a focus on what can most effectively be achieved regionally, such as regional storage, bulk purchase, and tariff policies.

The goal of the new offensive is to reach regional rice self-sufficiency by 2018. The objectives are to improve rice production sustainably, to promote the regional rice value chain, and to create a suitable institutional environment to support the offensive's goal.

Once a feasibility study has been conducted, a business meeting will be arranged to source funding for the offensive.

"Dialogue at the regional level is very important for the sustainable development of the rice sector, to achieve regional self-sufficiency in line with ECOWAS policy objectives," concludes Dr. Coulibaly. "The CET must not be the only focus—we need policy advocacy and investment in all segments of the rice value chain, especially for processing and marketing."

A rice by any other name

Boosting production and improving quality have not been enough to help locally produced rice in Senegal in the fight against imported brands, which still dominate in many urban markets. GRiSP partner Africa Rice Center (AfricaRice) has therefore been looking at the role of branding and labeling in consumers' perceptions.

Branding—which includes advertising, packaging, logos, taglines, and other marketing activities—creates an emotional response from consumers when thinking about a product. The right branding can give a product an edge in the marketplace by giving it a "premium factor" that customers are willing to pay for even if cheaper alternatives are available.

Having been rocked by the rice price crisis of 2007-08, Senegal's government began a large-scale agricultural offensive for food and abundance to increase domestic rice production. Then, in 2011, Senegalese rice importers (who are keen to diversify their business to include the domestic rice value chain), producers, and processors created a commercial venture to buy, mill, and market local rice to Senegalese consumers. In the process of progressively upgrading the value chain for local rice (to enable it to compete with imported brands), the next big question is how to market local rice to African consumers.

The brandname game

AfricaRice value-chain economist Matty Demont, Fulbright research fellow Caitlin Costello, and sociologist Maïmouna Ndour examined the role of labeling in raising demand for local rice varieties in Dakar and Saint-Louis. The rice markets in these cities use two types of branding to sell imported rice. Some brands are labeled in French or Wolof (the national and local languages, respectively) with images indicative of Senegal or Africa (for example, a baobab tree, a drum, or a lion) to portray a "local" image. Others are labeled in French or English with images unrelated to Africa (for example, a rose, a U.S. flag, or a star) to portray an "international" image.

According to the research team, a key question in the marketing of local rice is, "Should local rice brands mimic imported brands or should they create a distinctive identity?" Eight prototype brands were designed. Four of them—two local and two international—were selected through

M. Dermont, AfricaRice

a participatory choice experiment conducted with local women's associations and then tested through experimental auctions with consumers in the two cities. The sample consumers were women shopping in the markets, as earlier research had indicated that women are the dominant decision-makers and buyers of rice in Senegal.

The same rice, different perceptions

The women were asked to express a preference between one local and one international brand. They were then permitted to sample the rice in the sacks and vote again. What the women didn't know was that the same high-quality local rice variety was in both sacks.

An experimental auction showed that consumers typically placed 17% greater value on the brand they preferred, regardless of whether it was local or international. Since the rice used in the two bags was identical, the label added 17% to the value of the rice to the consumers. Although 70% of the consumers in Saint-Louis (close to the production zone) preferred the local brands, this dropped to 55% in the capital Dakar, showing that more women in the metropolis were brand-sensitive to an international image.

The implication is that local rice will best be sold under a local brand in Saint-Louis, whereas local and international brands are likely to be equally popular in Dakar.

In January 2013, the women's association Khar Yalla Gueye at Pont Gendarme in the Senegal River valley started selling local rice under the new local brand "Ndanane," meaning "nobleman" in Wolof.

What's in a brandname? A research team from AfricaRice is studying how marketing influences consumer behavior and purchasing decisions—and could this connection create a substantial shift to higher sales of locally produced rice?

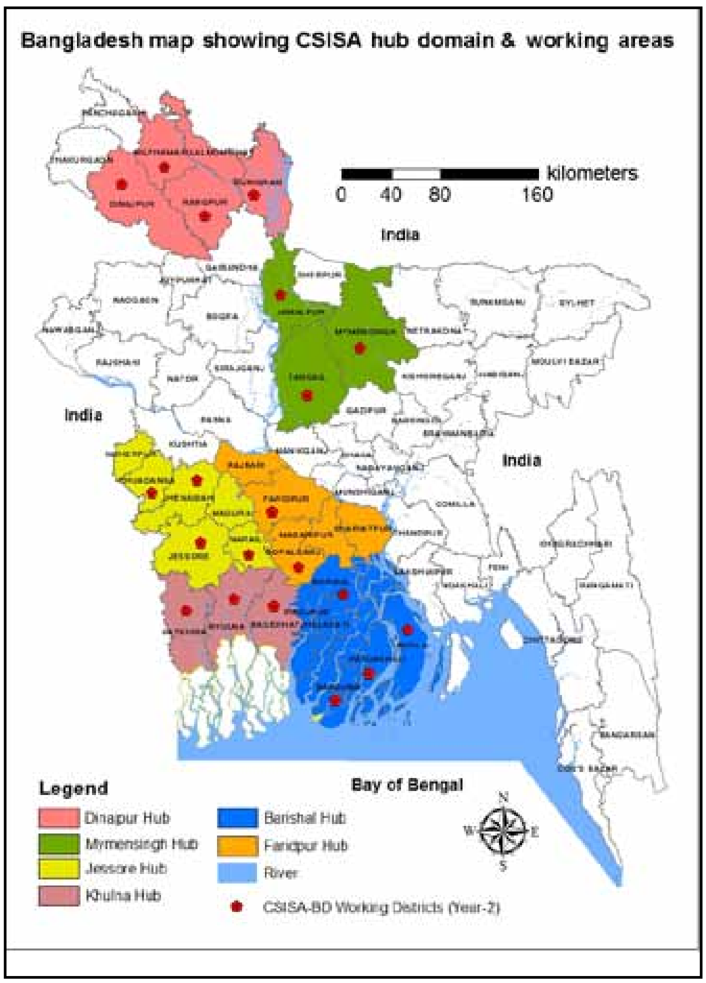
M. Demont, AfricaRice

Customizing communications for local audiences

Using "rice hubs," GRiSP partners the Cereal Systems Initiative for South Asia (CSISA) and Africa Rice Center (AfricaRice) are able to deliver information and technology tailored to the needs and situations of local farming communities.

CSISA's wheel of information

Named after a bicycle wheel, which has a central hub with a series of connecting spokes, the hub and spoke model greatly simplifies a network of routes, making overall operations more efficient. This model was adopted by CSISA and is proving to be effective when it comes to relaying agricultural technology and information from centers of research and knowledge out to those who need them the most—farmers.



CSISA

Shortcut to South Asia's farmers

CSISA implemented this model to encourage faster dissemination of information to improve farm productivity and farmer income. It set up a network of 13 hubs (6 in Bangladesh, 5 in India, 1 each in Pakistan and Nepal) to serve farmers in the region. Each hub has a manager, an extension worker, and several field staff.

Led by Technical Working Groups, the hubs have a decentralized and localized decision-making process and they conduct workshops to identify, set, and implement technology targets and work plans tailor-made for their respective localities.

A hub's output reaches farmers through the spokes—partners with complementary stakes in the growth of the farming industry in their area. They include government research and extension agencies, nongovernment organizations (NGOs), private seed companies, manufacturers of farm equipment and supplies, farmers' organizations, banks, and local media. CSISA now has more than 350 partners.

The efficient and quick transfer of knowledge has created an engine for growth of the agricultural sector. CSISA has reached more than 150,000 farmers in South Asia, resulting in the transformation of rural households.

Sowing rice centers across Africa

As part of its 2011-20 Strategic Plan, AfricaRice is working with its partners across the continent to set up Rice Sector Development Hubs to concentrate research and development efforts, establish a critical mass, connect partners along the rice value chain, and facilitate the spread of innovations. The hubs are testing grounds for new rice technologies and follow a "reverse-research approach," that is, starting from the market.

The hubs bring together large groups of farmers (1,000–5,000) and partners from the whole rice value chain—input suppliers, seed producers, processors, millers, wholesalers, retailers, and consumers—to facilitate change.

Targeting an audience. Glazoué, an important rice zone in Benin, has been chosen as one of the country's rice hubs where research and development activities are conducted in collaboration with NARES, academic institutions, advanced research institutes, farmers' organizations, nongovernment organizations, and donors—for the benefit of African farmers, mostly small-scale producers, as well as the millions of African families who depend on rice for food.

Custom-made for farmers. Rice hubs are a knowledge-sharing and communication platform for linking farmers, agri-service businesses, the public and private sector, the scientific community, and other stakeholders in South Asia. Through rice hubs, such as those in Bangladesh (see map on opposite page), CSISA can deliver location-based information that accelerates the impact of agricultural investments across South Asia.

These represent key rice-growing environments and different market opportunities across African countries, and will be linked to major national or regional rice development efforts to speed up wider adoption of rice knowledge and technologies.

The geographic positioning of each hub is determined in national workshops convened by the national agricultural research and extension systems. By the end of 2012, national partners had identified 54 hubs in 19 West, Central, and East African countries.

Setting Africa's priorities

In 2012, as a first step, national scientists, extension workers, and NGOs identified the factors that limit rice productivity and quality through surveys conducted in the 19 countries with value-chain partners. They then tested and adapted innovations developed through GRiSP, Africa Rice Task Forces, and local innovations through participatory learning and action research with "first-generation" value-chain stakeholders.

The second generation gains access to the validated technologies, knowledge, and institutional arrangements via training of trainers (for capacity building), exchange visits, and video materials.

Once these mechanisms have validated the technologies, development partners will take the lessons and principles and make them available to the wider community served by the hubs and beyond to achieve development impact.

Cambodia's rice field of dreams

Development can take time, but change is definitely happening in Cambodia as it plans to produce 4 million tons of paddy surplus and export 1 million tons of milled rice. With support from the Australian government, the Cambodian Agricultural Value Chain (CAVAC) program was established by Australian partners, and works with the International Rice Research Institute (IRRI) in alignment with GRiSP and other institutes in Cambodia to help farmers maximize their productivity.

Cambodia has achieved a remarkable feat with its rice production. Just over a decade ago, its state of agriculture was nothing more than rubble from its civil war. Today, agriculture officials project that Cambodia could export 1 million tons of milled rice by 2015. But, this lofty target depends on the nation's ability to raise its rice productivity and maintain the flexibility of its rice production systems.

CAVAC, an initiative of the Australian Centre for International Agricultural Research, is a program in which Australian partners, including the Australian Government Overseas Aid Program, New South Wales Department of Primary Industries, and the University of South Australia, are working with IRRI and Cambodian institutes to help farmers maximize their cropping opportunities and help the country meet its production target. The program zeroes in on Takeo, Kampong Thom, and Kampot provinces, where rice is the main source of subsistence, although farmers also trade rice locally.

Breaking new grounds. Cambodia is working through GRiSP in making its rice sector more productive through better farming technologies such as the use of laser leveling. Laser leveling reduces the cost of irrigation and improves crop establishment of dry-seeded rice.

M. Gummert, IRRI

Revising the rice calendar

Rice is mainly grown in Cambodia from June to December as the monsoon rains set in, according to David Johnson, who leads IRRI activities on crop establishment. "There are opportunities, though, to establish the rice crop earlier with direct seeding rather than transplanting, and as a dry-season crop after the rains," he said. Further productivity can be realized by the use of short-duration varieties that mature within 110–120 days.

"We established field trials to test short-duration varieties so that farmers could grow rice at least twice a year," explained Dr. Johnson. "As part of the bigger initiative that Australia is funding, they're also supporting an IRRI rice breeder at the Cambodian Agricultural Research and Development Institute who is helping develop short-duration rice varieties."

Other institutes are also taking active roles in transforming Cambodia's rice sector. The Royal University of Agriculture will train the next generation of rice farmers

A sign of things to come. Cambodia's rice fields may produce 4 million tons of surplus grain and the country has plans to export 1 million tons of milled rice by 2015.

while the Rice Department of the General Directorate of Agriculture will be responsible for rice crop extension.

Another alternative is to use different methods of establishing the rice crop. "We have systems of mechanization for wet and dry direct seeding that take place at different times of the year, so we currently have three different establishment options for farmers," Dr. Johnson continued.

"Dry seeding as we come out of the dry season and before the main rains really start, and wet seeding after the rains have passed and as the floods start to recede. In the middle of the rainy season, transplanting can be done.

"As the 'windows of operation' can be quite narrow, we're looking at how machines can help farmers get their rice crop planted on time so they can schedule three crops a year to maximize productivity," Dr. Johnson concluded.

Laser beam farming

Laser leveling is the process of leveling the land surface using a laser transmitter and a "drag bucket" that farmers use to move soil from one area to another. Compared with traditional methods, laser leveling is a better way of making the field surface uniformly flat.

"Laser leveling reduces the cost of irrigation because less water is needed to flood the field for efficient weed control," said Martin Gummert, IRRI's postharvest and machinery expert. "And, it results in better crop establishment when using direct seeding, which also translates to a better harvest."

Using one laser land leveler that IRRI provided to the Department of Agricultural Machinery and another one from CAVAC, 30 hectares of farm fields in Kampot were leveled in 2012.

"The technology that we introduced is also included in a 5-hectare demonstration rice farm at Don Bosco School in Battambang, and in other national programs with funding from the Cambodian government and foreign partners," Engr. Gummert said.

Mr. Chan Saruth, director of the Department of Agricultural Engineering, General Directorate of Agriculture, Ministry of Agriculture, Forestry, and Fisheries in Cambodia, reported the effect of laser leveling on rice productivity. "After farmers harvested their rice, they had their rice fields laser leveled as part of a demonstration we organized in 2012," he said. "As a result, we noted rice yields increased significantly by 20% to 30%."

Oliver Moeckli ©

Beyond the "good old times"

In 2010, the Second Africa Rice Congress supported the re-establishment of a research collaboration mechanism that served West Africa well in the 1990s and early 2000s. GRiSP partner Africa Rice Center (AfricaRice) has taken the reins in re-animating the Rice Task Forces throughout the continent.

In 1991, WARDA (now AfricaRice) and its partners in the national agricultural research and extension systems (NARES) initiated Rice Task Forces—a research partnership mechanism for collaboration, sharing of resources, capacity building, and development of critical mass for research.

How it works

The essential premise of the new Task Forces is that they bring together AfricaRice/GRiSP and NARES from all over Africa in a partnership based on principles of sustainability and building critical mass.

"There are four key elements to achieving impact from GRiSP research for development in Africa," says AfricaRice deputy director general Marco Wopereis. "First, we need to rebuild critical mass in rice research in Africa—this is what we do through our Africa-wide Rice Task Forces." This is crucial on a continent where specialist researchers are few and far between. For example, there may be just one rice agronomist in a particular country, with the risk that they become isolated and out of touch with what is going on elsewhere on the continent and beyond.

Attaining critical mass is not only a matter of pooling resources but also re-building human capacity through short training courses on specific topics, degree training, and training of trainers. "In the Breeding Task Force, we found a disconnect between thesis research and the real problems that breeders should be addressing in their home countries," says Rice Breeding Task Force coordinator Moussa Sié. "I believe that a solution to this would be to offer sandwich courses in which the students spend as much time at their home institution tackling real-life concerns as they do at the university learning the principles and methods."

This ties in with Dr. Wopereis's next point: "We need to ensure that these researchers are connected with the real rice world (avoiding 'scientific islands')." Consequently, Task Force activities are, as much as possible, integrated into and conducted in the Rice Sector Development Hubs in a value-chain context.

"Through our work in the hubs, we also concentrate our efforts in certain geographic areas while covering the whole rice value chain. And, last but not least, we need to communicate what we are doing to learn from our successes and failures," Dr. Wopereis says.

This requires working in well-defined partnerships with clear roles and responsibilities. The Africa-wide Rice Task Forces are aligned with the main thematic areas of GRiSP, and can therefore leverage knowledge from other continents and from within Africa. They also serve as on-the-job training grounds for young scientists.

Variations on a theme

By March 2013, there will be a full complement of Africa-wide Rice Task Forces covering breeding, agronomy, processing and value addition, mechanization, policy, and gender. The six task forces are all interconnected and share the same basic modus operandi, but each is a variation on the theme.

For example, the Rice Agronomy Task Force works with farmers to develop baskets of good agricultural practices and evaluates varieties from the Rice Breeding Task Force or a piece of new equipment, such as a rotary weeder developed by the Rice Mechanization Task Force.

"More than in the past, researchers in task forces work on large 'overarching themes,' using common methodologies and approaches, instead of discrete projects," says Dr. Wopereis. "That will enable powerful cross-country comparisons and enable much faster transfer of ideas and technologies from one country or region to another. The other difference is that we are now concentrating and integrating the work of Task Forces in well-defined geographic areas, the hubs. This will allow us to work in a much more systematic manner towards outcome and impact."

Women of force. Women in Ndour Ndour, Senegal, discuss a resource map they generated as part of the Gender Task Force climate change study,

R.A. Agboh-Noameshie, AfricaRice

Name that weed!


D. Makokha, AfricaRice

To advise farmers on how to deal with weed problems in their fields, extension agents, lead farmers, and other change agents operating in sub-Saharan Africa first need to be comfortable with identifying such weeds. GRiSP partners Centre de coopération internationale en recherche agronomique pour le développement (CIRAD) and Africa Rice Center (AfricaRice) therefore developed software to help identify almost 200 of the commonest weeds of rice in Africa—online, off-line, or via a smartphone or tablet.

Ask African rice farmers what problems they face and the chances are that weeds will be near the top of the list. According to GRiSP surveys conducted across 20 African countries, farmers see weeds as the most serious problem in rice production on the continent. In sub-Saharan Africa, annual rice production losses caused by weeds are estimated to reach at least 2.2 million tons. This is equal to about 10 million hectares of rice annually, according to AfricaRice.

Identity crisis

Farmers usually have local names for their most common weeds, including names of well-known personalities from everyday life. In some French-speaking countries, the worst weeds are simply referred to as "Sida," which is French for AIDS, the dreaded human disease.

Local names allow farmers to communicate about weeds and weed management within a community, but a more formal identification is needed to mobilize knowledge from outside the community on a specific weed or group of weeds.

The project *African weeds of rice* (AFROweeds)—implemented by CIRAD and AfricaRice, and led by CIRAD weed scientist Thomas Le Bourgeois—brought together the information available in West and East Africa and Europe to establish a comprehensive online tool (AFROweeds Identikit) and knowledge base for identifying and managing weeds in rice in Africa.

Weeding out guesswork

"The identification tool works very differently from a classical botanical key; it is much more user-friendly, as it does not require the user to be an expert in botany," explains AfricaRice weed scientist Jonne Rodenburg. "The user selects the most eye-catching characteristics of the plant to be identified and indicates in pictorial multiple-choice menus what the character looks like."

The Identikit progressively narrows down the number of possible species with each choice. The user can review the results at any moment. Clicking on the species names in the list of likely fits accesses species' pages from the database with information on ecology, biology, and distribution. Users can also compare the plant being examined with field and herbarium photos.

"Weed identification can be helpful in choosing the best management strategy," explains Dr. Rodenburg. "The database linked to the tool also provides information on effective management. Sometimes this is species specific, but often the advice is meant for a group of species such as grasses, sedges, or annual species."

The weed identification tool is available for free online (at www.afroweeds.org/idao/) and has been adapted for smartphones, tablet computers, and other mobile devices. Tablets preloaded with the app were distributed to participants of the AFROweeds project closing workshop.

"We expect to receive feedback from users on the tool's functionalities and usefulness, in order to further improve it," explains Dr. Pierre Grard, CIRAD botanist/computer scientist, who was in charge of the development of the Identikit.

Facebook for weeds

Apart from the tool, the AfricaRice–CIRAD team established an open-access online African weed science network called *Weedsbook* (at www.afroweeds.org/network). "This online network enables students, lecturers, extension workers, and researchers to exchange information on all aspects of weed science, from identification to management," explains Dr. Rodenburg. "It is comparable to social networks like Facebook, but with a professional objective dedicated to weeds."

Farmers will eventually benefit from these investments through interaction with better-informed change agents. Use of the Identikit will allow them to discover the real identity of particularly obnoxious weeds on Africa's rice farms, known without doubt by many farmers under a wide range of local names.

J. Rodenburg, AfricaRice

A new breed of breeders

In 2012, GRiSP partners across both the public and private sector provided advanced biotechnology training in a concerted international effort to improve the skills of rice breeders in developing countries with the most modern breeding methods. The result? New breeders from across the rice-growing world now have the expertise to develop new rice varieties, with traits of use and value to their local rice sector, which was not possible through conventional breeding methods.

Rice is the first food crop for which the complete genome sequence is available to researchers all over the globe. The completed genetic map of rice is a key tool for plant breeders, but it requires highly specialized skills in biotechnology to convert the knowledge into a new rice variety.

Although biotechnology breeding approaches have the potential to be used to develop unique rice with beneficial traits, the technology has not been widely deployed for the benefit of developing countries. The lack of skilled researchers in these countries has prevented biotechnology from being fully integrated into their breeding programs.


R. Raman, AfricaRice

Improving the breeder. Dr. Mounirou Sow from Niger, a breeder trained in biotechnology, is helping national researchers in other African countries to apply molecular biology techniques.

Breaking the biotech barrier

It was a proud moment for three students from West Africa participating in their PhD graduation ceremony at the University of KwaZulu-Natal, Pietermaritzburg, South Africa.

Mounirou El-Hassimi Sow of Niger, Honoré Kam of Burkina Faso, and Kouadio Nasser Yao of Côte d'Ivoire all had worked in the biotechnology laboratory of Africa Rice Center (AfricaRice) in Benin, under the supervision of Marie-Noelle Ndjiondjop. Their sense of pride was shared by Gustave Djedatin from Benin, who successfully defended his PhD thesis in front of an international panel of scientists at the University of Abomey-Calavi in Benin.

"These students have each made major contributions to global knowledge of rice in Africa," declared Prof. Mark Laing, director, African Centre for Crop Improvement at the University of KwaZulu-Natal. "They are also keen to apply their newly acquired skills in their respective countries."

Their doctoral research was supported through a USAID-funded AfricaRice project on the application of marker-assisted selection (MAS)—a method to help breeders incorporate useful genes and their associated traits into new rice varieties.

Their aim was to find solutions to rice yellow mottle virus (RYMV) infection and two other devastating rice pests and diseases. African rice gall midge and bacterial leaf blight. As part of their studies, the students traveled thousands of kilometers by motorcycle and boat to interview rice farmers and collect their local varieties. Mounirou, for instance, collected about 270 local rice varieties, many of which face extinction. These varieties were then characterized through field trials and DNA profiles for use as parental material in breeding for RYMV resistance.

The making of a work force

In rice breeding, the efficiency of MAS to transfer major rice genes is now widely recognized as it offers rice breeders a better opportunity to develop varieties that are resistant to diseases and pests and tolerant of abiotic stresses such as drought and salinity.

However, many developing countries lack adequate local research capacity in this area. In response to a strong demand from its member countries, AfricaRice is progressively helping develop a work force of national researchers trained to apply molecular biology techniques critical to solving agricultural problems.

For Dr. Ndjiondjop, the overall strategy is to advance Africa toward the concept of "modern breeders" to efficiently exploit this potential for food security in Africa.

AfricaRice has also trained more than 60 NARES researchers, including PhD and MSc students from Africa, in molecular breeding.

This training of rice breeders in MAS and other modern biotechnology techniques to improve breeding is part of a bigger global effort by GRiSP partners to improve biotechnology skills of rice researchers within developing countries.

Transforming rice scientists

In 2012, the International Rice Research Institute (IRRI) in the Philippines conducted the Advanced Indica Rice Transformation Course—the first time the Institute provided training on the genetic modification of rice. Indica, the rice most produced in South and Southeast Asia, is a broad group of many different types of rice that are usually grown in hot climates.

Nine public- and private-sector participants from across a mix of different GRiSP partners from China, Colombia, India, Indonesia, Nepal, the Philippines, and the U.S. attended the training. They had hands-on experience and learned about biosafety issues and international guidelines for biosafety management in research.

"After this training, I'm hoping that I will be able to put some genes into rice plants and especially in indica varieties, which are more susceptible to drought and nematodes," said Ms. Ritushree Jain, an Indian national who is doing her PhD at the University of Leeds in the UK. "A lot of rice cultivation is affected by drought, and nematode infestation, and this is a big problem.

"My hope is that I will be able to find some genes to integrate into Indian rice varieties and develop something new that will help farmers," she added.

IRRI

Mastering a new skill. Participants in the Advanced Indica Rice Transformation Course learn rice improvement techniques not possible through conventional breeding in IRRI's Genetic Transformation Laboratory.

Building the foundation of rice science

GRiSP partners provide young scientists with scholarships in the various fields of rice science. But, more than higher education, the ultimate goal is to develop the next generation of leaders, movers, and shakers who will face the tough challenge of fighting poverty, combating hunger, and fueling rice productivity growth in the future.

The increasing cost of a college education and the dramatic decline in the number of students enrolling in agriculture programs will affect how the world meets the challenges to food security brought about by continuous population growth, the degradation and growing scarcity of natural resources, and climate change. Empowering young people to become catalysts of change can help solve many of these problems.

The Global Rice Science Scholarship initiated by GRiSP aims to increase technical and research capacity globally in tackling the major and current problems in rice production. These scholarships offer young agricultural scientists a tremendous opportunity to develop and lead in their field of expertise related to agronomy, crop physiology, entomology, plant pathology, soil and water science, plant breeding, and social sciences.

Under GRiSP, the hosting institutions of IRRI, Africa Rice, CIAT, CIRAD, and IRD have been provided with funding to support 31 scholars from Asia (17), Africa (9), South America (4), and Europe (1).

Return on investment

Investing in brilliant young students can return great benefits, not only to the students but also to the entire rice sector.

IRD-CIRAD PhD scholar Phung Thi Phuong Nhung started her project in 2011 on identifying new genes and alleles associated with root developmental traits in a core collection of Vietnamese rice varieties. She has recently identified 214 varieties collected and grouped them based on their root system.

"I feel very lucky to have been chosen as a scholar," she says. "This allowed me to finish my data collection."

Ms. Nhung's work is important because water scarcity for rice production is an imminent threat due to climate change. By 2025, it is estimated that 15–20 million hectares of irrigated rice will suffer some degree of water scarcity and her findings could very well be part of the solution.

Strong leadership at every level is critical to rice science if it wants to continue making a valuable contribution to global food security. In partnership with the University of Leuven in Belgium, IRRI launched a pilot program designed to create future leaders and innovators in 2012. A total of 23 participants were selected from Asia (17), Africa (4), and South America (2).

The course on Enhancing Global Rice Science Leadership was directed toward improving the impact of knowledge from research organizations, particularly targeting the poorest areas of Asia and Africa, by ensuring improved skills and competencies in research leadership. It included personality development and enhancement of technical skills for project management and leadership, an Action Learning Project in the participants' own environment, and a period of reflection and further learning.

As a PhD scholar of CIAT and the University of Melbourne, Laura Moreno of Colombia says that the course gave her "the incredible opportunity to get in touch with many future leaders from different cultures and visit rice farmers and understand the problems that affect their lives." She adds that the course taught her self-organization and time management that she has put into practice during her studies.

IRRI Training Center Head Noel Magor shares that the course helped equip young scientists with knowledge, skills, competencies, and confidence to better define, manage, and communicate research and perform their leadership roles.

Open classrooms. GRiSP scholars embark on a "learning journey" to interview farmers in Rizal, a province in the Philippines, as part of their training to develop their technical skills for project management and leadership.

Earth-cooling technology

The alternate-wetting-and-drying (AWD) technology developed by the International Rice Research Institute (IRRI), a GRiSP partner, not only saves water in rice fields but also helps reduce agriculture's methane emissions. Now, farmers applying this simple and inexpensive technology could potentially earn extra income from the carbon credit market.

The fact that rice usually grows in a field flooded with water makes rice farming a source of the potent greenhouse gas (GHG) methane. When rice fields are flooded, the layer of water prevents oxygen from the atmosphere from penetrating the soil. In the absence of oxygen, organisms known as methanogenic bacteria thrive and decompose organic matter in the soil. This biological process produces methane gas, which escapes to the atmosphere through different ways, one of which is through the rice plant.

Globally, this type of rice production accounts for 10% to 14% of the total methane emissions through human activity. The key to reducing methane generation by rice cultivation is better water management practices.

Extra credit for being clean. Flux chambers are used to measure GHG emissions on an experimental station in Vietnam. Through AWD technology, farmers can reduce the carbon footprint of rice farming and earn carbon credits.

Bjoern Ole Sander

Farmer-friendly technology

This is where water-saving technologies, such as AWD technology, come in. AWD was developed and validated by IRRI and its national agricultural research and extension system partners in Asia in response to increasing water scarcity.

Simple and inexpensive, AWD technology allows rice farmers to dry their fields for a certain number of days after ponded water has disappeared. It is also highly suited for irrigated rice-based systems, which account for 75% of global rice production.

"AWD could reduce water use by as much as 30%, while maintaining yield at the level of that of flooded rice," says Dr. Ruben Lampayan, IRRI water scientist. "This technology has been adopted and widely promoted in Vietnam, Bangladesh, Indonesia, and the Philippines."

Cleaner farming

AWD technology also has the potential to reduce methane emissions from rice fields by more than 50%, depending on soil type and weather. In 2012, the United Nations Framework Convention on Climate Change (UNFCCC) included the AWD technology as part of a certified Clean Development Mechanism (CDM) methodology. This methodology can now be used in CDM projects under which carbon credits can be claimed for applying water-saving techniques in rice production. Carbon credits were introduced in the Kyoto Protocol as a means for climate-friendly development.

"According to the CDM methodology, a rice farmer practicing AWD could get carbon credits for approximately 4 tons of carbon dioxide equivalents per hectare per season from a certified CDM project, and these credits could then be sold on international carbon markets," explains Bjoern Ole Sander, a climate change scientist at IRRI.

Green incentive

Farmers can take advantage of the carbon credits earned from adopting AWD technology. An agriculture-related organization can help local farmers draw up working plans for a CDM project or offer the additional input required to make a project financially viable for local farmers. "For example, an agency that manages the irrigation system where farmers pay a service fee can be the project developer," adds Dr. Sander. "The money from the carbon credits they sell could be used to subsidize the cost of pumping irrigation water or improve irrigation facilities."

GRiSP provided additional funds to support the dissemination of AWD technology throughout the Philippines, Vietnam, Laos, Indonesia, and Bangladesh. Through GRiSP, Drs. Lampayan and Sander were able to work with other research and extension institutions for cleaner, more efficient rice production while improving farmers' livelihood and food security.

A new eye on Africa: putting rice on the map

Rice is the most rapidly growing food source in Africa. But, although the continent's rice production is expanding rapidly, not much information is available to boost Africa's rice productivity. To help fill this information gap, GRiSP partners Africa Rice Center (AfricaRice) and the International Rice Research Institute (IRRI) are taking to the sky to see what's really happening on the ground.

Rice is a staple in many African countries. However, Africa's rice sector relies heavily on imports to satisfy the increasing demand for rice because the potential of local production remains largely untapped.

Unlike Asia, Africa still has a large reservoir of underused agricultural land and water resources, according to AfricaRice. Yet, Asia continues to enjoy higher rice productivity because most of Africa's production increase has come from area expansion rather than intensification. These increases are not keeping pace with demand. Reducing reliance on imports and increasing production sustainably are therefore major goals of any food security strategy in Africa.

NASA

Knowledge gaps across Africa

AfricaRice and its partners have set up task forces across the continent, which will operate under GRiSP, to accelerate the delivery of new rice technologies. The task forces will focus their research and development efforts on breeding, agronomy, postharvest, and value addition, as well as policy and gender, in 59 rice-sector development hub locations in 20 countries. The hubs will require accurate and up-to-date spatial information on where and how rice is currently being cultivated, and the areas most suitable for future production expansion. The mapping of rice in Africa will contribute to the successful dissemination of the technologies demonstrated in the hubs to the farmers.

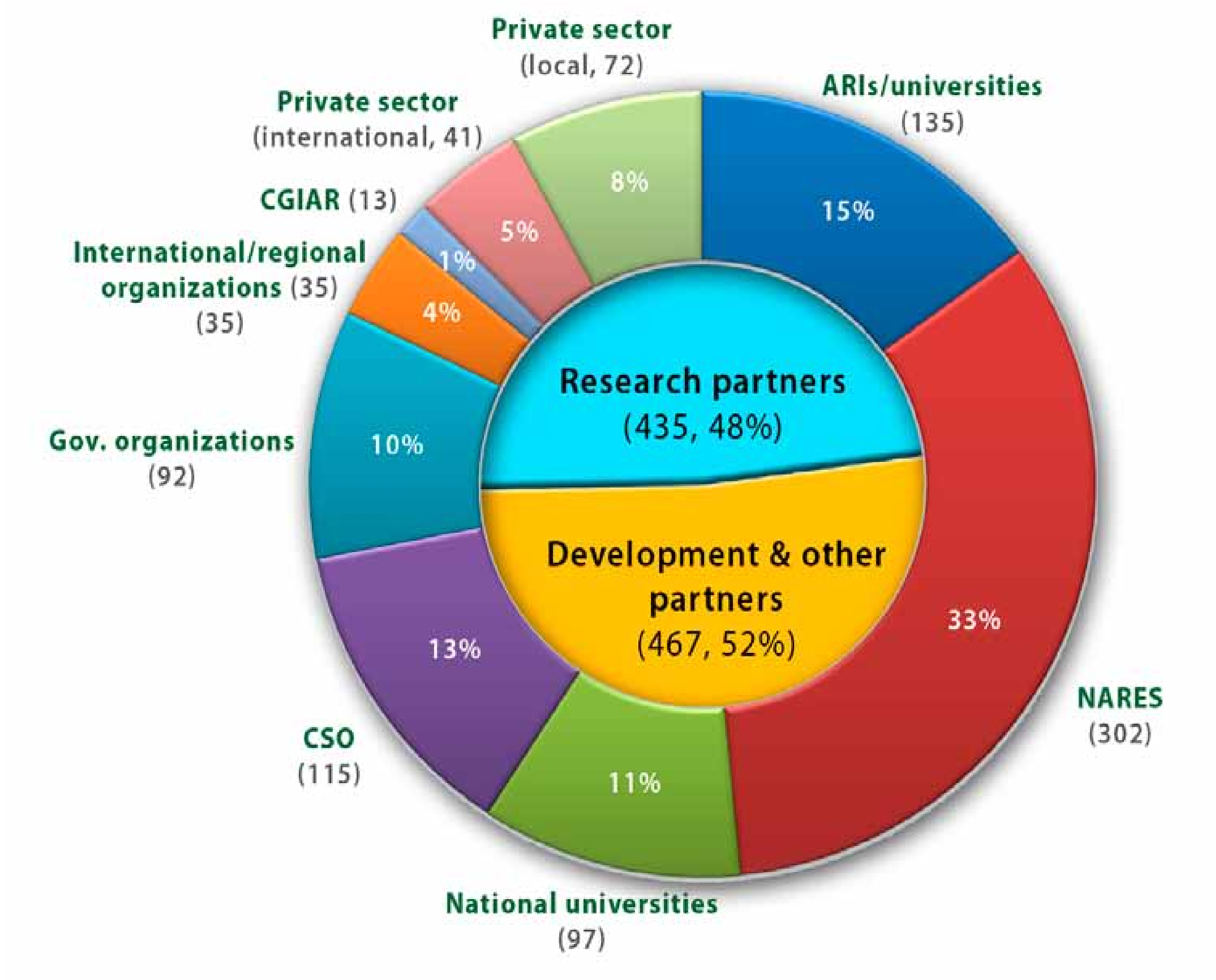
"There is a large body of work on mapping and monitoring rice environments in Asia," said Dr. Andy Nelson, head of the GIS group at IRRI that develops spatial information on rice across Asia for mapping rice areas, their cropping patterns, and their social and environmental characteristics. "But there has been little work to assess how much of this can be translated and applied to African conditions. The rapid growth in rice production and consumption and the lack of information on where this is occurring and the impact that this growth is having both suggest that such an assessment is overdue."

Re-mapping of Africa

Using partnership development funds from GRiSP, AfricaRice and IRRI co-organized an expert meeting on rice mapping for Africa to review the applicability of rice-mapping methods developed and validated in Asia for African conditions.

One of the conclusions of the meeting was that mapping methods used in Asia are not universally applicable to Africa, which has more fragmented rice cultivation across landscapes, smaller fields, heterogeneous growing seasons, and rice environments not commonly found in Asia. The expert meeting proposed to test a number of promising methods at selected sites in 2013 and 2014 and thus combine the rice mapping knowledge accrued in Asia and Europe with the knowledge of African conditions to develop a methodology tailored to African rice environments.

"The goal of the project is to develop and implement a framework to monitor rice production in the AfricaRice rice-sector development hubs using radar remote-sensing methodology," said Dr. Sander Zwart, remote-sensing and GIS specialist at AfricaRice. "Rice maps and statistics will be essential to monitor and evaluate the impact of our rice research and development activities with our national partners."



Number and type of GRiSP partners as of September 2010; the inner circle provides a breakdown by partner roles (research vs. boundary partners). The outer circle provides a classification by organizational categories. About 48% of the GRiSP partners mainly play a role as research partners, whereas 47% are mainly development partners and 5% are other boundary partners.

GRiSP's Mission

GRiSP's mission is to reduce poverty and hunger, improve human health and nutrition, reduce the environmental footprint, and enhance the ecosystem resilience of rice production systems through high-quality international rice research, partnership, and leadership.

Objectives

1: To increase rice productivity and value for the poor in the context of a changing climate through accelerated demand-driven development of improved varieties and other technologies along the value chain.

2: To foster more sustainable rice-based production systems that use natural resources more efficiently, are adapted to climate change and are ecologically resilient, and have reduced environmental externalities.

3: To improve the efficiency and equity of the rice sector through better and more accessible information, improved agricultural development and research policies, and strengthened delivery mechanisms.

Global research themes

1: Harnessing genetic diversity to chart new productivity, quality, and health horizons.

2: Accelerating the development, delivery, and adoption of improved rice varieties.

3: Ecologically and sustainably managing rice-based production systems.

4: Extracting more value from rice harvests through improved quality, processing, market systems, and new products.

5: Enhancing impact through technology evaluations, targeting, and policy options.

6: Supporting the growth of the global rice sector.

CGIAR

Research Program on Rice
Global Rice Science Partnership

CGIAR is a global research partnership for a food-secure future. Its science is carried out by the 15 research centers of the CGIAR consortium in collaboration with hundreds of partner organizations.

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