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RICE FOR THE FUTURE

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Summary

A second Green Revolution in the rice bowls of the world is needed now as much as the first Green Revolution was needed 40 years ago to avoid famine. It must be sustainable and it will require both short- and long-term investments in R&D as the principal vehicle for technology improvement. The best strategy for finding the right balance between the need to keep rice prices low for poor buyers of rice and to keep them high enough for farmers to improve their livelihoods is to ensure that production increases faster than demand, and that it is highly profitable, resource-efficient, and sustainable. This can only be achieved through an ecological intensification of rice systems -- based on solid scientific principles. Many new technologies for this exist, but they need to be applied in a systems management context and with clearly defined targets for critical performance indicators. Because of a lack of investments in the agricultural sector, they have not been fully exploited. Speeding up the delivery of new technologies and, at the same time, investing in the future requires new public-private-sector partnerships that build on the comparative strengths of each sector.

What is happening?

Of the world's 1.1 billion poor people, almost 700 million people with income of less than a dollar a day reside in the rice-growing countries of Asia. Rice is a staple food in Asia. It accounts for more than 40% of the calorie consumption of most Asians. Poor people spend as much as 30–40% of their income just to buy rice. The amount of rice production and price are thus important factors in determining the progress that can be made in reducing poverty in Asia. Keeping the price of rice low and affordable to the poor is crucial for poverty reduction. Given this, the current sharp upward movement in the price of rice is a major cause for concern.

In 2008, world energy and food prices touched record levels. The world price of Thai rice 5% broken—a popular export grade—was under $200 per ton in 2000, but it rose to more than $360 per ton by December 2007 and has more than doubled since then (Fig. 1), reaching $1,000 per ton in recent weeks. Major exporting countries such as Vietnam and India have announced export restrictions to protect their domestic consumers. These restrictions have further contributed to the recent increase in rice price as the rice supply in the world market has dwindled. In several countries, food riots have occurred and soldiers are guarding food trucks to prevent looting.

Rising food prices increase inequality – the millions of rural landless and urban poor in South Asia will suffer most from it – and may lead to political instability in this major world region. A 1% increase in prices of food leads to a 0.75% decline in food expenditure of the poor, and much of that happens in the cereals basket. High prices of rice and wheat particularly affect the poor in South Asia. In Bangladesh, the poorest 20% of the population spend 69% of their household income on food and rice alone accounts for 38% of their total expenditures. In India, the poorest 20% spend 62% of their income on food, with rice and wheat accounting for the largest share. The average Pakistani spends about 50% of his/her total expenditures on food and a 30% rise in food prices is estimated to increase the number of poor by 22 million in that country alone (ADB, 2008). Sharp rise in cereal prices also do not automatically translate into greater economic welfare of farmers. For rice, for example, the average increase in real domestic prices is about one-third of the increase in real US dollar world market rice prices. Moreover, sharply rising energy and fertilizer prices have driven up production costs for farmers.

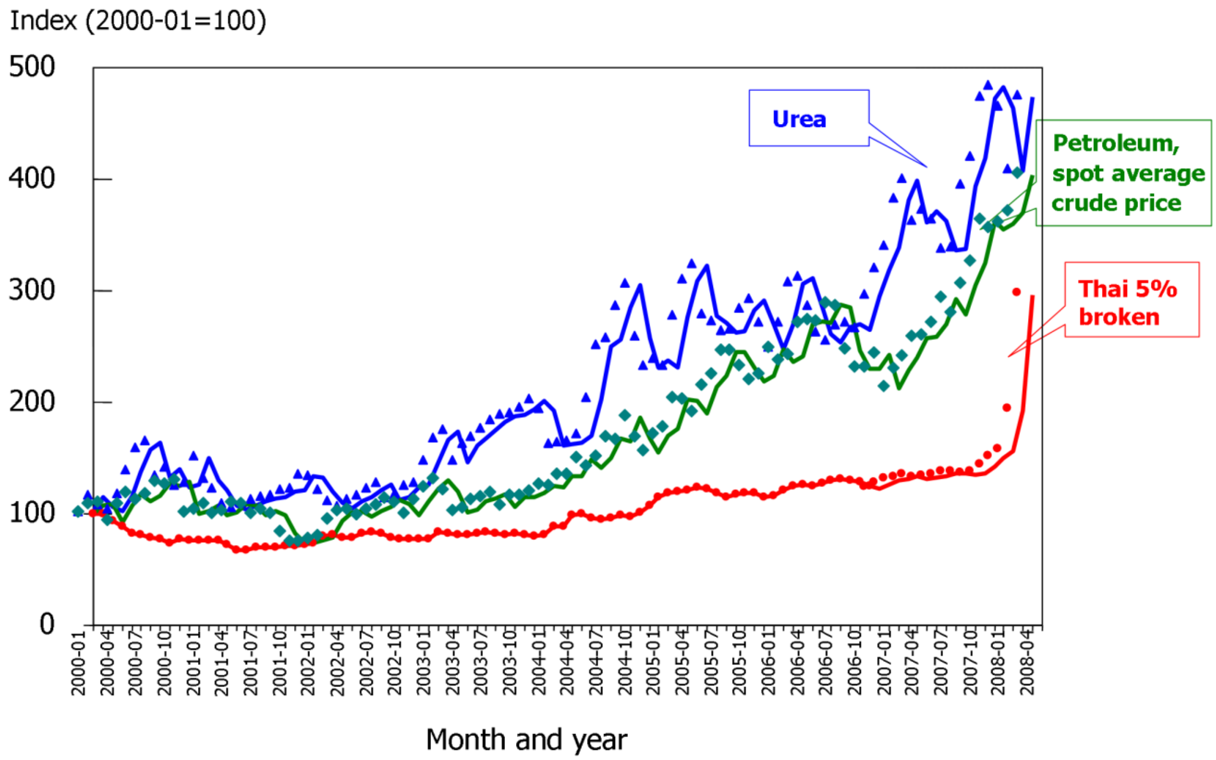


Figure 1. Monthly prices of oil, urea, and rice (Thai 5% broken), January 2000 to April 2008. Data from The Pinksheet, World Bank.

There are many reasons behind the rising rice prices, some short-term and some longer-term. Short-term reasons include supply shocks due to extreme weather, depletion of grain stocks, speculation by traders, diversion of food for bio-fuels in developed countries, pest outbreaks, and the rising cost of critical inputs such as energy and fertilizers. Behind these, however, are other slow-moving but relentless factors: slow growth in cereal yields, rapid increases in cereal demand for food and feed from fast-growing Asia, increased scarcity of agricultural water and other resources, re-occurring pests and the unfolding consequences of climate change. Taken together, these factors suggest that high prices are likely to prevail for years to come

In the past 10 years yield growth of crops that primarily rely on public sector investments in R&D has dramatically lagged behind the global yield growth achieved in crops with heavy private sector involvement. In both rice and wheat, average annual yield growth rates were **below 1%** per year during most the past decade, well below the annual population growth in Asia. This slow-down in yield growth has been the primary factor for tightening supply-demand balances and the current crisis situation: we have been consuming more rice than we were able to produce (Fig. 2).

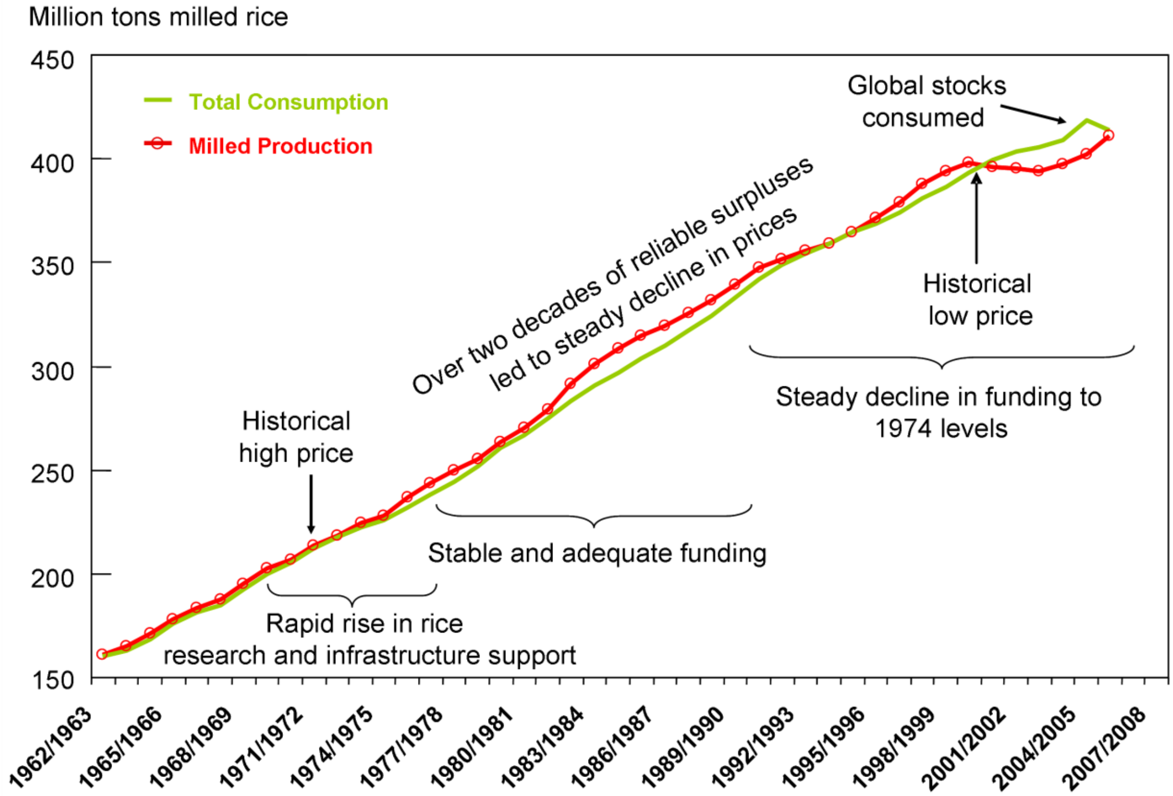


Figure 2. Rice prices and the race between rice production and consumption (USDA, 5-year moving averages). IRRI's budget changes are indicated as a proxy for investments in R&D and infrastructure directed to productivity increases.

An important factor accounting for the slowdown in yield growth is the insufficient public investment in agricultural research and development—the very engine that drove productivity growth to begin with. Breeding pipelines for new varieties have slowed down. Investments in irrigation have decreased substantially. Existing irrigation infrastructure has deteriorated considerably because of inadequate maintenance. Extension systems are dysfunctional in many countries. Research is lacking critical resources to make faster progress. A lack of well-qualified human capital hampers agricultural R&D. Many agricultural policies stifle investments. The steady decline in rice prices through the 1990s led to complacency -- many governments as well as international donors believed that there was a perpetual supply of plentiful food.

What needs to be done?

The immediate challenge for ensuring rice food security and slowly rebuilding buffer stocks is to stabilize global rice supply and demand balances by consistently producing about 8 to 10 million tons of rough rice more than in the previous year in each of the next 5 years. This would allow farmers to meet the rising demand for rice (at least 5 million tons annually) and slowly rebuild low buffer stocks to secure levels. After this period, the production increases required will likely be less, but they will remain above 5 million tons per year.

Rice production can be increased by expanding the area planted to rice, by increasing the yield per unit area, or by a combination of the two. Reclaiming more land for rice, increasing the irrigated area, or increasing cropping intensity may occur in some areas as an immediate response to high prices. Over the longer term, however, net increases in rice harvest area will probably remain small because of continuing losses of rice land for other uses, including for the cultivation of other food crops. Expansion of rice into new areas would also be at the expense of natural resources and ecosystem services, and should proceed with great care. Additional rice supply has to primarily come from (1) increasing yields by reducing yield gaps, (2) increasing yields by increasing the yield potential of rice varieties or hybrids, and (3) reducing grain losses that occur during harvest, storage, or processing of rice.

The gap in yield between the best agronomic and economical farm practices and the actual yield harvested on average by farmers is still large. We estimate that economically exploitable yield gaps of 1 to 2 t/ha exist in most rainfed and irrigated lowland environments. In some areas, they may be as large as 3 t/ha. Grain losses occurring at harvest or subsequently are often 10–20%, or even more. Furthermore, poor seed storage also affects crop yields by causing poor seed health.

Global average rice yields must continue to rise at an annual rate of more than 50 kg/ha (>1.2% per year) to keep pace with the expected demand, or by at least 0.5 t/ha over the next 10 years (about 12%), and they must retain acceptable quality for each market. Actual yield growth in the past decade has, however, mostly been below this target due to a combination of (1) lack of progress made in raising the yield potential of rice and (2) yield losses caused by multiple crop damage resulting from abiotic and biotic stresses and natural disasters.

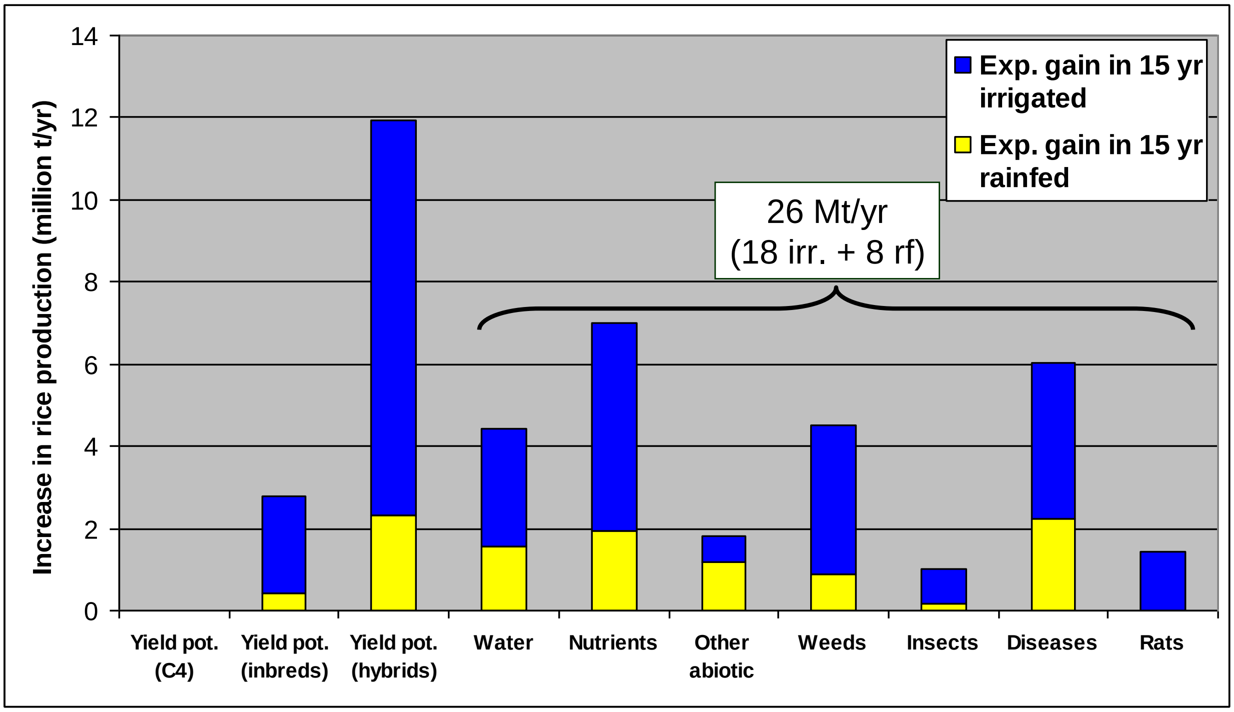
There are no silver bullets. The problems encountered cannot be handled in a piecemeal fashion through few traits, component technologies or blanket recommendations. The existing public sector extension system cannot achieve sufficient impact alone. Many players are required to reach millions. For example, an ex ante assessment for South Asia suggests that, over the longer term, technologies that focus on closing existing yield gaps caused by abiotic and biotic stresses may produce about 2/3 of the rice required 15 years from today, whereas the remaining 1/3 has to come from increased yield potential (Fig. 3). IRRI is calling for implementation of the following nine-point program of short- and long-term interventions:

1. Bring about an agronomic revolution to reduce existing yield gaps
Depending on production conditions, an unexploited yield gap of 1–2 t/ha currently exists in most farmers' fields in the rice-growing areas of Asia. This yield gap can be reduced through the integrated use of stress-resistant varieties and better crop management practices. This requires funding support to programs aimed at improving farmers' skills in practices such as land preparation, water and nutrient management, and control of various pests, diseases, and weeds.

2. Accelerate the delivery of new postharvest technologies to reduce losses
Postharvest includes the storing, drying, and processing of rice. Considerable losses occur in terms of both quantity(10-20%) and quality of rice during postharvest operations because of the use of old and inefficient practices. Active promotion of exciting new technologies that are currently available for on-farm storage and drying will reduce losses considerably.

3. Accelerate the introduction and adoption of higher-yielding rice varieties
New rice varieties are available today that can increase production, but farmers are not using them because the systems that introduce new varieties are under-resourced. Enhancing

germplasm exchange, variety testing, and release pipelines can make current high-yielding stress-resistant varieties and hybrids more widely available to farmers in irrigated and rainfed lowland areas of Asia and Africa.



Adoption (%): 0 5-10 20 30-35 20-30 20-35 20-30 15-20 20-40 20

Figure 3. Estimated expected increase in rice production in South Asia due to different technologies (breeding and management) for increasing yield potential or exploiting yield gaps by reducing abiotic and biotic stresses (assuming the stated adoption rates in 15 years).

4. Strengthen and upgrade breeding pipelines for developing new varieties and hybrids

Funding for the development of new rice varieties has declined steadily over the past decade or more. This must be reversed in order to develop the next generations of new rice varieties that will be required for productivity growth in sustainable agriculture. Many opportunities are available to accelerate the development of new rice varieties and hybrids with higher yield, better grain quality, and increased tolerance of abiotic stresses, and with multiple resistance to insects and diseases through new molecular breeding approaches.

5. Accelerate research on the world's thousands of rice varieties so scientists can use the vast reservoir of untapped genetic resources they contain

Working with IRRI, the world's nations have spent decades carefully collecting thousands of rice types. More than 100,000 rice types are now being carefully managed and used at IRRI and in Asian nations. However, only a small fraction of the genetic resources has been characterized in detail or used widely. New molecular methods have now opened the door for revealing the valuable alleles in each accession.

6. Develop a new generation of rice scientists and researchers for the public and private sectors

Part of the current rice crisis reflects the lack of investment in science, including human capital investment. The education and training of young scientists and researchers are also a vital concern for the rice industry. Asia and Africa urgently need to train a new generation of rice scientists and researchers to enable them to exploit the developments in modern science more effectively.

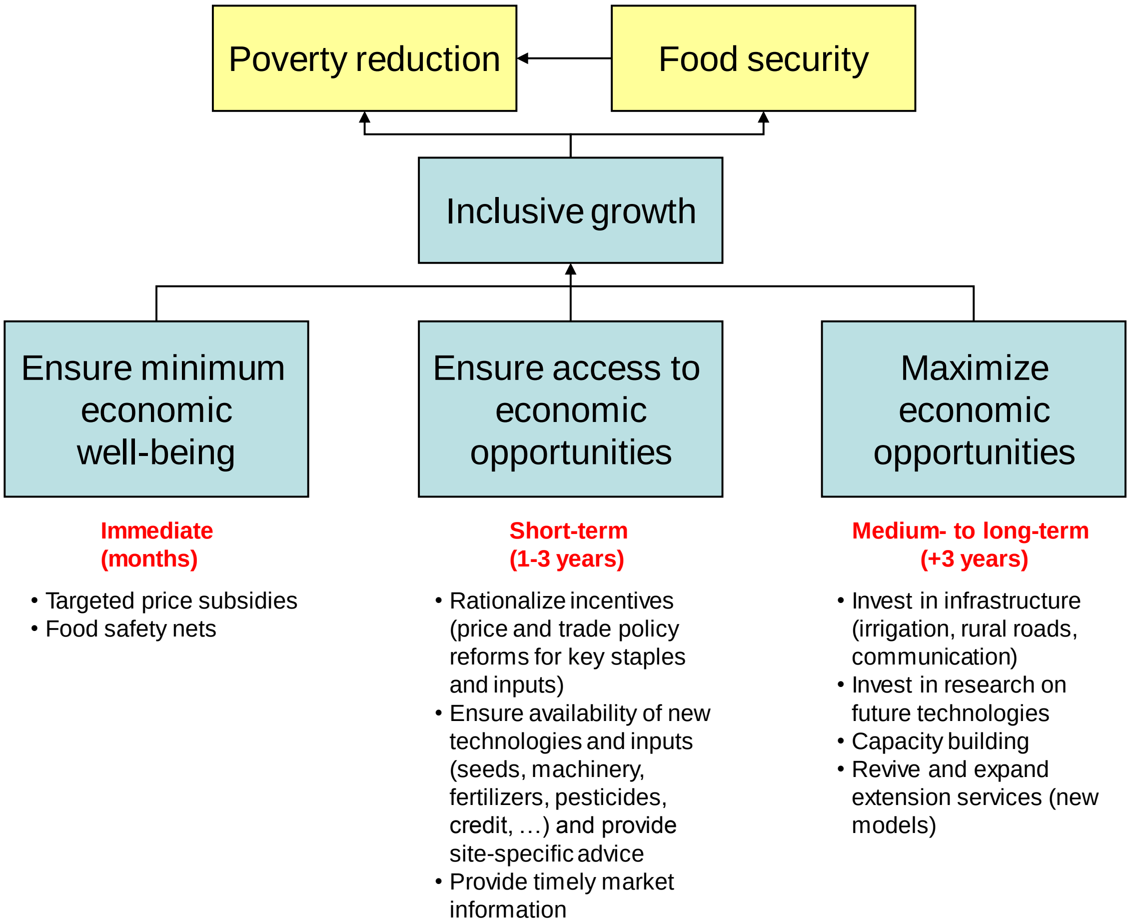


Figure 4. Inclusive growth through improvements in agriculture (modified from ADB, 2008)

7. Increase public investment in agricultural infrastructures

Adequate investments in agricultural infrastructures such as road, irrigation and marketing are critically important for raising and sustaining the productivity growth. Like with agricultural research, there is an underinvestment in agricultural infrastructures and needs to be corrected urgently.

8. Reform policy to improve the efficiency of marketing systems for both inputs and outputs

Opportunities exist for improving the marketing systems, both domestic and international, so that price signals are efficiently transmitted to both the producers and consumers. Policies should be revised to remove barriers to such efficient transmission price signals and to create enabling conditions for private sector to function smoothly.

9. Strengthen food safety-net for the poor
Poor and disadvantaged people who are highly vulnerable to food shortages require support from a strong food and social safety net programs to ensure that their needs are adequately met.

Both the private and the public sectors must take on a leadership role in this process. Governments in the rice-producing countries of the world must lead this effort and make the resources as well as supporting policies available so that NARES, the private sector, NGOs, and other civil society organizations can carry out most of these activities (Fig. 4). International institutions such as IRRI must play a catalyzing role in accelerating the development of key innovations and new products, supporting new delivery mechanisms through public- and private-sector channels, and building capacity.

Global efforts should also be made to explore additional areas that could potentially contribute to food security. For example, sub-Saharan Africa still remains largely unexploited in terms of land and water resources suitable for the production of cereal crops. With concerted efforts, Africa could at least meet local demand and free the one-third of the world rice exports currently being imported into African countries. To succeed in this, farmers in Africa will need better access to seeds, fertilizers, markets and information.

Agro-ecological intensification of intensive rice systems

Worldwide, about 80 million ha of rice are grown under irrigated conditions. These systems account for 75% of rice production and provide the staple food for about 2 billion people as well as the basic livelihood of some 50 million farm families. Producing cheap rice for the domestic market is a goal of strategic importance in developing countries with high rice consumption and it largely depends on the productivity of irrigated rice systems. Irrigated rice systems also provide many ecosystem services that are not directly valued (Bouman et al., 2007). Paddies are important for flood control. Water retained in bunds increases groundwater recharge. Rice can be grown as a desalinization crop. Soil degradation and erosion are negligible. Irrigated areas cool air temperature in peri-urban areas. Risks of water pollution caused by inorganic fertilizer are minimized by the particular conditions in the floodwater-soil system. Atmospheric CO_2 and N_2 fixation by aquatic flora and fauna contribute to maintaining yields and increase soil organic matter. Fish and ducks are raised in rice fields, ponds, or irrigation canals. Irrigated rice landscapes sustain rich biodiversity. Rice cultivation in Asia involves aesthetic, spiritual, religious, educational, cultural, and recreational values.

Intensification of lowland cropping systems in Asia since the mid-1960s has increased the number of crops grown per year and the yield per crop cycle. This was accomplished through genetic improvement, changes in management, and infrastructure development (Fig. 5). Genetic improvements provided the “engine” while improved crop and resource management technologies supplied the “fuel” for growth in rice yields, income, and resource efficiency. Since the mid-1960s, average world rice yield has increased at an annual rate of 52.4 kg ha^{-1}. However, the adoption of modern rice varieties has levelled off in the 1980s or 1990s in many countries. With the exception of hybrid rice, there has been no significant increase in rice yield potential since the release of IR8. Hence, the yield gains in recent decades have come from closing yield gaps through improved varieties that are better adapted to abiotic and biotic stresses (Peng and Khush, 2003) and improved crop and resource management technologies.

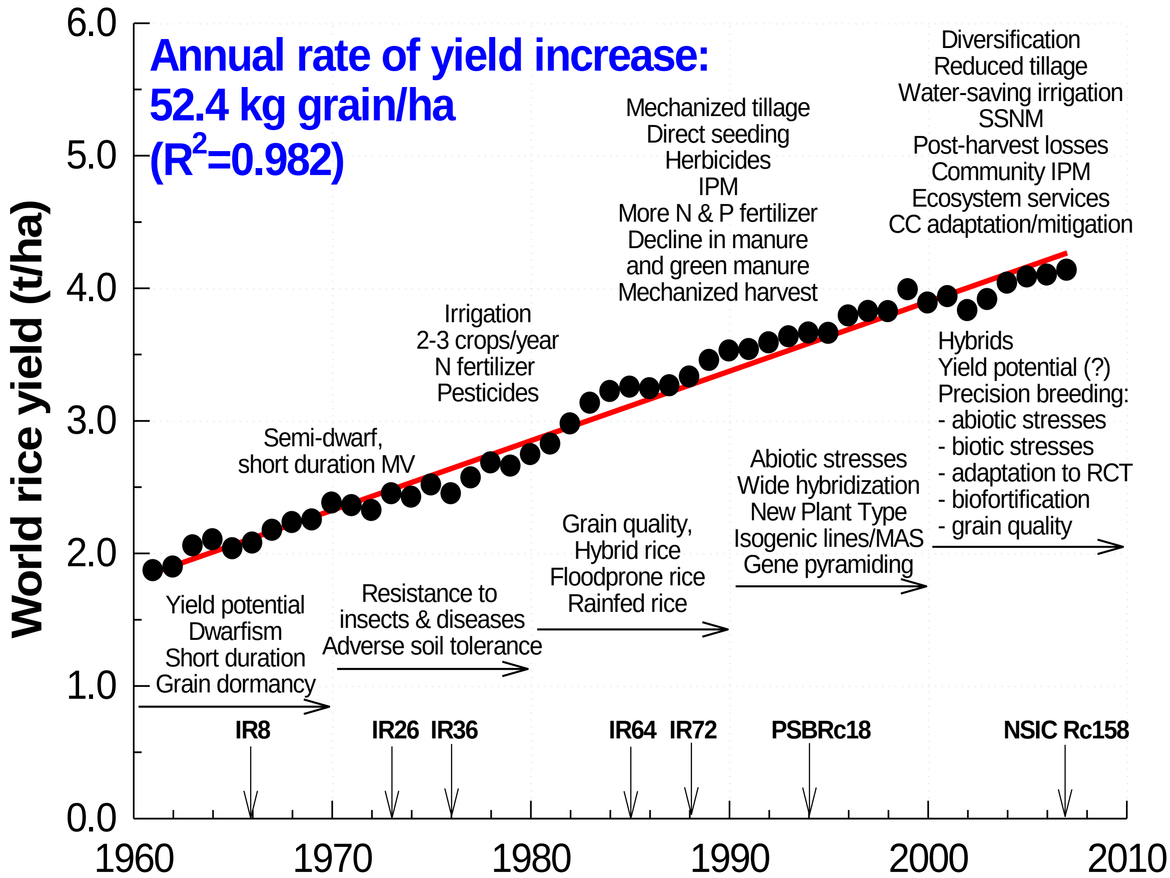


Figure 5. Trend in average world rice yield (1960 to 2007) and the key technological interventions associated with it. Changes in breeding objectives and release years of selected IRRI rice varieties are indicated in the bottom half. Major changes in management and emerging new management objectives are indicated above the yield trend line.

Rice yield growth rates have consistently stayed below the long-term trend line during the past 6 years (Fig. 5). Slow yield growth resulted from a combination of lack of progress made in raising the yield potential of rice and yield losses due to multiple crop injuries resulting from abiotic and biotic stresses. In many areas, current constraints also result from inadequate management practices, not a generic non-sustainability of intensive systems *per se.* Hampering progress are lack of education, poor access to information and new technologies, lack of effective input supply and marketing chains, poor pricing and support policies, and inefficient extension systems. In irrigated rice areas, the current average yield of 5.4 t ha^{-1} represents about 65% of the climatic-genetic yield potential of rice in Asia, which averages about 8.5 t ha^{-1} across different environments and growing seasons. Depending on the changes in irrigated rice area and the yield advances achieved in rainfed rice environments, average yields of irrigated rice must continue to rise at an annual rate of at least 1% to reach 6.5 to 7 t ha^{-1} by 2030. Assuming that target yields for well-managed rice systems are near 80% of the yield potential, an economically exploitable yield gap of about 1 to 2 t ha^{-1} exists in most intensive rice fields of Asia planted with the current generation of inbred or hybrids.

Many management deficiencies limit yields and bring about losses in the rice fields of Asia and elsewhere. Critical deficiencies include:

- Poor leveling, levee construction, and water management
- Slow variety replacement
- Nonoptimal date of sowing or planting to capture the full yield potential
- Seedling pests and weeds caused by poor-quality and unhealthy seeds
- Too high seeding rates (direct seeding) that can cause disease epidemics
- Suboptimal plant densities under transplanting
- Lack of timely and effective weed control
- Unbalanced and untimely fertilizer application
- Insufficient control of rodents, diseases, insect pests; overuse/misuse of pesticides

Intensification of cereal production systems to satisfy the anticipated increase in food demand while meeting acceptable standards of environmental quality will require an ecological intensification and, where appropriate and sustainable, diversification of agriculture (Cassman et al., 2003). A central hypothesis for an ecological intensification of agriculture is thus that an optimal balance of high productivity, profitability, sustainability, and environmental protection can be achieved by fine-tuning of management towards better exploitation of crop yield potential (Cassman, 1999).

Ecological intensification is an evidence-based process of identifying options for best management practices through scientific research and participatory evaluation. Genetic improvements targeting better crop adaptation to biotic and abiotic stresses and better crop and soil management practices are of equal importance for optimizing crop performance within the context of cropping systems. Ecological intensification focuses on key scientific principles within a decision making or problem solving process. Major steps include:

(1) socio-economic and biophysical characterization to identify principal opportunities for responding to drivers of change in agricultural systems,
(2) designing principal cropping systems management options to address main constraints,
(3) identifying suitable performance indicators and setting quantitative targets for those,
(4) using scientific principles to identify Best Management Practices (BMP) for reaching these targets,
(5) implementing optimized management solutions in a participatory manner, with high scientific standards and with dynamic adjustments, and
(6) conducting *post ante* analysis to distill practical guidelines and learn for the future.

Ecological intensification thus provides science-based strategies for integrating advanced germplasm, crop and resource management technologies to secure food production at high economic and environmental standards. Examples of critical performance indicators include:

- Stable yields within 70-90% of the genetic-climatic site yield potential, including resilience to climatic extremes and global climate change
- Agronomic N use efficiency of >20 kg grain yield increase per kg N applied, >50-60% fertilizer-N uptake efficiency and low residual soil nitrate levels (low leaching risk)
- >80% water use efficiency in irrigated systems
- Minimum use of harmful pesticides through a combination of plant resistance to biotic stresses and integrated pest management (low A.I. applied per ha or per kg harvest product).

- Ecological resilience at field, landscape, and regional levels, including sufficient biodiversity for maintaining natural pest control mechanisms and other ecosystem services
- Improved/maintained soil quality (nutrient stocks, soil organic matter, soil physical properties, …)
- Positive energy balance, low global warming potential, or even a net reduction in atmospheric greenhouse gas emissions
- Nearly closed C and N cycles through multiple products and recycling in integrated crop-livestock-(bioenergy) systems

During the past 15 years, IRRI and its partners have developed numerous new crop and resource management technologies that are designed to reduce existing yield gaps through either minimizing yield-limiting factors (water, nutrients) or reducing yield losses due to insects, diseases, weeds, and other factors. Many of these technologies also reduce production costs and risks. They also favour yield stability—the key to sustainable agriculture in poorly endowed environments. Key technologies include

- Land leveling for direct seeding, including laser leveling
- Water-saving technologies (controlled irrigation, aerobic rice for temperate zones)
- Site-specific nutrient management
- Integrated pest management (of weeds, diseases, insects, rodents)
- Conservation agriculture (reduced tillage, direct seeding, residue management)

Delivery mechanisms for scaling such new technologies up and out to millions of rice farmers vary, but they will generally require new public-public- and public-private-sector partnerships. Resources are required for the following:

- Biophysical and socioeconomic characterization and monitoring of key rice environments. This is key to (1) deploying technologies that are adapted to environments and social needs, (2) anticipating needs for future research and development in a context of global change, and (3) setting priorities for research, development, and higher education.
- Designing scalable delivery mechanisms for new seeds and crop management technologies, including linking up with input supply and advisory systems developed by the private sector, and linking the agricultural sector with the irrigation management sector.
- Using mass media for raising awareness and providing critical, timely, and readily usable information in nontechnical words, while it is actually based on strong fundamental research.
- Establishing novel capacity-building programs for agronomists in the public and private sector, including professional certification programs.
- Providing improved content for use in modern information and communication technologies (ICTs), including the Cereals Knowledge Bank (CKB) and new electronic communication networks designed to reach millions of farm households.
- Monitoring and analysis of effective pathways for delivery (cultural, social, economic, and political context).
- Policy support to enable adaptation and adoption of new technologies.

Major changes in intensive cereals systems in Asia require investments in strategic breeding and cropping systems research that must be made now to adapt to future scenarios and lay the foundation for continued yield growth. Rice systems will be affected by decreasing water availability and rising temperatures – two cross-cutting abiotic stresses. Diversification of cropping systems in the form of crop substitution or in the form of increased cropping intensity will alter rice landscapes that have been under monoculture for decades or much longer. Adoption of more mechanized Resource Conserving Technologies (RCT) that follow principles of Conservation Agriculture is likely to become a principal direction for increasing systems productivity and sustainability, particularly in rice-upland crop systems. Key implications arising from this are that modern rice cultivars need to be equipped with new traits to (i) have higher yield potential, (ii) grow well at high yield levels under RCTs such as reduced/partial irrigation with short periods of water stress, zero-till and residue retention, (iii) be resilient to high temperatures during flowering and grain filling, and (iv) maintain broad-spectrum resistance to existing and newly emerging diseases and insect pests in systems that undergo change. This will require renewed investments in public sector rice breeding along with establishing better linkages between the public and private sectors for utilizing the comparative strengths of each in germplasm improvement and seed delivery. More targeted breeding for cropping systems and traits for integration with modern RCTs will be needed, towards offering holistic germplasm x management solutions for the key rice growing environments in Asia and elsewhere.

Conclusion

Rice yield growth rates have slowed down in many rice growing regions due to resource constraints, poor policies, barriers to adoption of new technologies and lack of investment in rice breeding. Complacency may have resulted from the success of the Green Revolution, but recent trends in world markets have re-iterated the need for more investments in research as well as establishing better delivery mechanisms for new seeds and technologies to millions of rice farmers. This must include forming innovative, pro-poor public-private sector partnerships. Exploitable gaps in yield and resource efficiencies exist. They call for an *ecological intensification of rice systems*, one that is based on scientific principles for integrating germplasm with modern management solutions.

Acknowledgement

This paper is based on contributions by many IRRI scientists to recent IRRI publications and information that can be found at http://solutions.irri.org.

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Rice Science for a Better World

Rice for the Future

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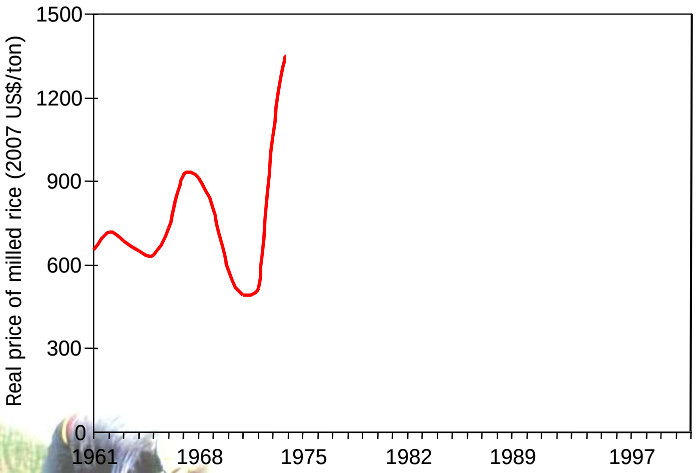
World rice price, 1961-2007 (in 2007 US$/ton)



Source: Production: FAOSTAT © FAO Statistics Division 2007| 02 August 2007 update.
Rice Price: Relate to Thai rice 5%-broken deflated by G-5 MUV Index deflator (adjusted based on February 27, 2008data update)
Source: www..WorldBank.org

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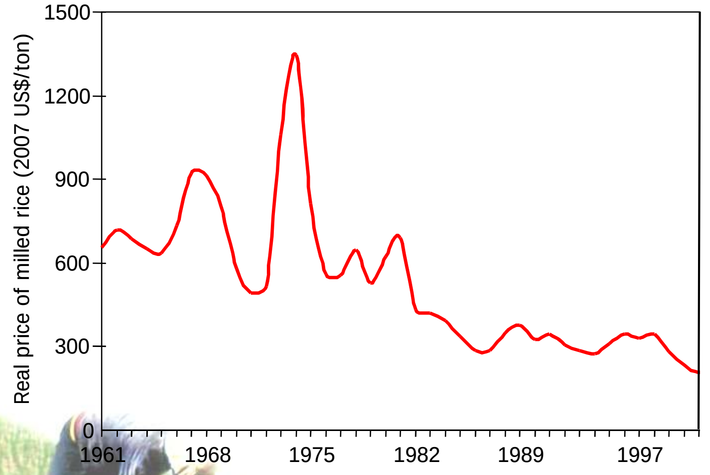
World rice price, 1961-2007 (in 2007 US$/ton)



Source: Production: FAOSTAT © FAO Statistics Division 2007| 02 August 2007 update.
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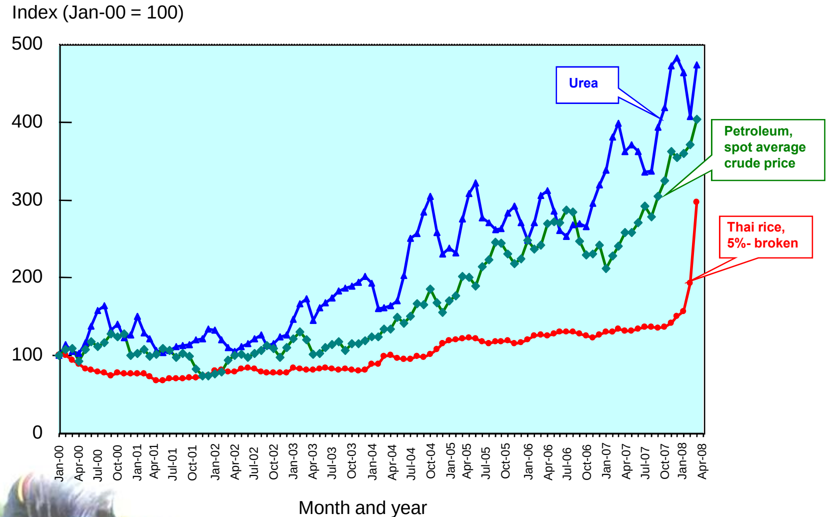

Monthly prices of oil, urea, and rice (Thai 5% broken), January 2000 to April 2008. Data from The Pinksheet, World Bank.

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Why are rice prices rising now?

Short-term causes:

- Extreme weather (floods, droughts)
- Pest outbreaks (planthoppers & viruses)
- Rising energy costs
- Price of other commodities
- Behavior of importers and exporters, speculation

Long-term causes:

- Continuing high demand
- Pressure on resources – land, labor, water,
- Slow yield growth due to lack of investment

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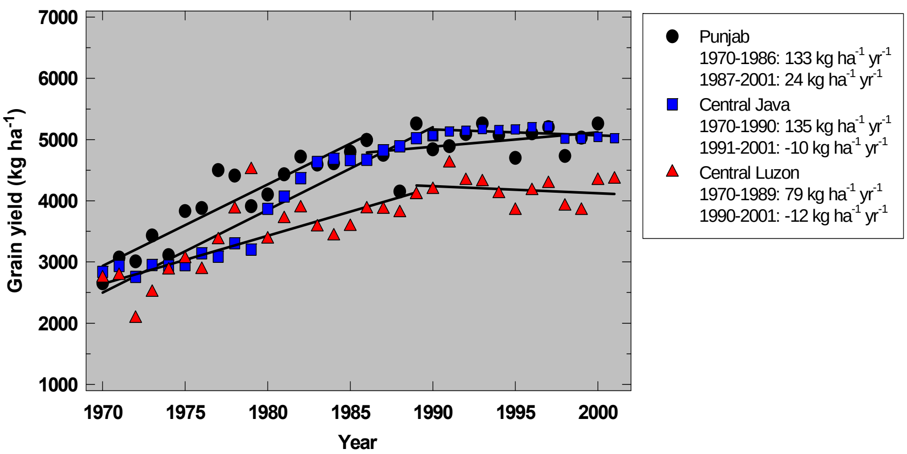
Slowdown in yield growth rates in areas with early adoption of Green Revolution technologies



Irrigated rice yield trends in Punjab (India), Central Java (Indonesia), and Central Luzon (Philippines) 1970 – 2001.

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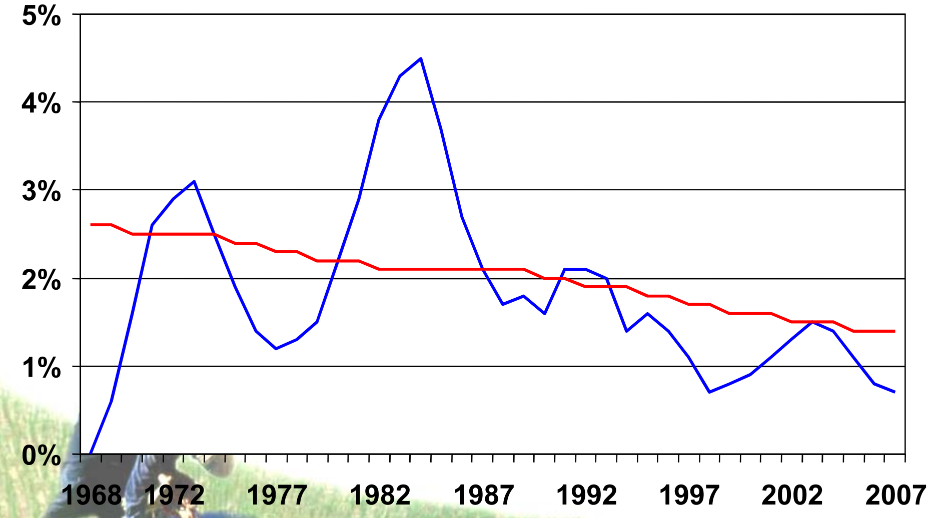
Asian rice yield growth has slowed substantially in recent years (SE Asia)



David Dawe, FAO, 2007

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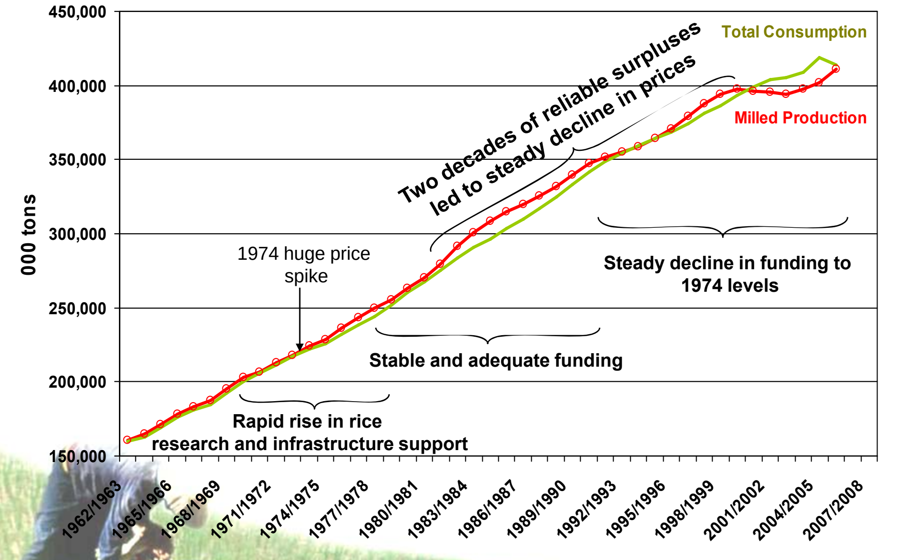

5-yr moving averages; source of rawdata: USDA, 16 April 2008

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Immediate needs:

- In each of the next 10 years produce 8-10 million tons rice more than in the previous year
- Small increase in harvested area
- Re-vitalize global annual rice yield growth to >50 kg/ha/year (1.2%/yr)

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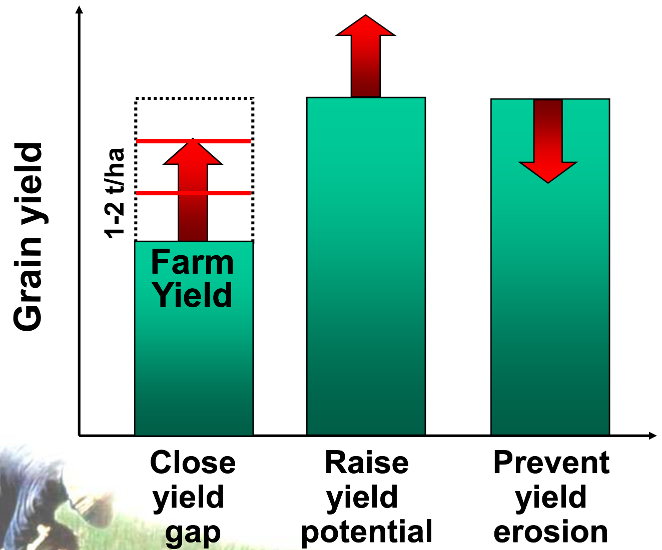

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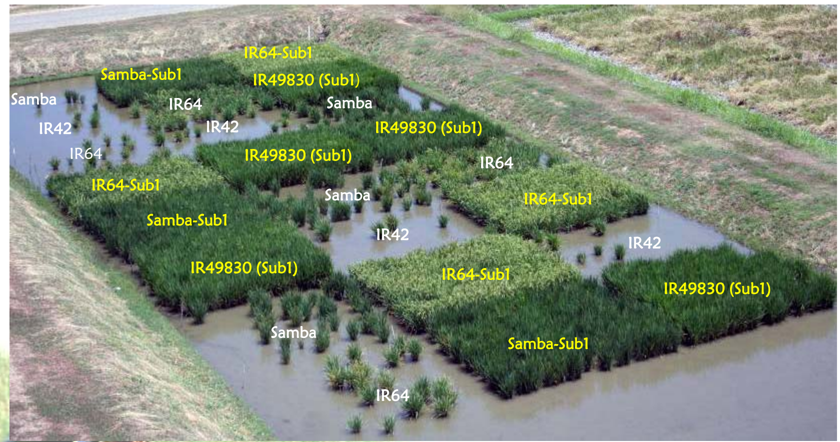
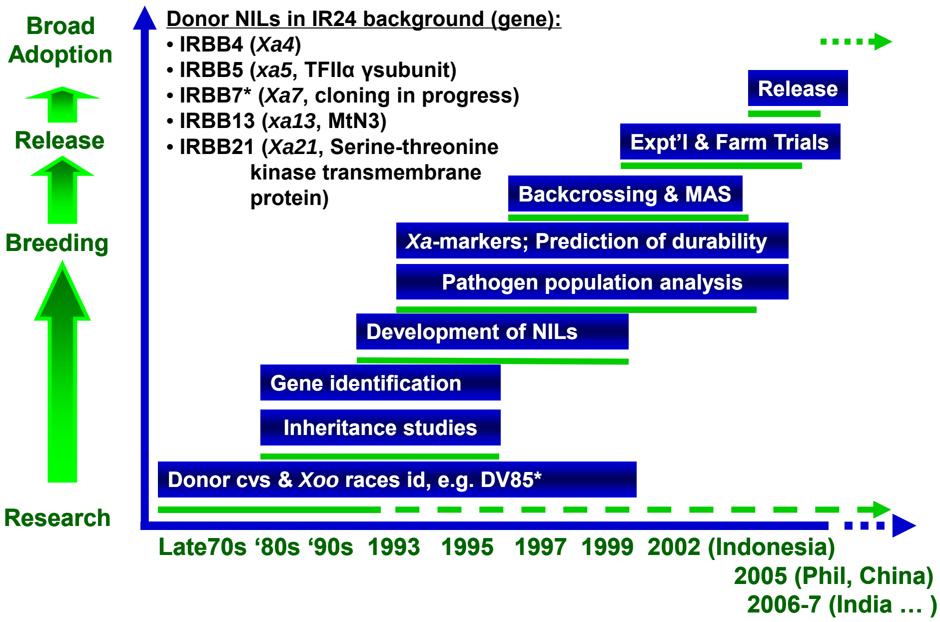
New *Sub1* lines after 17 days submergence in the field at IRRI



Bacterial Blight: form gene discovery to varietal release



Taking some tricks from other grasses

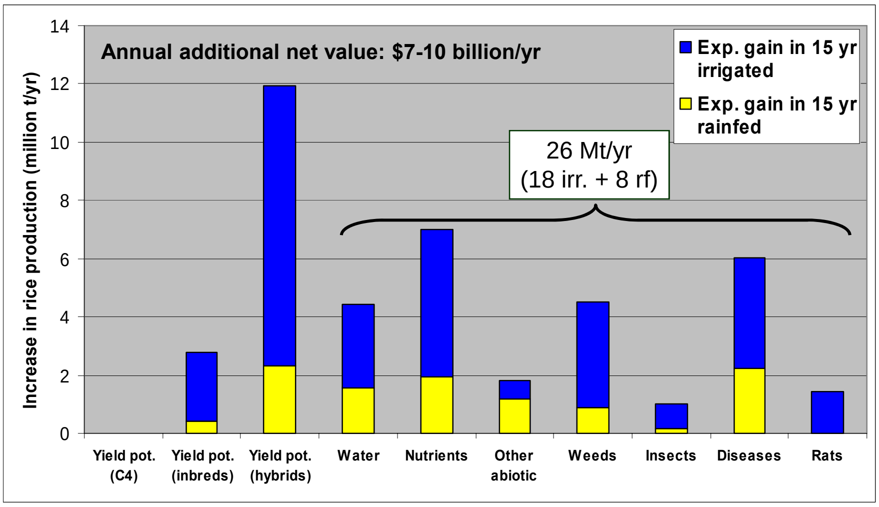
Rice (C3) → (C4)

30-50% more yield
Greater WUE
Greater NUE

15 years
>$150 million

C3 + Anatomy Change + Biochem Change + Fine Tuning = C4

Ex ante assessment for South Asia



Adoption (%): 0 5-10 20 30-35 20-30 20-35 20-30 15-20 20-40 20

Based on expected actual adoption in 15 years

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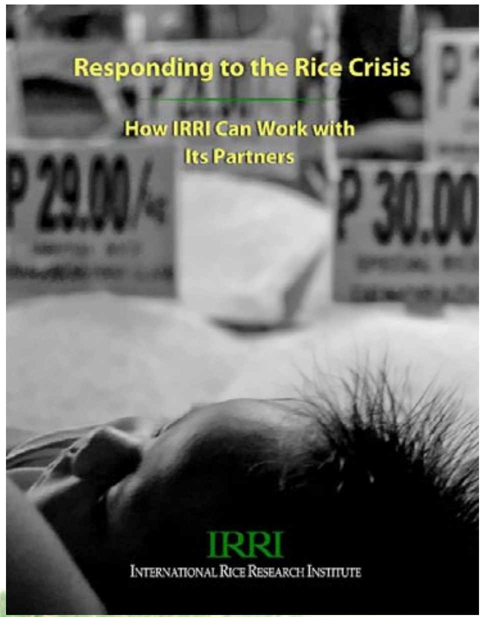
1. Agronomic revolution to close existing yield gaps
2. Delivery of new post-harvest technologies
3. Accelerate variety replacement
4. Strengthen breeding and NRM research for the future
5. Tap the vast genetic reservoir
6. New generation of rice scientists & professionals
7. Infrastructure investments
8. Policies that support productivity growth
9. Strengthen food safety nets for the poor



Long-term continuous cropping experiment (LTCCE)

- Located at IRRI, Los Baños, Philippines
- The most intensively cropped experimental site in Asia
- 3 rice crops per year since 1963
- Managed with BMP
- Huge scientific and educational value

✓Sustainable rice production at 80% of yield potential: 18-20 t/ha/year
✓Minimum, safe pesticide use
✓High N use efficiency
✓Increasing soil organic matter

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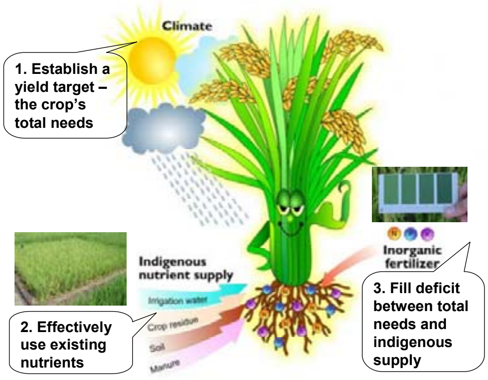
Site-Specific Nutrient Management (SSNM)

- +10 years public-private sector partnership
- Generic principles for rice, maize, wheat
- Simple rules and tools for tailoring to local needs
- 10% more yield + profit
- 30-50% higher NUE
- Sustainable nutrient budgets
- Environmental benefits



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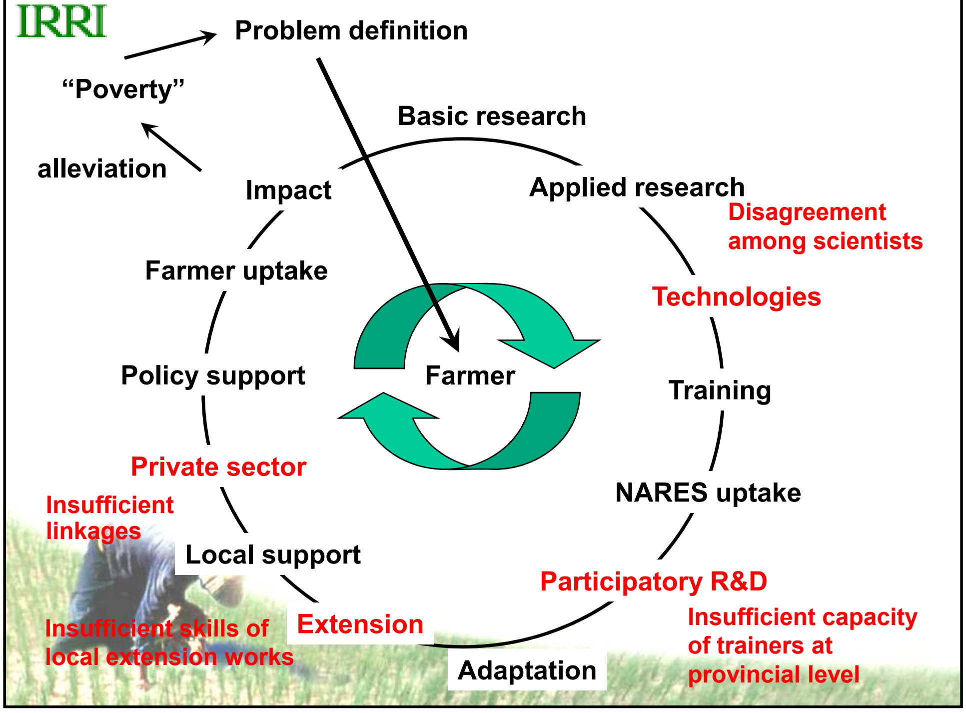
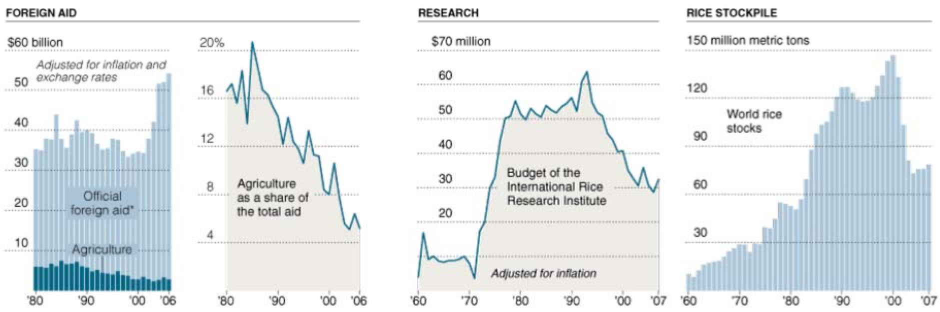


IRRI

The New York Times

Losing Focus on Food Production



*Does not include some figures that fluctuate sharply, like humanitarian aid.

THE FOOD CHAIN

World's Poor Pay Price as Crop Research Is Cut

By KEITH BRADSHER and ANDREW MARTIN

Published: May 18, 2008

May 18, 2008

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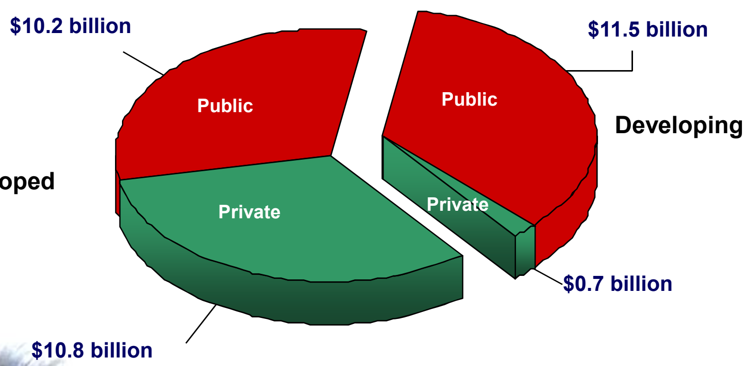
Global Investment in Agricultural R&D in 2000



D. Byerlee et al., www.worldbank.org/WDR2008

IRRI

What should the fertilizer industry do?

- Focus on nutrient use efficiency – BMPs and and tools based on scientific principles
- Connect millions of farmers in the developing world to better information and service
- Enter Africa
- Provide leadership and long-term support for R&D and capacity building

IRRI

Public sector investments in agricultural research and extension will not be sufficient to re-vitalize and sustain productivity growth

IRRI

A call for PEIRS: Partnership for Ecological Intensification of Rice Systems

- Managed by the IRRI Foundation
- High quality agronomic research on BMP for high-yielding, resource-efficient rice-based systems
- Support for long-term studies
- Capacity building for public and private sector
  - Graduate scholarships with leadership training
  - Specialized training courses
  - Professional certification programs (CCA)
- South – south technology and information transfer
- Impact assessment, policy briefs and public awareness

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