TRENDS IN GLOBAL RICE RESEARCH

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ABSTRACT

Rice farming has an annual value of over $150 billion, and directly or indirectly affects over 2 billion people who either depend on rice as their food staple or are involved in the production or processing of it. Rice provides 20% of the world's food calories. Some 400 million chronically hungry people depend on rice for their livelihood. Rice is also rapidly rising in its importance as a food staple in Africa and Latin America.

Changing environmental, economic, demographic and social landscapes will change the way rice will be grown in the future, towards eco-efficient production systems, including diversified cropping systems and value chains. This will require innovations derived from strategic, increased R&D investments. It will also require a transformation of the agricultural research and extension systems to ensure that these innovations are what farmers and others in the value chain need, and to get them to these users faster.

This paper will provide an overview of global priorities for rice research and examples of recent innovations and developments to better serve the needs of rice producers and consumers, and also make major contributions to the world's pressing environmental and social issues. The Global Rice Science Partnership (GRiSP, www.grisp.net) provides a new strategy and work plan for global rice research through which hundreds of R&D partners can contribute more effectively to solving development challenges - regionally, nationally, and locally. GRiSP also provides new opportunities for Japanese rice researchers to participate in international research or lead that research in key areas, and thus also benefit for addressing high-priority challenges in Japan.

KEYWORDS

rice, research, GRiSP

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INTERNATIONAL RICE RESEARCH INSTITUTE

Trends in Global Rice Research

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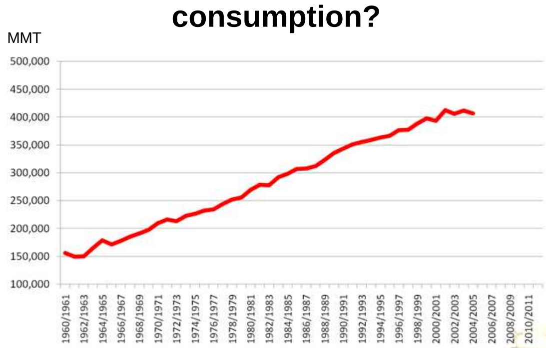
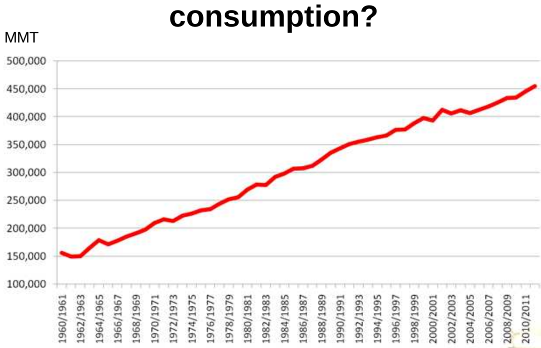
Rice Science for a Better World

Slowdown in global rice consumption?



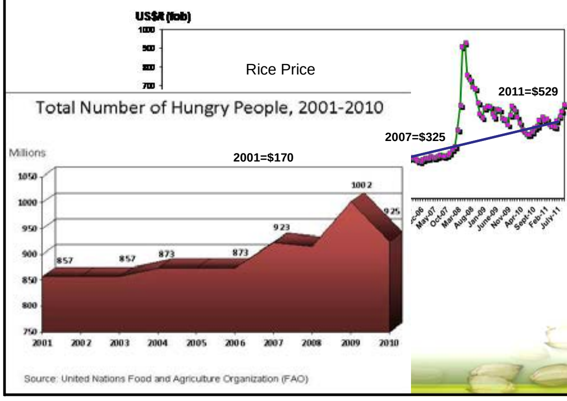
IRRI

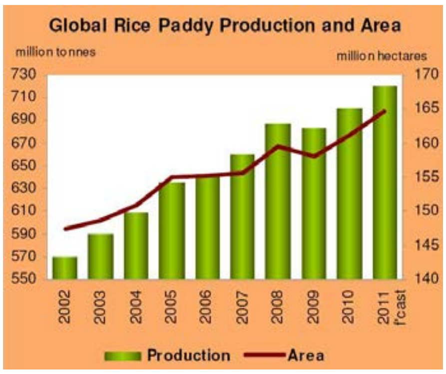
Slowdown in global rice consumption?



IRRI

Paddy & poverty go together





Yield growth remains too slow.

FAO Rice Market Monitor, 11/2011

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Future rice needs

Rice demand:

- 2035: 116 million t milled rice/yr more than in 2010

Rice supply:

- In each of the next 10 years produce at least 8 million t rice more (rough rice)
- Yield growth: 1.2-1.5% until 2020 (+0.6 t/ha total)
  1.0-1.2% after 2020

Change how we grow rice:

- Adapt to climate change
- Less tillage, water, labor, pesticides; more efficient fertilizer use
- More resilient, diversified rice-based farming systems
- Added value, new products from rice and by-products

Smarter people who implement these changes

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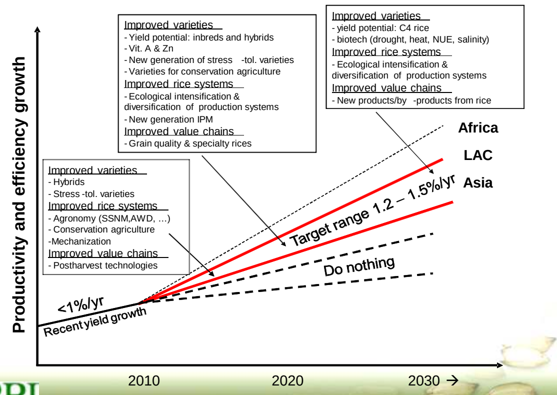
Six megatrends in agriculture

- Productivity increase: land, labor, water, fertilizer, energy
- Skillful, precise agriculture – more control over the environment and higher value
- Integration of value chains towards consumer-driven, transparent agriculture
- Connection to health – Good Agricultural Practices
- Meet multiple objectives
- Interactive knowledge: global/regional/national science - industry – policy networks

R. Rabbinge, WUR

IRRI

Pipeline of R&D innovations



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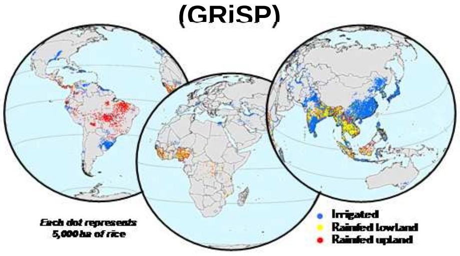
CGIAR Research Program (CRP) 3.3.

CGIAR

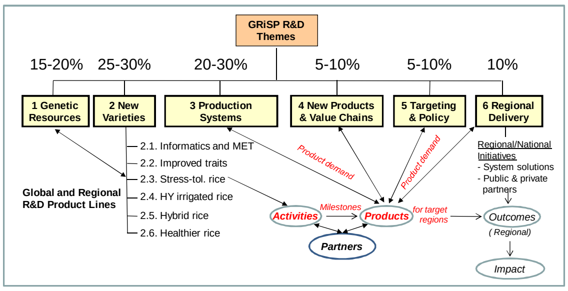
Global Rice Science Partnership (GRiSP)



An evolving alliance of IRRI, AfricaRice & CIAT with Cirad, IRD, JIRCAS and ~900 research and development partners worldwide

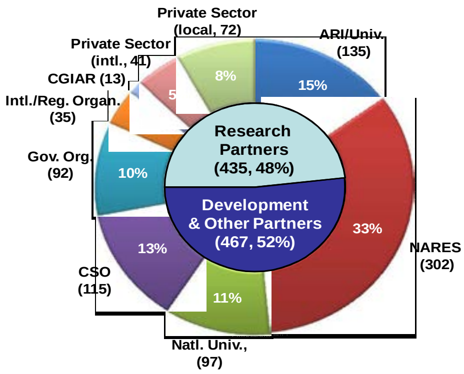
IRRI AfricaRice CIAT

GRiSP Approach



- 5-yr work and business plan: 2011-2015
- Interdisciplinary, product-oriented R&D: 94 R&D Products clustered in 26 Product lines under 6 Themes
- New frontiers research
- Science capacity building

IRRI



Over 900 R&D partners worldwide

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www.grisp.net

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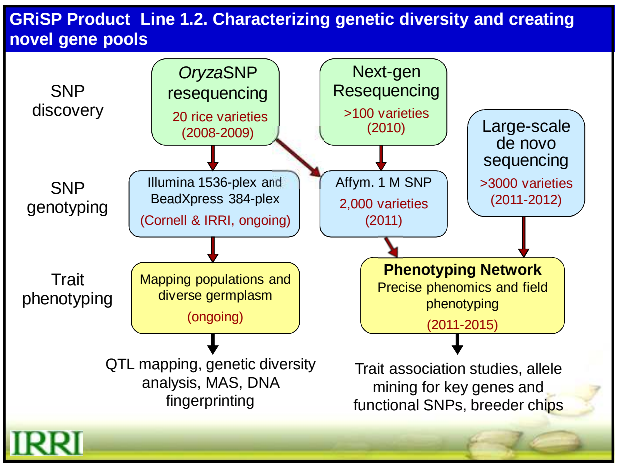
GRiSP Product Line 1.2. Characterizing genetic diversity and creating novel gene pools
SNP discovery
SNP genotyping
Trait phenotyping
OryzaSNP resequencing
20 rice varieties (2008-2009)
Next-gen Resequencing
>100 varieties (2010)
Large-scale de novo sequencing
>3000 varieties (2011-2012)
Illumina 1536-plex and BeadXpress 384-plex
(Cornell & IRRI, ongoing)
Affym. 1 M SNP
2,000 varieties (2011)
Mapping populations and diverse germplasm
(ongoing)
Phenotyping Network
Precise phenomics and field phenotyping
(2011-2015)
QTL mapping, genetic diversity analysis, MAS, DNA fingerprinting
Trait association studies, allele mining for key genes and functional SNPs, breeder chips
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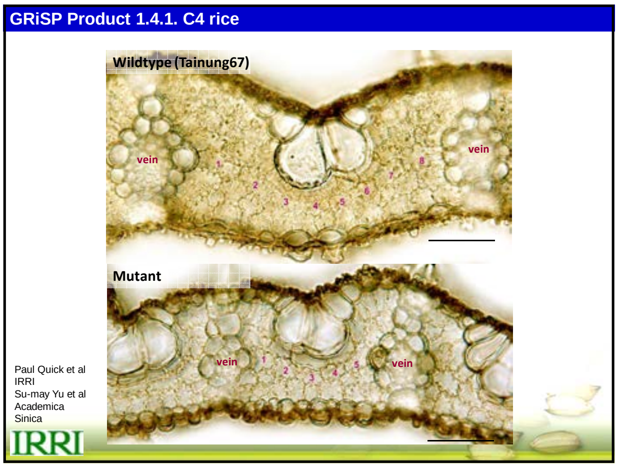
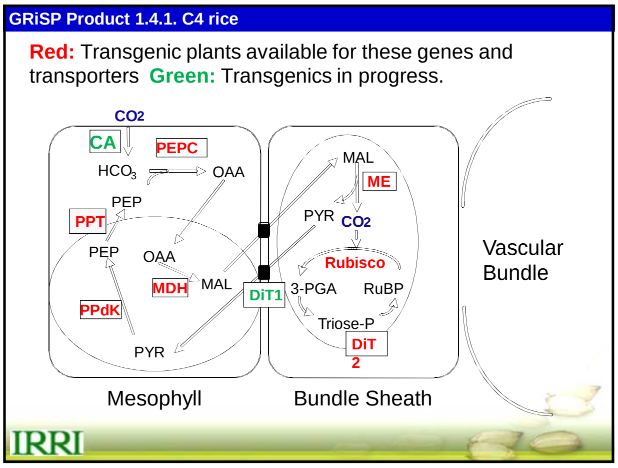
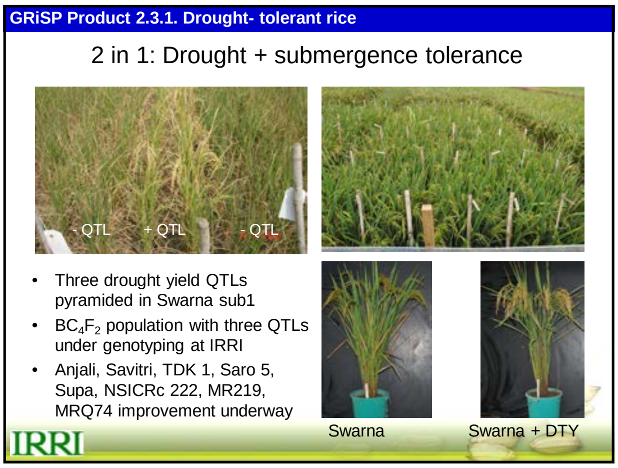
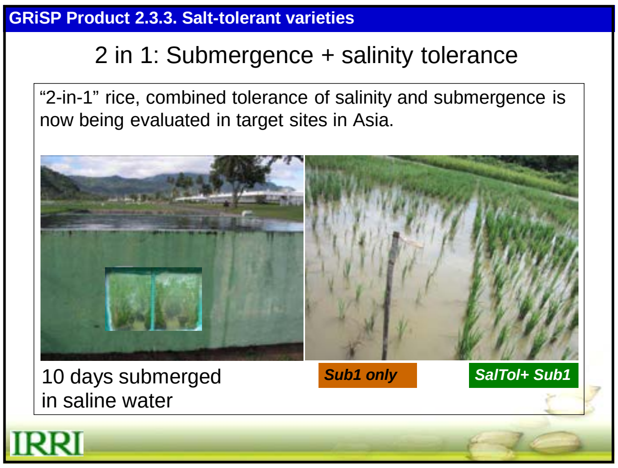
GRiSP Product 1.2.4. Specialized genetic stocks and novel populations
Indica MAGIC
Global MAGIC: indica x japonica S1 lines
IRRI


GRiSP Product 1.4.1. C4 rice
Wildtype (Tainung67)
vein
vein
Mutant
vein
vein
Paul Quick et al
IRRI
Su-may Yu et al
Academica
Sinica
IRRI


GRiSP Product 1.4.1. C4 rice
Red: Transgenic plants available for these genes and transporters Green: Transgenics in progress.
CO2
CA
PEPC
HCO3
OAA
PEP
PPT
PEP
OAA
MDH
MAL
PPdK
PYR
MAL
ME
PYR
CO2
Rubisco
DiT1
3-PGA
RuBP
Triose-P
DiT 2
Vascular Bundle
Mesophyll
Bundle Sheath
IRRI


GRiSP Product 2.3.1. Drought- tolerant rice
2 in 1: Drought + submergence tolerance
- QTL
+ QTL
- QTL
Three drought yield QTLs pyramided in Swarna sub1
BC4F2 population with three QTLs under genotyping at IRRI
Anjali, Savitri, TDK 1, Saro 5, Supa, NSICRc 222, MR219, MRQ74 improvement underway
Swarna
Swarna + DTY
IRRI


GRiSP Product 2.3.3. Salt-tolerant varieties
2 in 1: Submergence + salinity tolerance
"2-in-1" rice, combined tolerance of salinity and submergence is now being evaluated in target sites in Asia.
10 days submerged in saline water
Sub1 only
SalTol+ Sub1
IRRI

GRiSP Product 4.3.1. Phenotyping platform and tools for evaluating quality and speciality traits

QTLs work in different grain shapes and germplasm classes

IR 60/6461
Long, bold
Not chalky

6993/6461
Medium,
chalky

93-11/6461
Medium bold
chalky

Teqing/6461
Short
chalky

Markers delivered soon

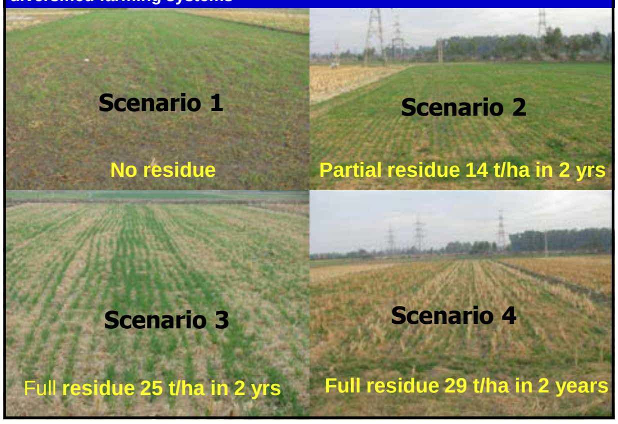
IRRI

Future rice-based cropping systems

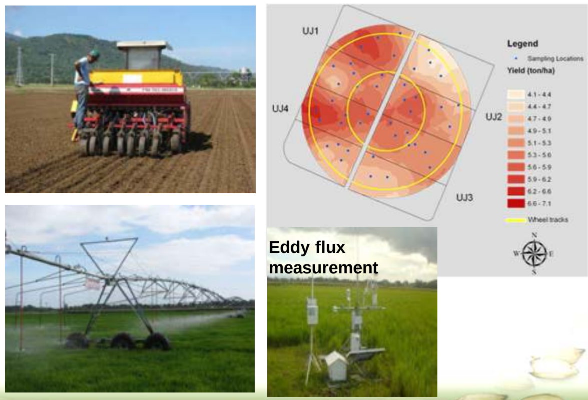
Tillage: Conventional | Reduced (Unpuddled) | Raised bed | Zero-tillage

Crop establishment: Transplant | Drum Seeding | Direct-drill-seeding

GRiSP Product Line 3.2. Resource-conserving technologies for diversified farming systems



GRiSP Product Lines 3.1. & 3.2. Future rice-based cropping systems



GRiSP Product Lines 3.1. & 3.2. Future rice-based cropping systems

	Conventional	Safe AWD	Aerobic rice
Land prep	Puddled	Puddled	Not puddled
Establishment	Transplant; wet seed	Transplant; wet seed	Dry seed
Water	Flooded; saturated	Saturated; mild drying	Drained
Soil aeration	Anaerobic	Anaerobic; mild drying	Aerobic
Water use	High	↓	↓↓
CH_4 emission	High	↓	↓↓
N_2O emission	Low	↑	↑↑
BNF	High	-- ?	↓
Soil N supply	High	-- ?	↓
P availability	High	--	↓
C storage	High	-- ?	↓

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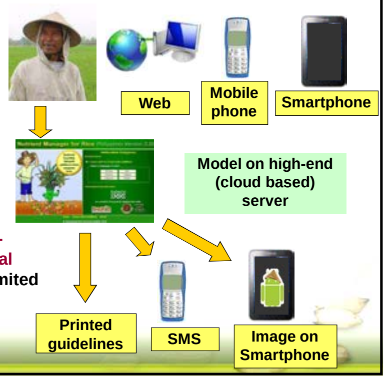
GRiSP Products 3.1.2. & 6.1.2. ICT tools for development

How to provide small-scale farmers with 'precision' management for their field?

1. Acquire information in local language for a specific field --- often less than 1 hectare
2. Compute field-specific guidelines
3. Provide customized field-specific guidelines in local language --- often with limited internet and infrequent contact with extension



IRRI

GRiSP Product 3.1.4. Integrated Good Agricultural Practices (GAP)

Sustainable Rice Platform (SRP)

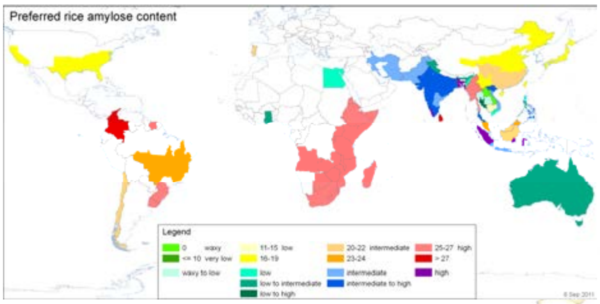
Ahold, adenvironment, AIT Asian Institute of Technology, CAPITAL RICE CO., LTD., iied, IRRI International Rice Research Institute, Kellogg's, Louis Dreyfus Commodities, UNEP, Nestlé, MARS, syngenta

- Newly created alliance to initiate a market transformation of irrigated rice production
- Set of site-specific targets related to yield, quality, food safety, greenhouse gas emissions and water quality
- Enhanced set of Good Agricultural Practices for resource efficiency and social welfare (GAP Plus)
- Develop BMPs to underpin GAP

IRRI

GRiSP Product 4.3.4. Market analysis and information for developing specialty rices and rice products

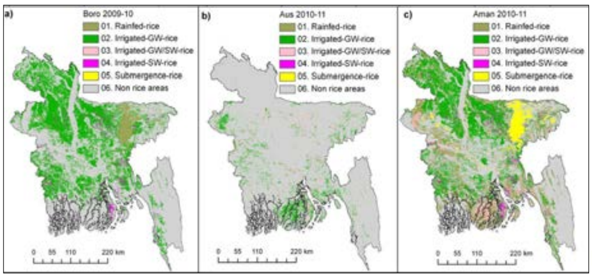
First maps of global grain quality preferences



IRRI

GRiSP Product 5.2.1. Seasonally updated information on rice agro-ecologies

Seasonal rice map of Bangladesh (2010-2011)



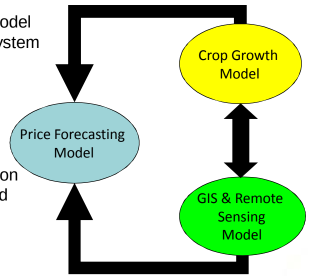
Boro rice: 5,011,631 ha | **Aus rice: 1,103,738 ha** | **Aman rice: 5,816,240 ha**

IRRI

GRiSP Product 5.3.1. Global rice monitoring and forecasting system

What it is and why we do it?

Three components
1 Global Rice Supply and Demand Model
2 Rice Monitoring and Forecasting System
3 Rice Database

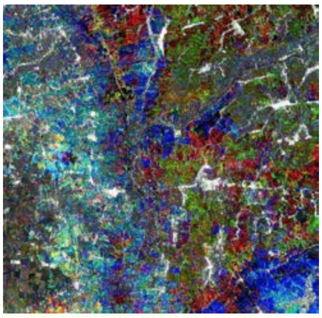


- Transparent and timely information on rice production – better planning and policies
- Crop insurance and crop loss assessments
- Delivered in a timely manner

IRRI

GRiSP Product 5.3.1. Global rice monitoring and forecasting system

Regular observations throughout the season show how much planting dates can vary over small distances



Color shows crop establishment

cyan late Dec to early Jan
blue mid-Jan
red & green still under land preparation in mid-Jan

The mapping component provides
- rice area estimates
- planting dates
- damage estimates (drought/flood)
- crop growth status

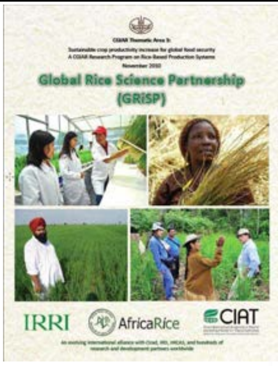
IRRI

Japan and GRiSP

- Strategic R&D partner for GRiSP – gain from global activities and contribute IP for wider international use
- Lead certain research areas for which Japan has a comparative advantage
- Capacity building (science and extension)
- Co-invest : align own R&D priorities and resources with GRiSP investments for greater synergy
- **Contribute globally – benefit nationally**

IRRI

"A US$ 20 investment in GRiSP will lift one person out of poverty."



http://www.grisp.net

IRRI

Achim Dobermann

I would like to start my presentation by first thanking our colleagues in JIRCAS and, in particular, President Masa Iwanaga for organizing this important and very interesting symposium at a very timely moment when it comes to talking about rice, rice research, and development.

I would also like to take this opportunity to thank the government of Japan for being a very strong and reliable supporter for international rice research and development for a long time and I would like to thank the entire Japanese rice science community for the tremendous discoveries and contributions that it has made over many decades.

I think it is fair to say that any scientist, anywhere in the world, who works on rice has one way or another in his or her career benefited from some knowledge, some discovery, and some information that originated from the excellent research done by many groups here in Japan. But we are here to talk about the future. I will only start this process by giving some general impressions and a few examples, but then other speakers will provide a lot more information, a lot more specific ideas and suggestions than I am able to cover in my talk.

Now, if we had come together about 10 years ago, people would have said it looks like global rice consumption is slowing down. You can see in Figure 1 that 7 to 9 years ago it looked like global consumption of rice was reaching a plateau, and people thought this was because consumers were shifting to other foods as economic development increased.

If we now add the past few years to this, we can see that this prediction, which at that time also included my own organization, IRRI, has not come true. We have accelerated the pace in global rice consumption and we are more or less following the linear rate of growth that we have had for most of the past 50 years. There are many reasons for this. I will not go into details, but the message is clear: rice in terms of direct food consumption by human beings is the most important staple food crop, and that will continue despite all kinds of socioeconomic changes in the foreseeable future.

Many discussions take place on what future rice demand will be and different projections exist, but they all depend on changes in global population growth and changes in consumer patterns, factors that are not easy to predict. The global rice equation for the past 50 years has been that, for every 1 billion people on Earth, we need to produce about 100 million tons of paddy more. That’s the fundamental food security equation for rice and at least for a while this is not going to change.

We have also all recognized that, in the past 10 years, rice prices have moved steadily upward. Even discounting the big spike that happened in early 2008, prices have come down since then, but they have never reached the low level that we had in 2001. What we have seen in recent years is increasing volatility in markets. Prices often fluctuate by $100 or sometimes even $200 per ton over relatively short time periods, which had not occurred in the years before. You can see an upswing in recent months again, and many different predictions exist.

The key point is that the time of cheap rice is over, at least for the near future. Those of us who work in developing countries also know that, when we have these fluctuations in rice prices, it is the poor people who are mostly affected. You can see how these trends move: the total number of hungry people worldwide, not just those eating rice, matches quite closely the price spikes in rice. This always happens with a slight delay.

Our own estimate is that, for about 580 million people worldwide who live below the $1.25 per day poverty line, rice is the primary food staple and that’s why you see these kinds of fluctuations. I think we have a fundamental problem in that over the past 10 years we have been able to substantially increase global rice production. But, when you look at how this was achieved, you can see that the changes in global rice production closely matched the trend in global rice area.

Compared to just 2002, we now have nearly 15 million hectares more land under rice cultivation. You ask how long that trend can continue and where more land is going to come from. This is very much driven by attractive prices that induce farmers to grow more rice or developers to develop more land. But, we have not made enough gains in yield growth: the proportion of yield growth has remained too small, and I think that cannot continue forever.

We made estimates last year that I think we will probably revise again soon, maybe even upward, that, compared with 2010, 20 years from now we will need about 116 million tons more milled rice. If you translate this into annual production, we would need at least an increase of 8 million tons of rough rice (paddy) each year.

Depending on what assumptions you make and how much of this can come from increasing rice area, I believe that the minimum we need in yield growth for the next 10 years is 1.2% to 1.5% per year. In some regions of the world, such as in Africa, we need much more than that because the starting base is much lower and we have to catch up. But, since 90% of world production comes from Asia, those are the growth rates that we need in Asia.

What is probably more challenging for all of us is that we need to accomplish this with a significant change in the way rice is grown. On the one hand, we all worry about climate change and we need to adapt to that. But, I think perhaps the fundamental challenge is that everybody wants us to grow this rice with, if possible, less energy or less tillage, less water, less labor, less pesticide, and probably also less fertilizer. The general public and also many politicians perceive that rice is a crop that consumes many natural resources. Many people have this perception. Right or wrong, I don't agree with it.

This also means that, when possible, people would like to try more diversified farming systems, not just rice all the time. I think that adding value through new products from rice and by-products will also be an important change. If we want to achieve this the fundamental requirement is not just more money and investment. It is people, knowledgeable people, who can implement those changes and that starts with scientists who think in the right direction and it ends with farmers who need to be able to apply more modern production technologies that are more knowledge-intensive as well.

When we look at rice production systems worldwide, of course there will be big differences, and we will also be affected. We will have to follow what colleagues such as Rudy Rabbinge from Wageningen have called the megatrends in agriculture. I will name just six, although one could argue that there are more.

The first megatrend is that agriculture has to become more productive in producing food per unit land, labor, water, fertilizer, and energy. The second is for agriculture to become more skillful and to become more precise. We need to not only adapt to the environment but also often need to learn how to control the environment and capture higher production volume. We cannot just continue adjusting based on how the environment forces us.

A third megatrend is often mentioned is the integration of value chains toward much more consumer-driven transparent agriculture. Consumers want to know where their food comes from, how it has been grown, and how it reaches their table from the field. Not only consumers in Japan and in Germany and in the U.S. but increasingly also consumers in developing countries will ask these kinds of questions, and that is to me a megatrend in agriculture.

This also relates to a fourth megatrend, which is a stronger connection to health and changes in lifestyle, therefore also requiring good agricultural practices to produce food that consumers can relate to in terms of nutritional and health value. The fifth megatrend is therefore also very clearly that agriculture will increasingly need to meet multiple objectives, in both developed and developing countries. One of the key requirements for all of this is thus interactive knowledge.

Many of these things require knowledge networks, the sixth megatrend, referring to connections among people who have pieces of knowledge in science, in policy, and in industry, and can contribute them to solutions that benefit them locally, but are often derived from combined global or international knowledge. That's where programs such as the Global Rice Science Partnership can also play a significant role.

We as scientists have significant innovations in the pipeline. This is just to illustrate how we work to achieve this 1.2% to 1.5% yield increase in rice on average or the same rate of efficiency in production. We know already that we have many good technologies in the pipeline that could be deployed very quickly to farmers. We have some that could have their impact maybe 10 years from now and we are already working on an interesting set of potential breakthrough innovations that could lead to technologies that could have an impact 20 years from now.

These are just some of the things that we at IRRI work on with our partners, but of course there are many more. The main point I would like to make is that I believe there are good solutions for many of the problems that we have to solve. I believe that many good scientists out there have the right ideas, and, if investments are made in a sustainable manner, in a focused manner, and if scientists find ways to collaborate effectively together, we will succeed in strengthening the pipeline for these types of innovations for the benefit of farmers and consumers.

This is the primary reason why we created the Global Rice Science Partnership (GRiSP), the very first of a series of new CGIAR (Consultative Group on International Agricultural Research) Research Programs (CRPs). It represents an investment of about $100 million per year from many different sources. These are direct investments, and many other contributions are not counted.

It combines for the first time the research programs and strategies of several international organizations in one program. IRRI, AfricaRice, CIAT, CIRAD, and IRD from France, and JIRCAS in Japan all have a very wide range of international partners. This alone is quite remarkable because until now we have collaborated with each other, but we all had our own strategies. Now, we have for the first time a global strategy and of course we still have a long way to go to implement this. But we will learn and we will make adjustments.

I want to explain the general philosophy behind these research programs in the way they are structured. What we want to achieve is product-oriented research for development. We have six research themes: five of them are really research and the sixth one is really development or the extension, delivery, or deployment of new technologies and knowledge.

The five research themes range from genetic resources and gene discovery to the breeding of new varieties, the design and optimization of new rice-based production systems, capturing more value from rice, which includes postharvest technologies, new by-products, bioenergy, higher grain quality, and specialty rice, including targeting and policy research. Theme six focuses on the delivery of these outcomes.

What we mean with product-oriented research is that, whenever we talk about a specific product, we need to understand what its purpose is. In terms of, for example, breeding for a new variety that is supposed to be tolerant of a stress such as drought, we need to understand the environment, production systems, consumer requirements, and processing chains. We need to target correctly also socioeconomic and ecological characteristics.

If we can use the different sources of inputs from different programs in designing this product, then we can go back to the gene pool that we have and the genetic resources and find those packages that we really need to breed a variety with the right partners involved, on both the upstream and downstream side, resulting in a variety that would most likely meet the specific requirements for a particular target environment much better.

We have a 5-year work and business plan in which we now have 94 of these R&D products. But we also invest in new frontiers research, something that needs to be explored for a few more years or even for many years before it might reach a stage at which it could become a more product-oriented research pipeline. We also invest as much as we can in revitalizing science capacity building to attract young people to a scientific career in rice, not just in science but also on the extension side.

I pointed out that now we already interact with about 900 partner organizations worldwide, half of them involved in research and the other half involved in development activities at the grass-roots level. You can see that they range from advanced research institutions in developed countries through to the national systems and developing countries and their universities, NGOs, government organizations, and also an increasing number of private-sector partners both locally and internationally.

We have a new Web site that is being improved, but I would like to encourage you to go to www.grisp.net and find out more about this program. There will also be a group interaction forum for which you can sign up. This is for anyone who would like to participate in specific research discussions or activities on specific topics.

Now, I would like to highlight a few examples of research activities that we have ongoing or are initiating, with a focus more on the global and Asian side because I know that several other speakers will go into more detail and will also talk more about Africa, for example.

In GRiSP theme one, just to point out one example, one of our key global activities is a massive effort for gene discovery in rice, which we believe really requires global coordination and a global effort because nobody can do it alone, as nobody could even technically do it or afford it. Therefore, we have started the de novo sequencing of more than 3,000 rice varieties and we are now building a global phenotyping network that is required to do association genetic studies and discover genes and markers for breeding applications that we can then use to develop new rice varieties. This is clearly an example of why a global program is needed. Until now, we had only the genomes of a few rice varieties, but a year and a half from now it will be 3,000 and we all need to learn how to use this information on both a global and national scale.

We also take new directions in plant breeding by diversifying genetic backgrounds using new projects for generating populations. Specialized genetic stocks, such as MAGIC breeding populations, will be tremendously valuable because we can rapidly generate large numbers of genetic materials that are indica and even between indica and japonica. These materials will have many useful traits for breeders to use.

We do basic research that some of you are of course aware of that attempts to create rice with the C_4 photosynthesis mechanism, similar to what maize, sorghum, and sugarcane have. If this works, the productivity and yield of this C_4

rice should be 30% to 50% higher for the same amount of sunshine and water than it would be for the current C_3 rice.

We have made good progress on various fronts already. One of the features C_4 rice needs to have is narrower vein spacing to concentrate CO_2 and have Kranz anatomy like C_4 plants have. We are finding first mutants that have somewhat narrower vein spacing. We have also been able to construct transgenic plants for almost all of the key enzymes involved in C_4 photosynthesis, which will then need to construct basically the biochemistry machine of C_4 photosynthesis into rice on top of the changed anatomy of the leaves.

In theme two, our breeding programs are moving toward what we call two-in-one varieties through molecular breeding, pyramiding genes for drought and submergence tolerance together into the background of already widely grown popular rice varieties. This maintains most of their attractive features for farmers, but equips them with drought and submergence tolerance because both stresses often occur in the same place in the same year. A similar approach is being used for creating rice with combined submergence and salinity tolerance. This is extremely important for many places facing climate change and other disasters.

We have also made a lot of progress recently in theme four in understanding the genetic basis of chalk. Chalk is a trait that rice consumers don't like ("chalky rice"). Rice needs to be translucent in most countries and we have found five QTLs for rice that, if we combine them into different genetic backgrounds, always results in very low chalk content.

These are some of the genetic activities or breeding activities that are going on. Almost more important, I think, are future changes in the way we grow rice. In many countries in Asia, or even Africa, it will not be possible to continue the current practice of wetland preparation and transplanting for many reasons. It's costly, it uses quite a lot of water, and it's slow.

Increasingly, people will be looking at systems that involve direct seeding into dry soil or even without any tillage. A lot of research is already ongoing on designing these new cropping systems and mechanized rice-growing technologies along with them. We aim to find out how we can grow rice in a sustainable manner under these types of new management practices.

At IRRI, we also have established a similar platform. This four-hectare field is equipped with a center-pivot irrigation system (Fig. 2) that we use to apply water and now also nitrogen in the most precise manner possible, and then also do direct sowing of rice into the field. This is our first crop that was harvested this year, yielding up to 7 tons/ha in some parts of the field. We still have a lot to learn, but the potential is there. It is possible to grow rice in these types of new systems using less water and other inputs than what is now the case. That's what we need to do in research - we need to look forward.

Many questions are unanswered. Many things we don't know yet in terms of what the sustainability of these systems will be. We know that the conventional rice system is extremely sustainable. It conserves soil fertility, but of course it also has high greenhouse gas emissions, particularly methane. For some of the new systems, such as this aerobic rice with sprinkler irrigation, we simply don't know yet what the long-term impact will be, how sustainable they will be, and how we can optimize their management. That is a research challenge that we all face in different environments where rice is grown.

I think one of the key challenges is how we can bring information and new technologies and tools to farmers where we know that one of the weaknesses in many parts of the developing countries in the world is the extension systems. It's just very difficult to reach millions of farmers, millions of small farmers, with any new technology or information through the classical, often poorly staffed, poorly equipped, extension system.

We've started to work a lot on mobile phone applications, including Android Smartphone applications, like this one here for site-specific fertilizer management (Fig. 3), in which farmers or extension workers can work through a series of questions and arrive at a field-specific recommendation for, in this case, fertilizer, but, in the future, also for other crop management decisions, financial services, crop insurance, and buying inputs through an application such as this. We are testing this now.

We are also working increasingly with partners that come from a very different end. The Sustainable Rice Platform (SRP) has been formed recently involving companies such as Kellogg's, Nestle, Mars, and Syngenta; rice traders such as Louis Dreyfus Commodities; UNEP; and research organizations such as IRRI and the Thai Rice Department. The goal is to look at the value chain to come up with good management practices for producing rice in a sustainable and transparent manner that the partners could then implement in their raw material processing chains.

This is a contribution that scientists also need to make increasingly: help partners establish the right standards and management practices, and connect farmers to markets through this. One new activity we are doing is for the first time creating a map of global grain quality preferences. One example is amylose content. In some parts of the world, people prefer very low amylose and others prefer very high amylose. We are mapping grain quality to understand market segments and guide our breeding efforts toward much more specialization in the future with regard to grain quality.

We also need to use remote-sensing information in a much more sophisticated manner in the future. One example is a seasonal mapping of rice-growing areas in Bangladesh (Fig. 4), allowing us now to more precisely determine for a whole country actual rice-growing area and the major growing seasons. We have developed semiautomatic algorithms for this purpose. We have also started work on a global rice monitoring and forecasting system that includes a forecasting model with supply-demand and trade. We are developing a GIS remote-sensing monitoring platform based on radar satellites and a crop growth simulation model.

To conclude, what should Japan do regarding its involvement in the Global Rice Science Partnership or in the global rice science community? We view Japan as a strategic R&D partner because of the current strength of Japanese rice science and your very excellent research history, but also the innovation that arises. We believe that, from a global point of view, Japan could contribute a lot to intellectual property for wider international use in addition to national use.

We also believe that Japan should and could lead a number of research areas for which it clearly has a comparative advantage because many others don't have that. We can't do this and we can't do everything. We have to focus on those things that we can do well and our partners also.

We believe that Japan can play a major role in capacity building for both science and agricultural extension. If we can find the right mechanisms, I think it is possible to align R&D priorities of Japan with those of GRiSP, therefore achieving greater synergy.

The philosophy that we propose is that, by contributing more globally, we believe that Japan would also benefit more nationally. With that, I would like to close and just remind you that, according to our R&D assessment, an investment of just US$20 in R&D in a global program like this would be sufficient to lift one person out of poverty. Not many other investments can achieve that rate of return if carried out well.