



Green Revolution in Asia and its Sustainability

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November 25, 2005



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In the 1950s and the early 1960s in Asia, population grew rapidly, grain yield was stagnant, and uncultivated land was being exhausted. Therefore, there was serious fear of famine in Asia.

- American Ambassador, Prof. Edwin O. Reischauer, argued in the mid-1960s that young Japanese should consider this difficult issue seriously and contribute to the solution.
- Contemporary Sub-Saharan Africa is similar to tropical Asia several decades ago.

Figure 1. Changes in Cereal Yield (ton per ha) in Sub-Saharan Africa and South/Southeast Asia

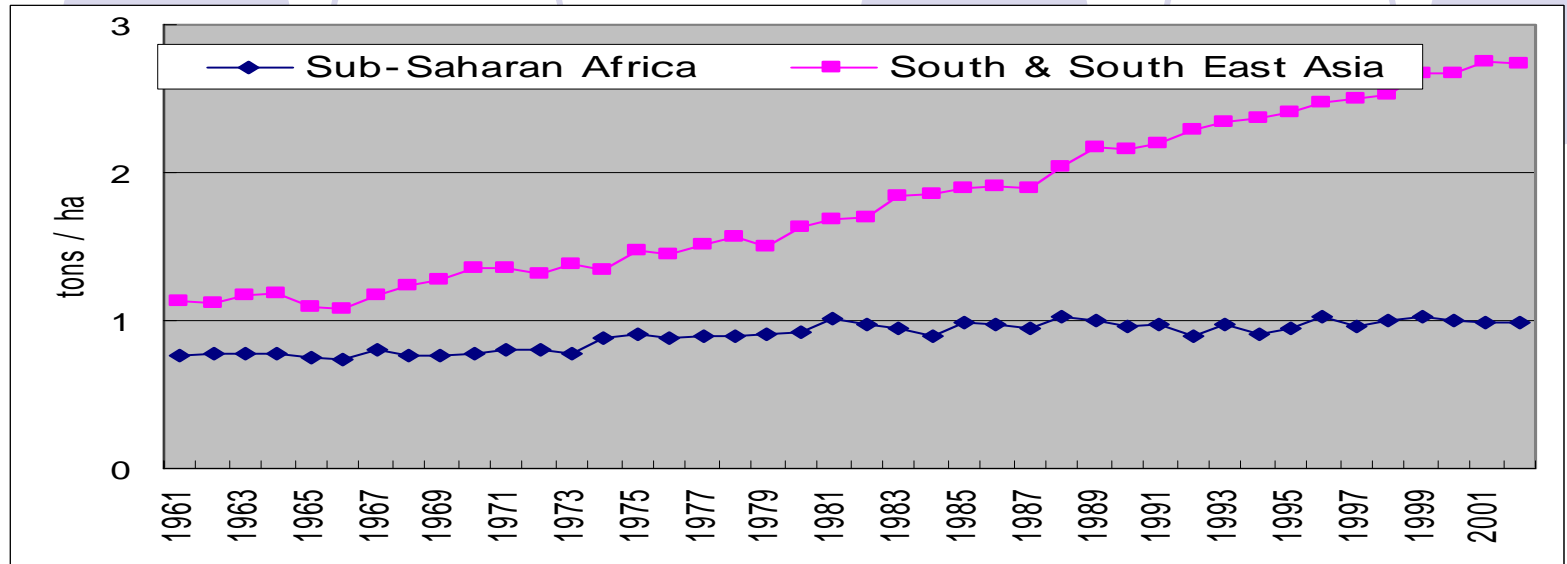
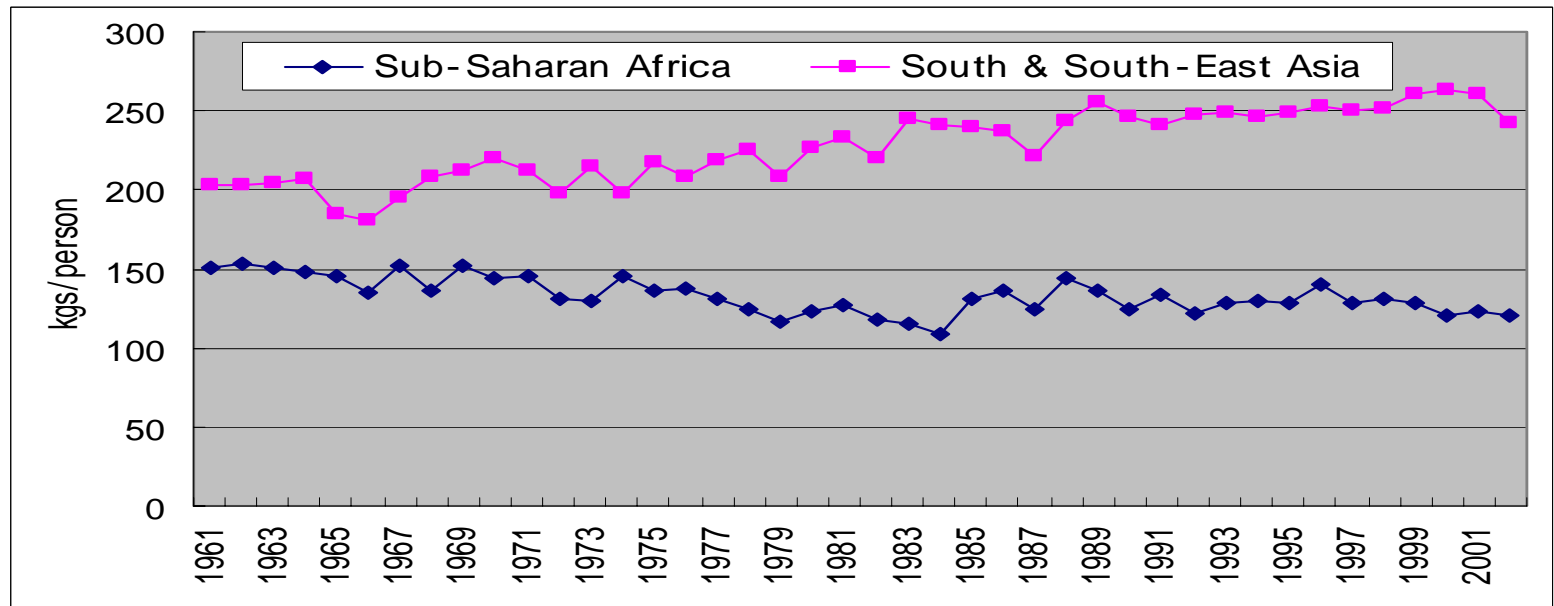


Figure 2. Cereal Production per person in Sub-Saharan Africa and South/Southeast Asia



What Is the Asian Green Revolution?

Development and diffusion of a series of fertilizer-responsive, short maturing, non-photoperiod sensitive, high-yielding modern varieties (MVs). GR is also called seed-fertilizer revolution.

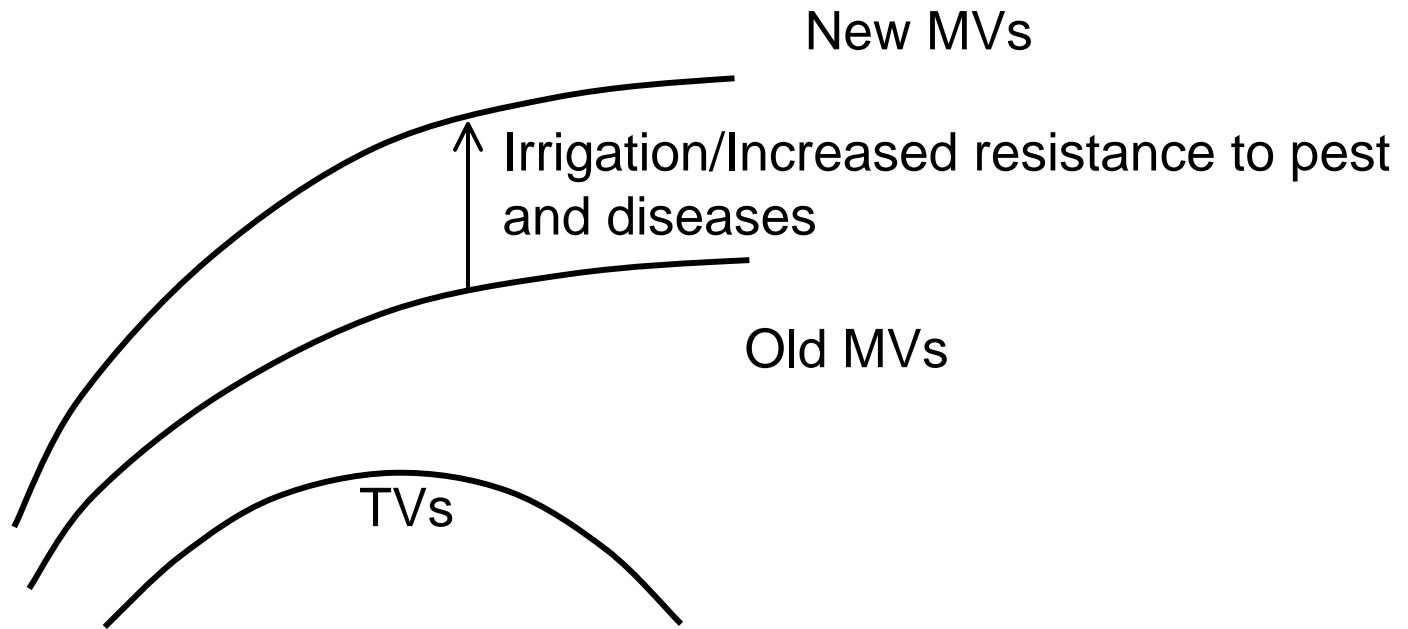
MVs are products of cross-breeding between semi-dwarf, high-yielding varieties in temperate or semi-tropical zone (e.g., Taiwan) and tall, low-yielding, but disease-resistant local varieties in tropics (e.g., Indonesia).

Comparison of IR8, the original shorter modern rice variety, with Peta, a traditional tall variety and one IR8's parents (1st two photos); lodging (bottom photo)



Figure 3. Yield Curves of Traditional Varieties (TVs) and Modern Varieties (MVs)

Yield/Ha



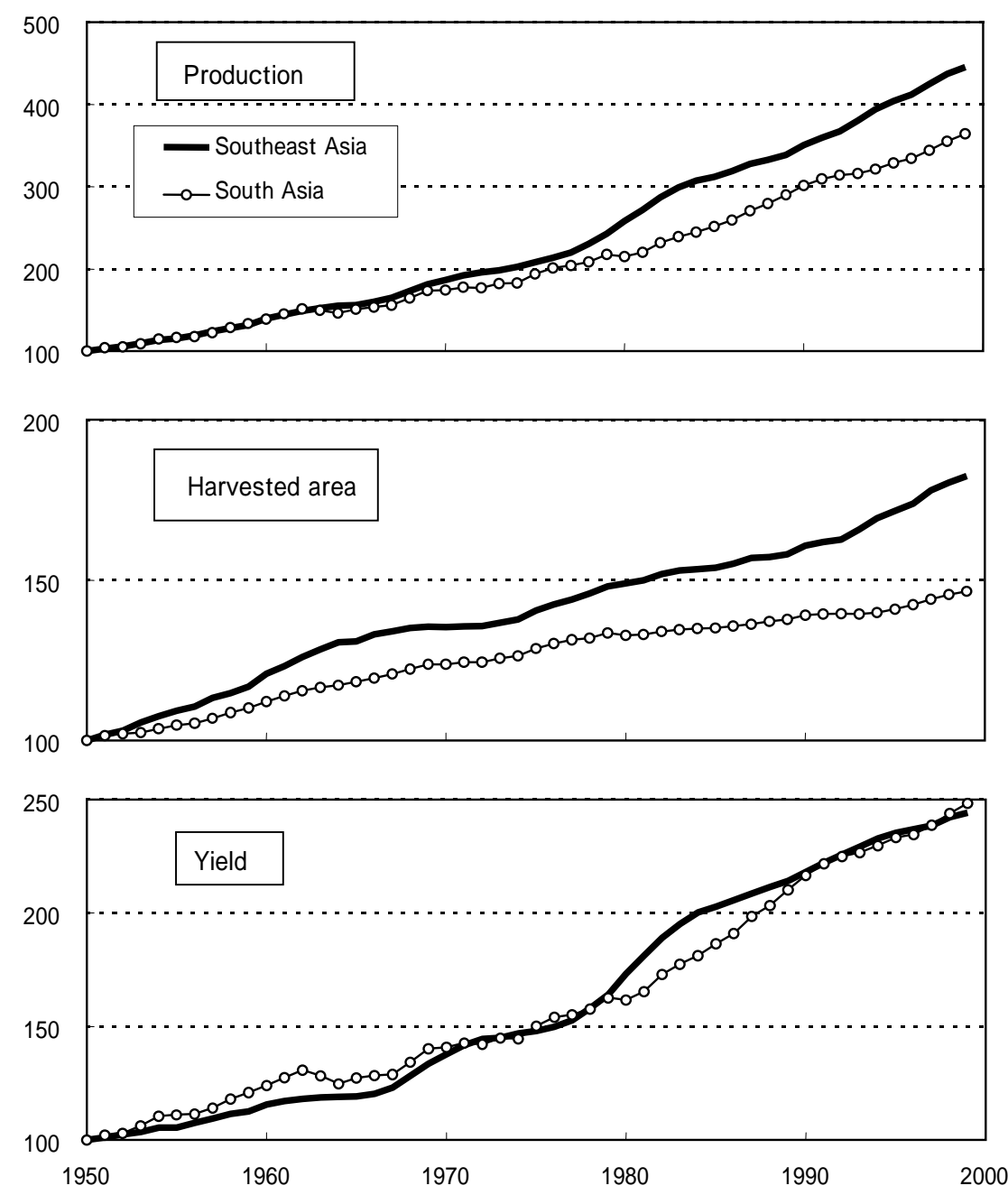
Fertilizer/Ha

Why Is International Agricultural Research So Important?

- MVs and research knowledge on rice and wheat production are “international public goods,” useful across country borders.
- If left to national agricultural research programs, there will be under-investment in research from global point of view.
- That is why international agricultural research centers, such as IRRI and CIMMYT, led the Asian Green Revolution.
- Rates of return to investment in international agricultural research are extremely high, reflecting underinvestment.

Figure 4. Changes in rice production, harvested area, and yield per hectare in Southeast Asia and South Asia

Five year moving average (index:1950=100),1950-99



Significance of Asian Green Revolution

- Rice yield per ha doubled, rice cropping intensity increased roughly by 50%, and, as a result, rice production tripled since the mid-1960s. This is undoubtedly historical revolution.
- If rice yields today were the same as in 1965, more than 135 million additional hectares of land, roughly the same as actual paddy fields, would need to be devoted to rice. This would mean large-scale deforestation and widespread famine.

Figure 5. Changes in rice yield in major rice- growing Asian countries, 1950-2000.

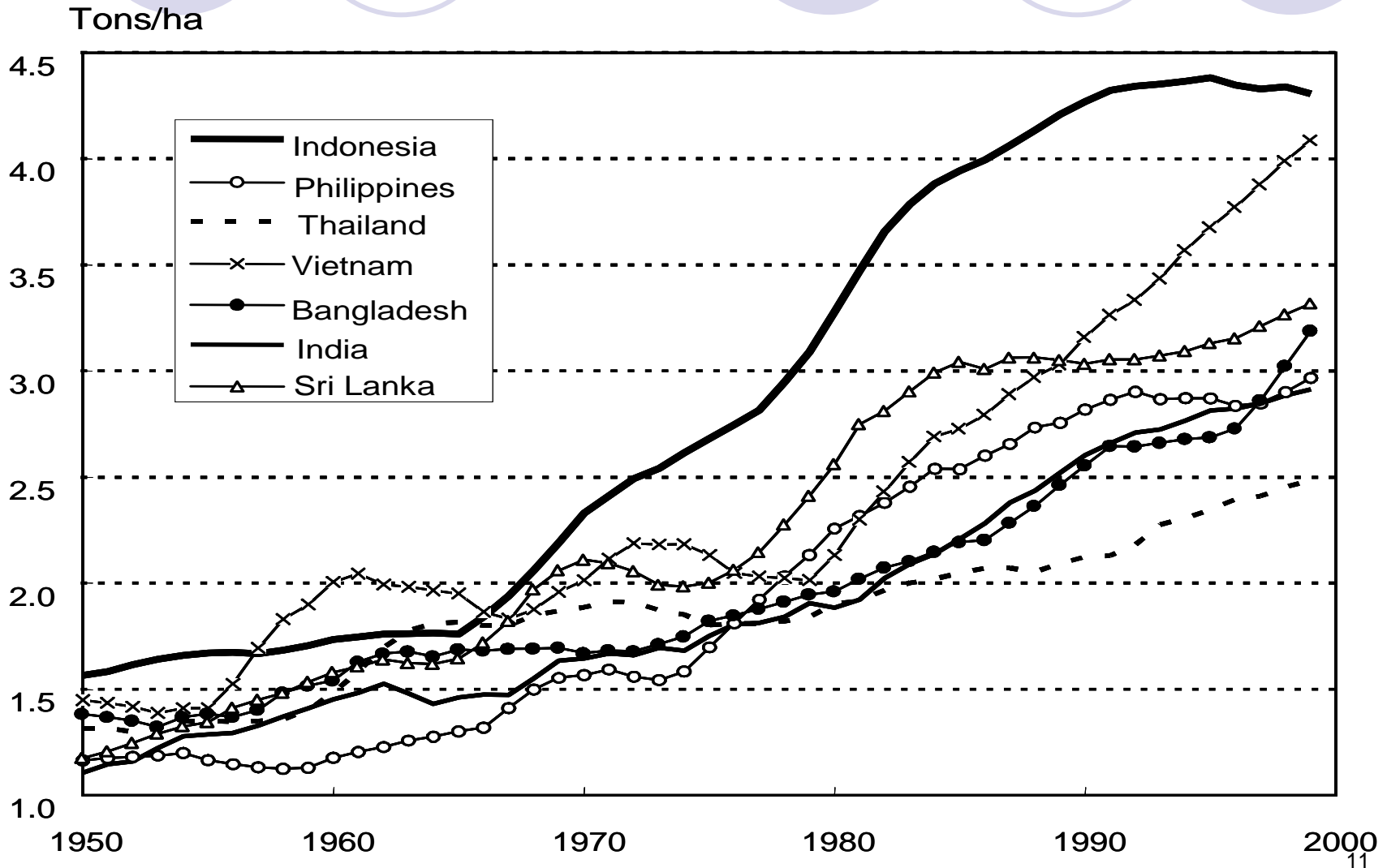


Figure 6. Green Revolution in Japan: Rice yields per hectare in Japan, Taiwan, and Korea, 1895-1935

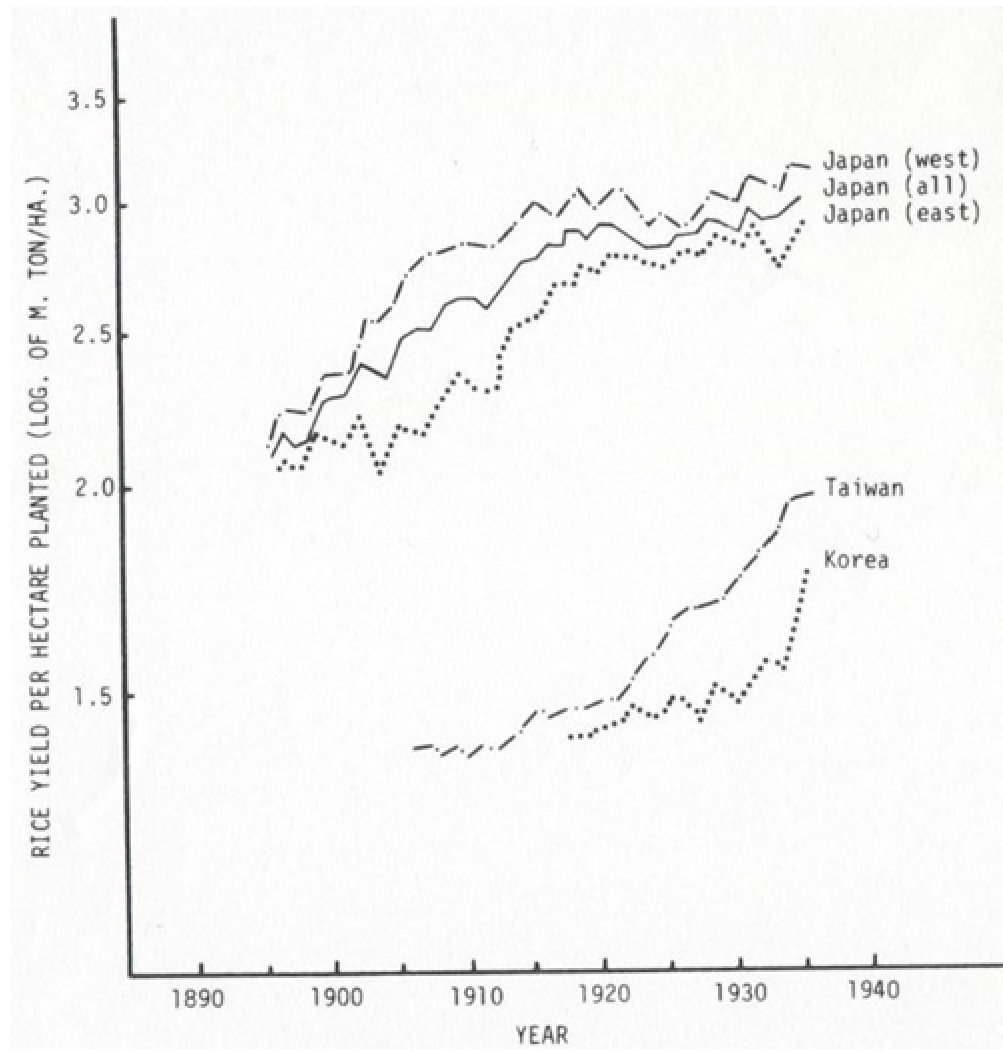
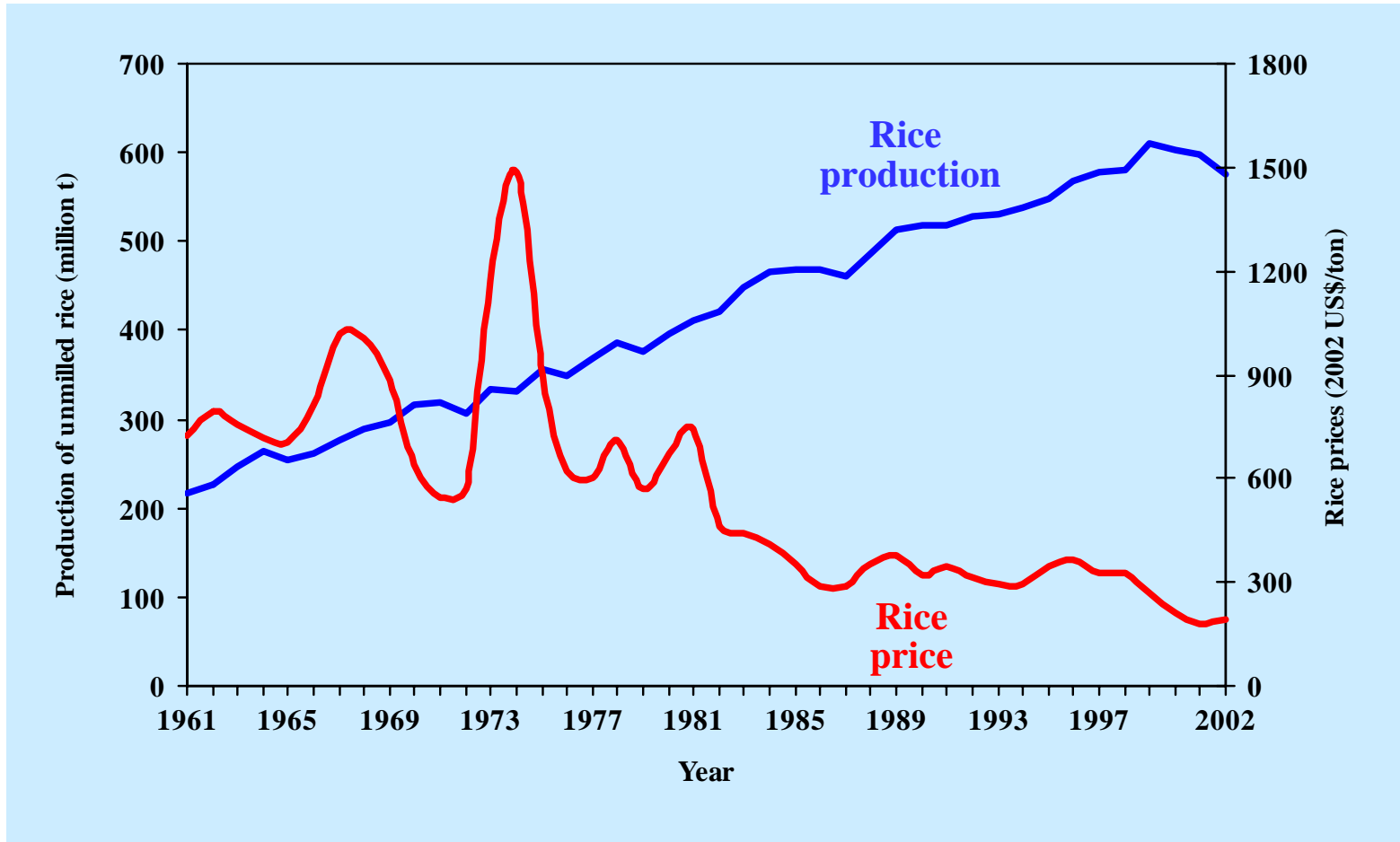


Figure 7. Trends in world rice production and price adjusted for inflation, 1961-2002



Source: Production: FAOSTAT Electronic Database, FAO.10June2003

Rice Price: Relate to Thai rice 5%-broken deflated by G-5 MUV Index deflator (adjusted based on 2002 data update)

Source: World Bank Quarterly Review of Commodity Markets

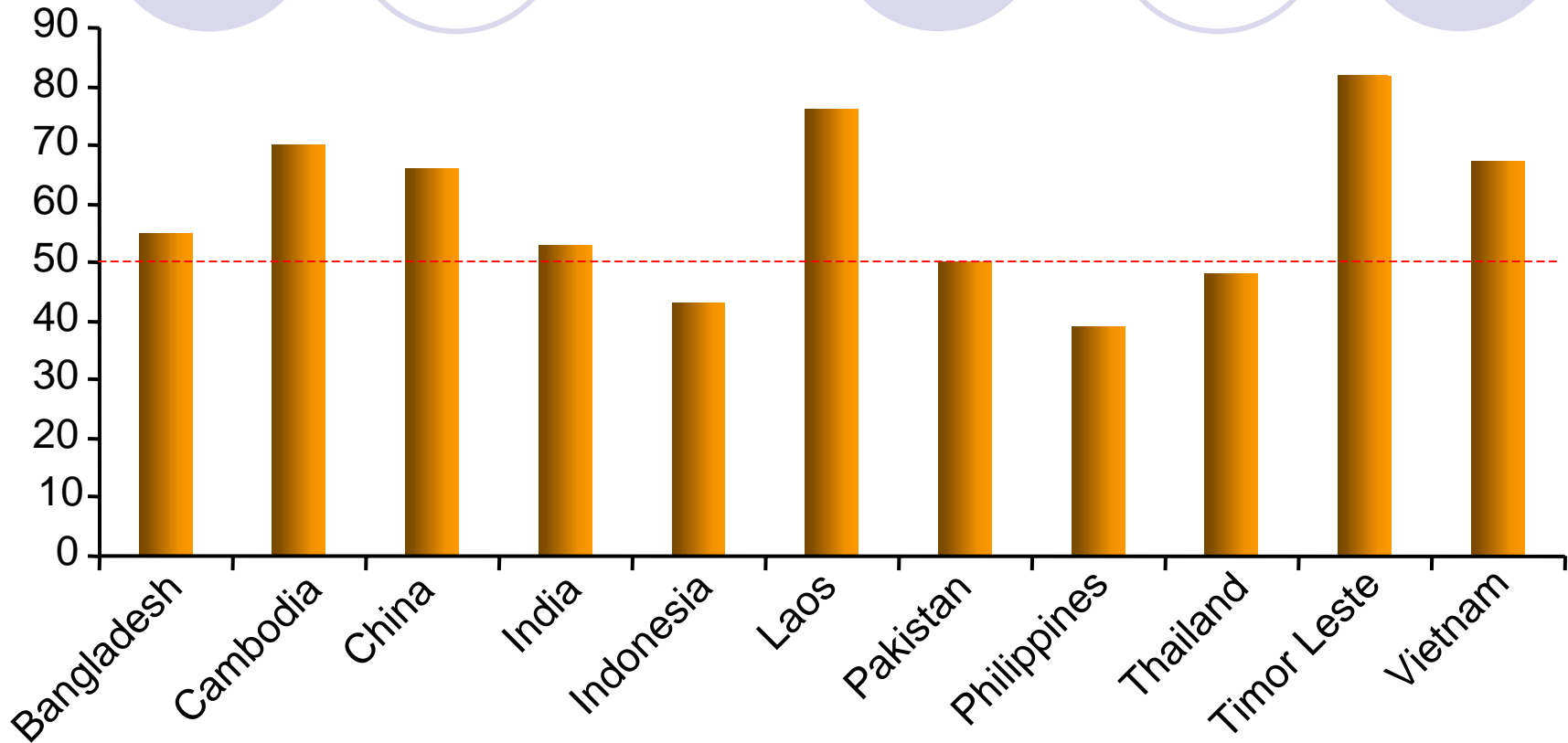
Summary of the Asian Green Revolution

- Continuous development and diffusion of fertilizer-responsive and pest- and disease-resistant MVs made revolution possible.
- IRRI took leadership followed by national agricultural research systems, as IRRI's research outputs were international public goods.
- MVs are particularly high-yielding in favorable areas, such as irrigated areas and shallow rainfed areas.
- There is, however, a strong sign that the GR is ending.
- MV adoption rate now is 70-75% in Asia, implying that nearly 25% of areas has been bypassed by the GR.
- Such unfavorable areas are primarily drought-prone areas, where people are particularly poor.

Can We Afford to be Complacent?

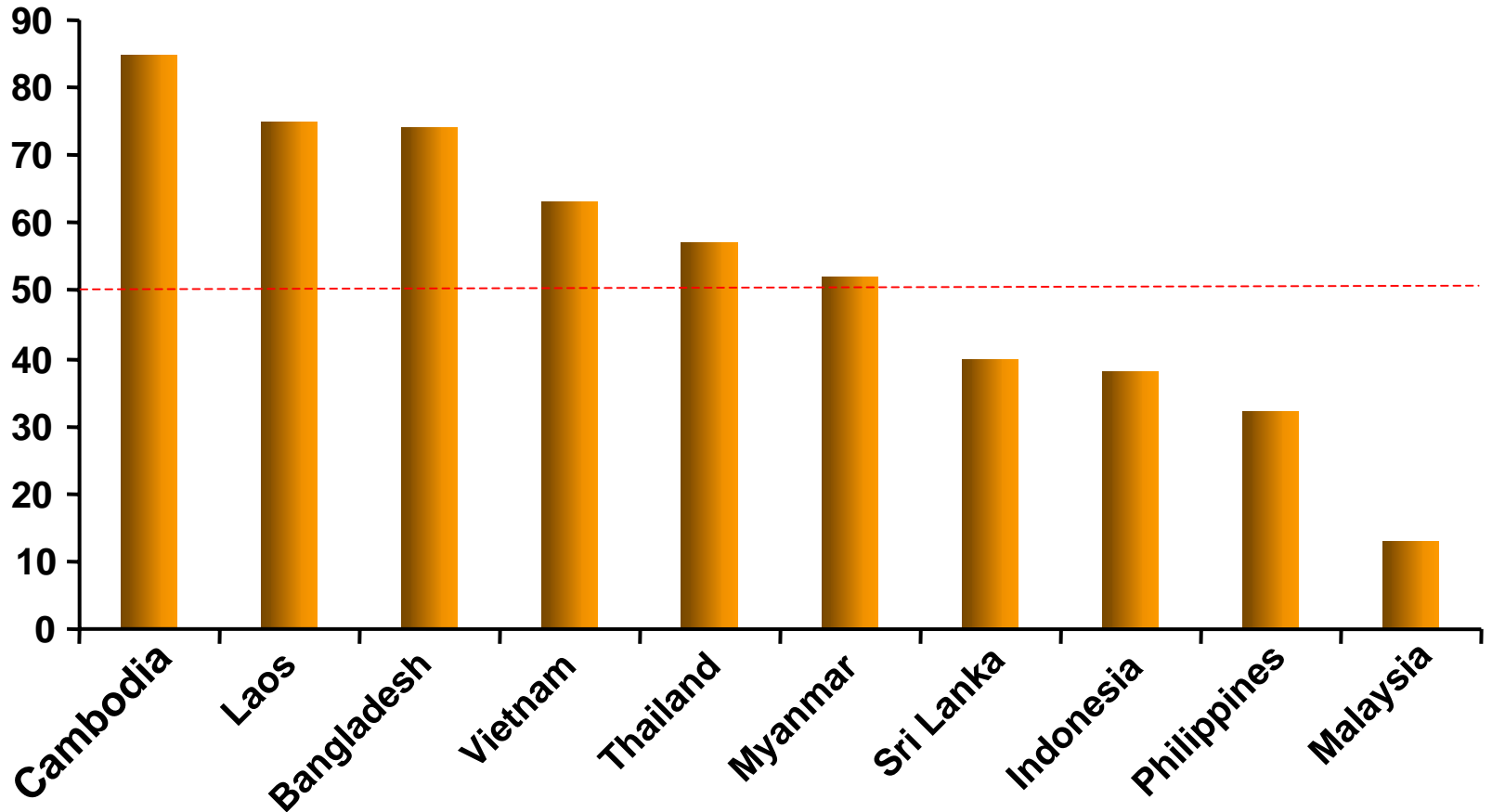
- Millennium Development Goal No. 1: Reduce poverty to one-half by 2015.
- Some 70% of the world poor, or a little more than 750 million poor, live in rice-growing areas of Asia.
- Many of them work on rice farms.
- Many of them eat a lot of rice (usually more than 100 kg per person per year).
- There are many factors adversely affecting rice production; e.g., climate change and rising prices of chemical fertilizer.

Figure 8. % population employed in agriculture, 2001



...and employment for many.

Figure 9. % agricultural land under rice



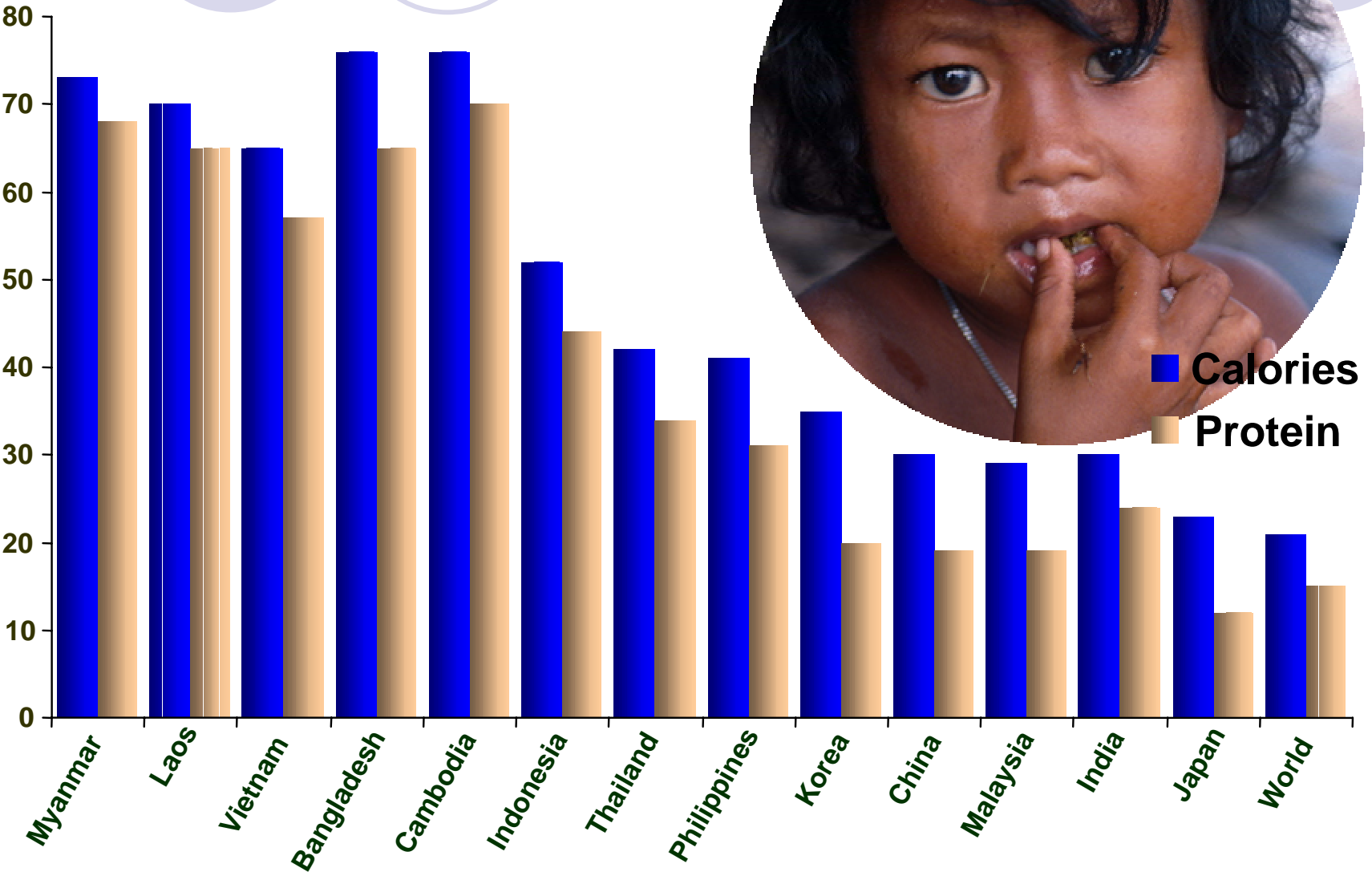


...and nearly all of them eat rice two or three times a day!

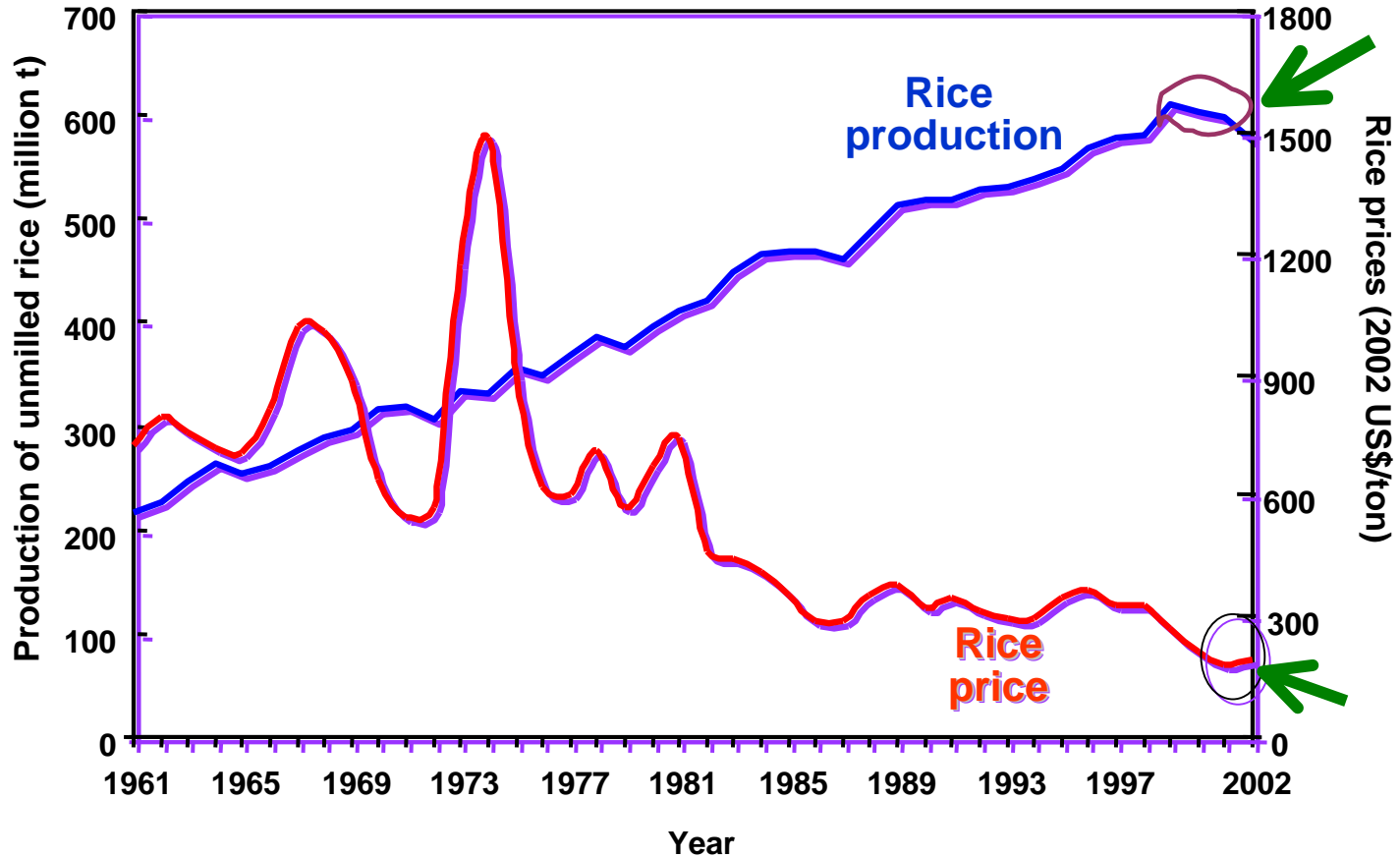
90% of the world's rice is produced and consumed in Asia.

Current annual demand for rice in Asia is 533 million tons of paddy (346 million tons of milled rice). Japan consumes about 8 million tons. Ten years from now, Asia will need additional 53 million tons of paddy.

Figure 10. Nutrition from rice
(selected Asian countries, 1999)



Reexamination of Figure 7

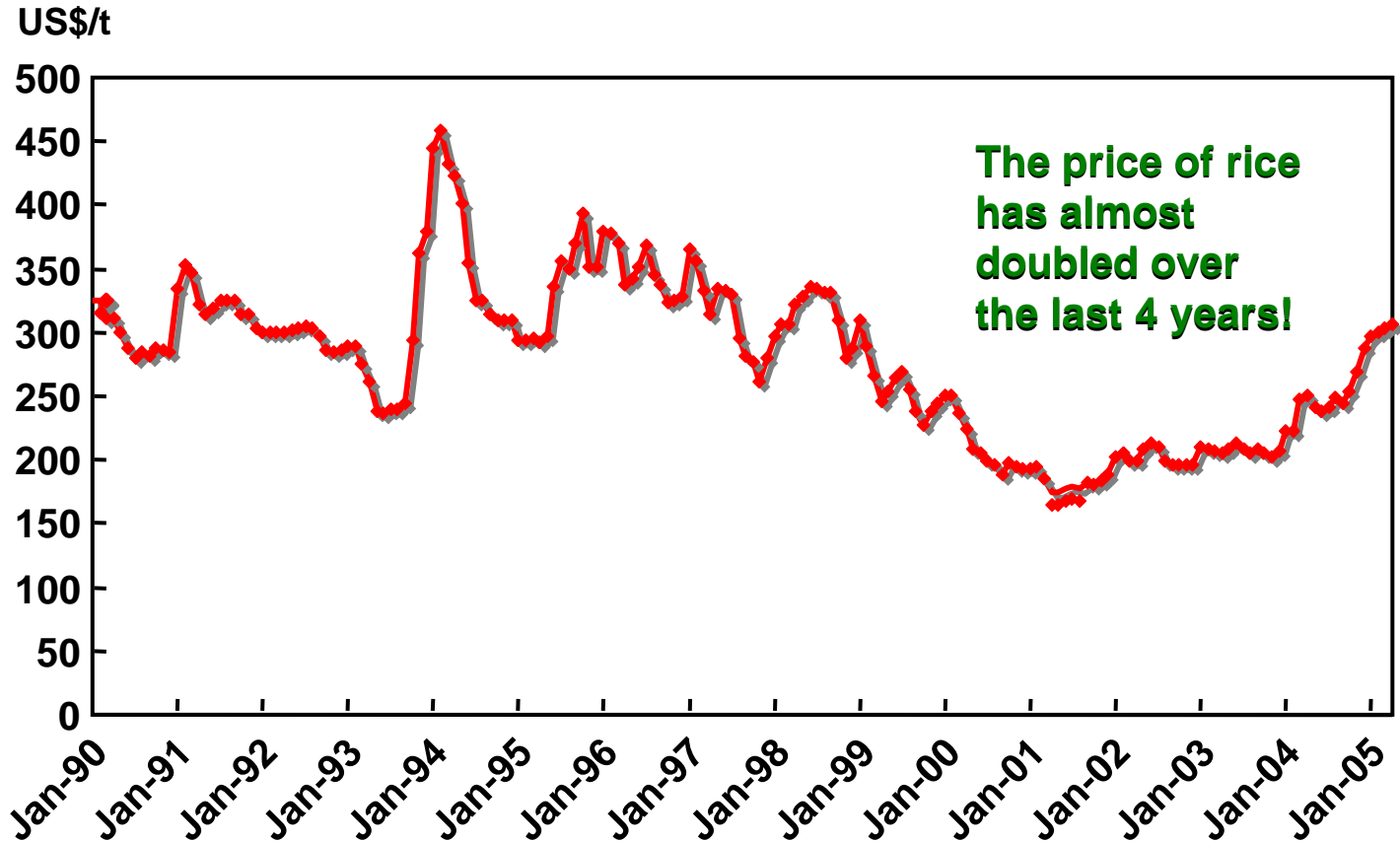


Source: Production: FAOSTAT Electronic Database, FAO.10June2003

Rice Price: Relate to Thai rice 5%-broken deflated by G-5 MUV Index deflator (adjusted based on 2002 data update)

Source: World Bank Quarterly Review of Commodity Markets

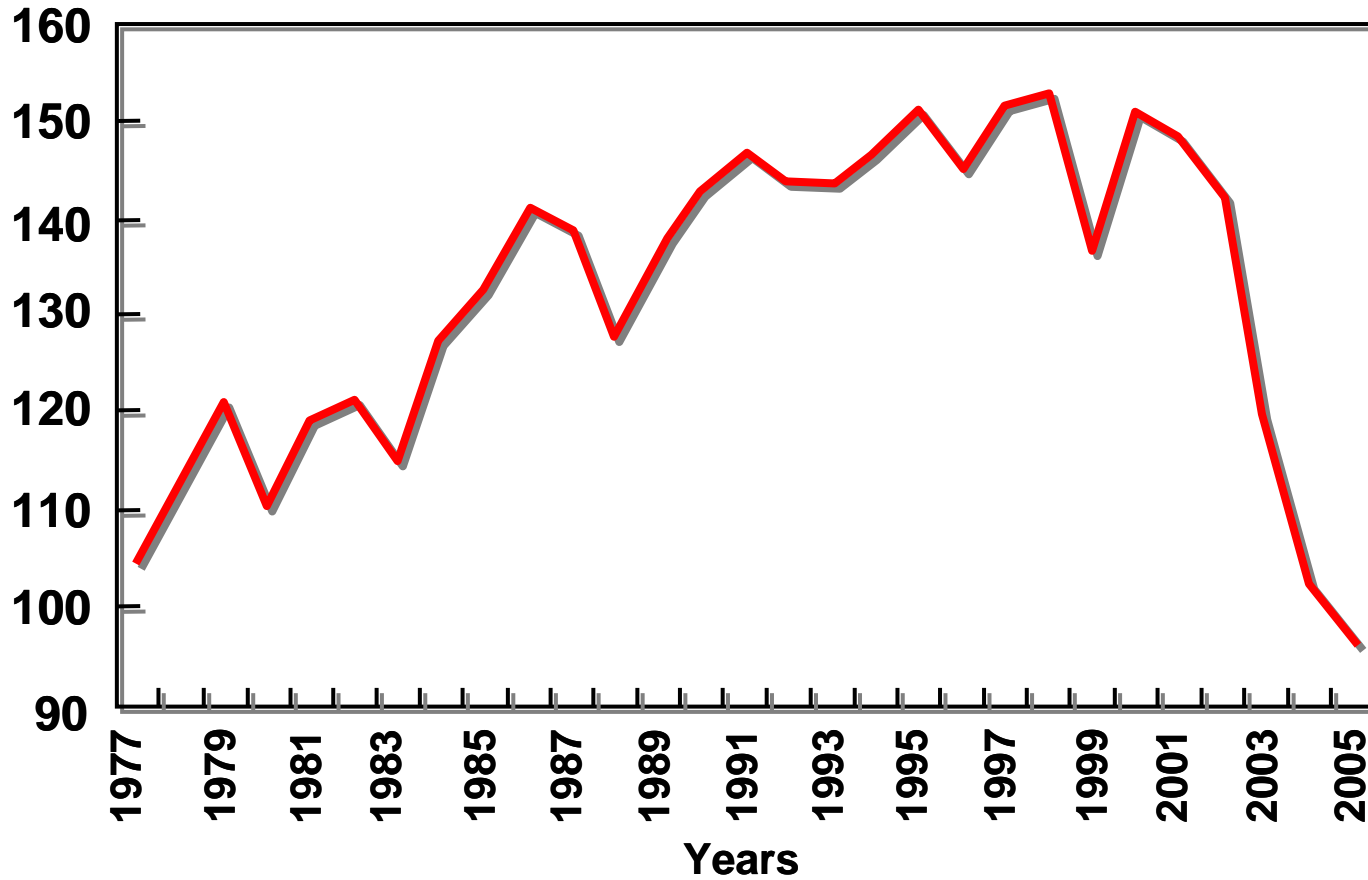
Figure 11. Monthly export price (US\$/t free on board) of Thai rice, 5% broken, January 1990 to April 2005



Source: The Pink Sheet. World Bank.

Figure 12. World Rice Stocks

Millions tons

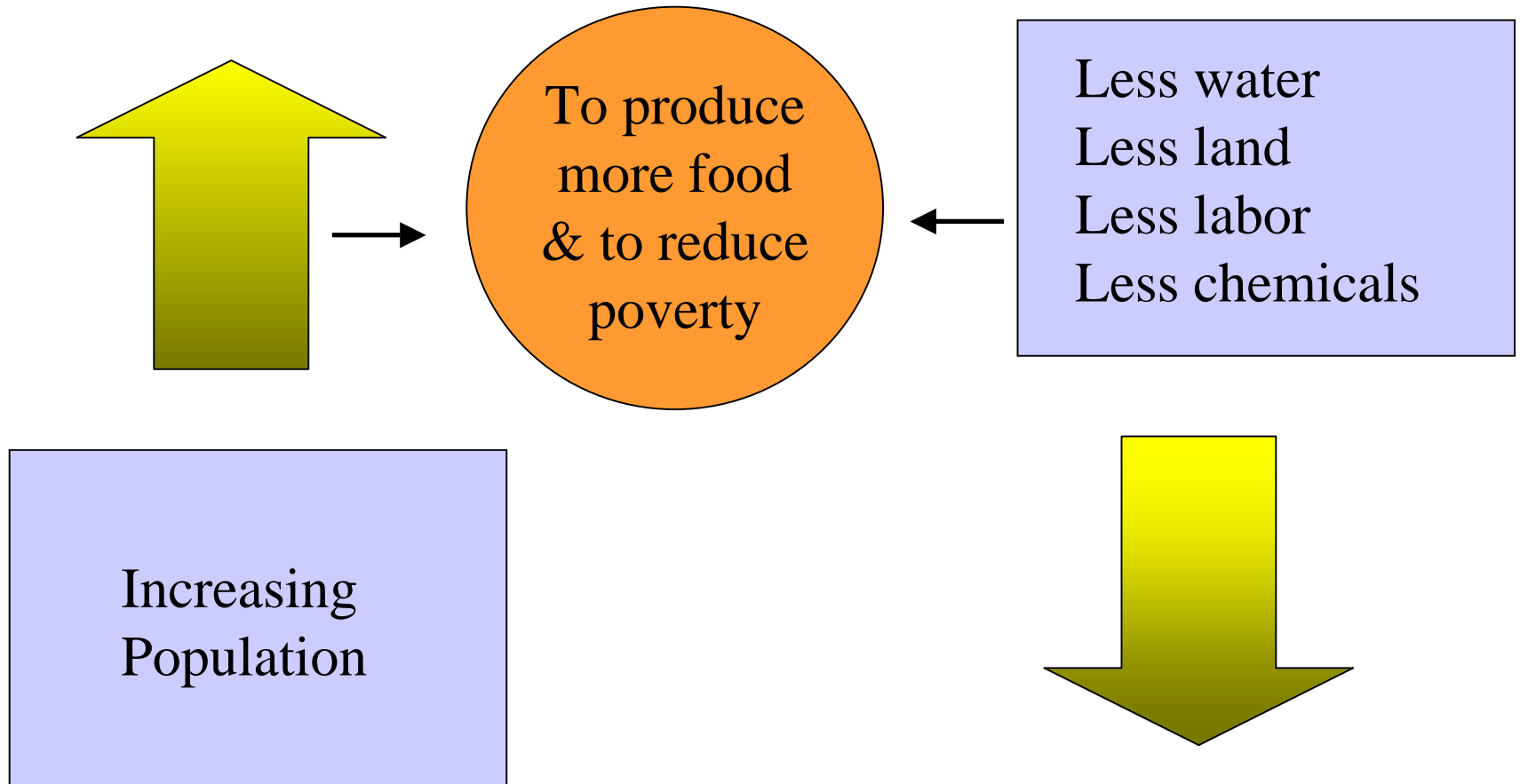


The slide features a decorative arrangement of five circles. Three solid light purple circles are positioned in the top row, and two hollow light purple circles are in the bottom row. The text is centered over these circles.

USDA Predicts 20 Million Tons of Global Rice Supply Shortfall for 2005

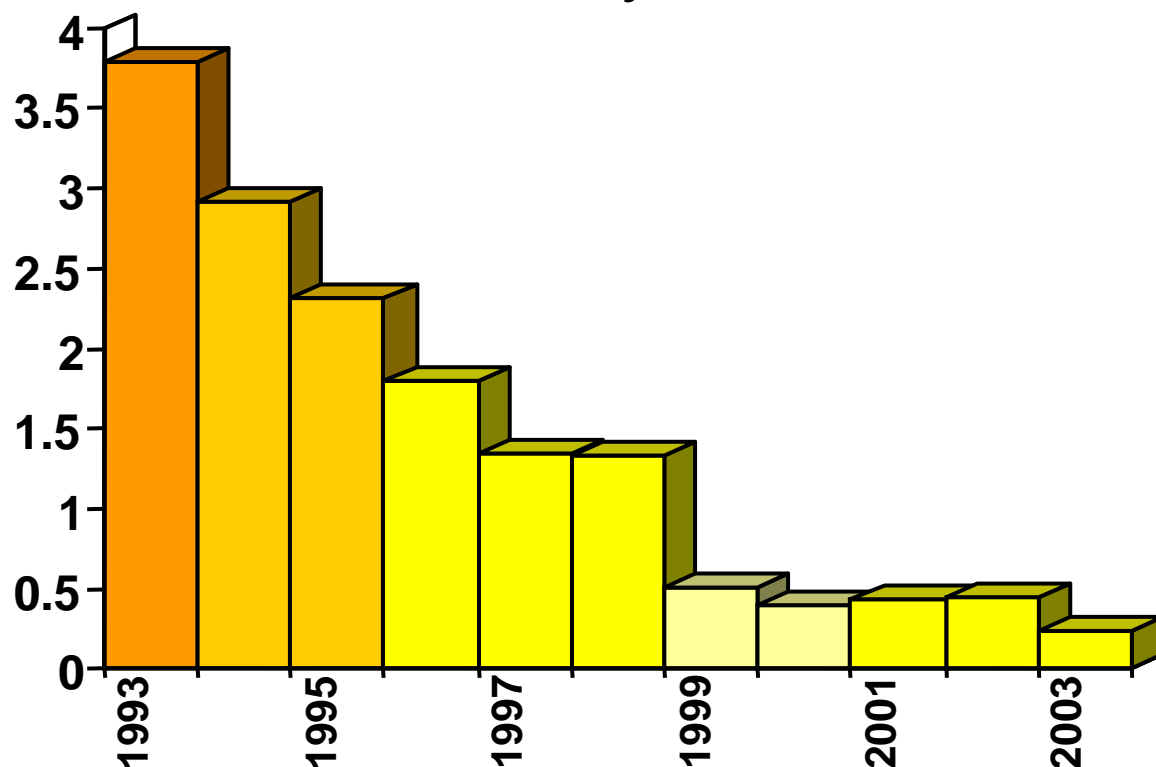
**What will that mean for world
rice prices?**

New Challenges in Asia



Labor can easily be substituted for by machines without affecting output, while pesticide use can be reduced by integrated pest management (e.g., selective spraying).

Pesticide use in IRRI's experimental fields dropped by 95% over the last 10 years



The water challenge

- **Nearly 90% of the fresh water diverted for human use in Asia goes to agriculture and, of this, well more than 50% is used for irrigate rice.**
- **It took 6 tons to produce 1 kg of rice before GR. It now takes 2 tons of water to produce 1 kg of rice!**
- **There is growing competition from cities and industry for available water supplies.**
- **Under the current technology, output deceases by 20%, when water use is reduced to 1/2.**
- **To reduce water use in irrigated paddy fields is the most cost-effective way to solve water shortages in future.**



Options – better water management and new rice varieties

- **Better irrigation management practices to use less water, such as alternate wetting and drying.**
- **New varieties that better tolerate drought (e.g., cross between low-land and upland rice varieties, see photo of aerobic rice).**



Towards the Second Green Revolution

- “Gene Revolution” makes it possible to develop (1) water-saving technologies for irrigated areas, (2) drought-tolerant, high-yielding varieties for unfavorable rainfed areas, and (3) pest- and disease-resistant varieties, ***e.g., by crosses between wild rice and cultivated MV rice so as to transfer useful genes for drought-tolerance and pest-resistance to MVs.***
- As in the first Green Revolution, the second Green Revolution requires the initial innovations by IRRI, which are international public goods.

The most difficult challenge is to save the use of chemical fertilizer while increasing or maintaining rice output. This seems contradictory.

- But oil prices will continue to increase sharply and, hence, prices of chemical fertilizers will also increase rapidly.
- The use of organic fertilizer (e.g., manure and plants with capacity to fix nitrogen) has never been accepted widely by Asian rice farmers, because of the high labor cost.
- Development of rice having capacity to obtain nitrogen from bacteria is one possible solution.

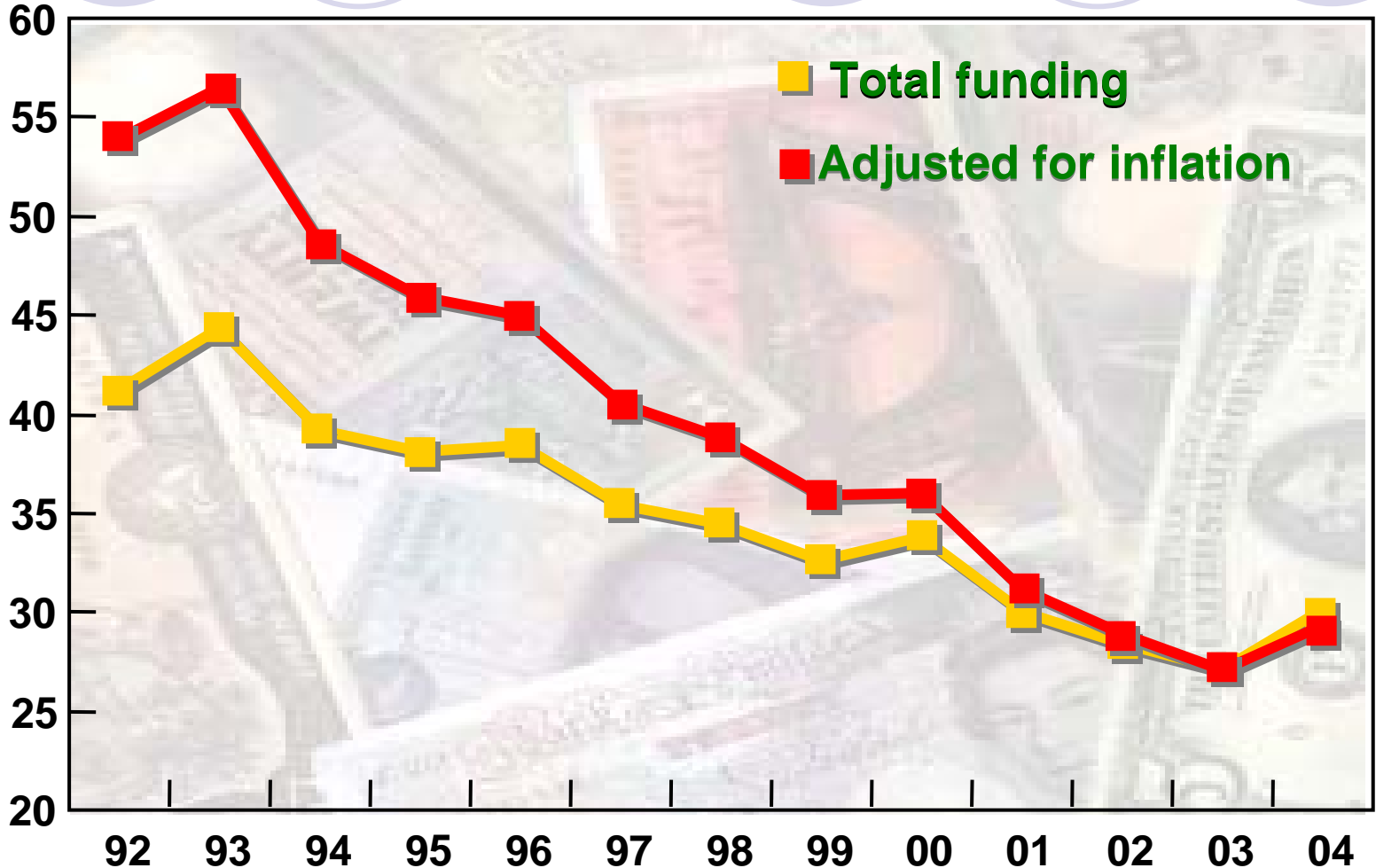
Is the Second Green Revolution (SGR) Possible?

Without SGR, Asia cannot feed itself, using less land, less water, and less chemicals. SGR, however, is possible if proper support is given to agriculture in general and rice research in particular.

But reality is

Support for rice research at IRRI, 1992-2004

US\$ (millions)





Concluding Remarks

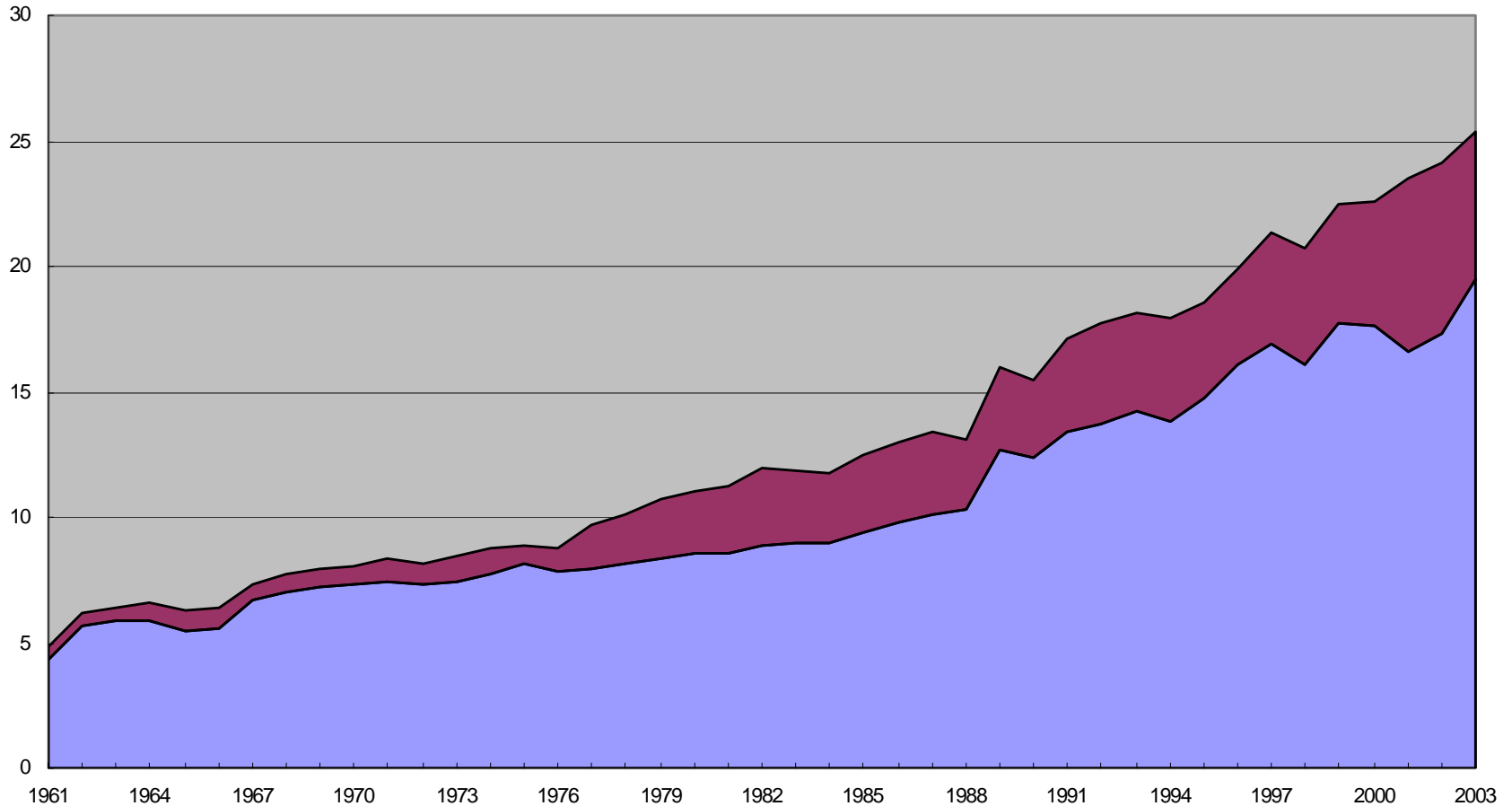
- In order to reduce poverty and achieve food security, we must produce more rice with less land, less water, and less chemicals in Asia.
- Using modern science, it is scientifically possible to do so, provided that sufficient investments are made.
- SGR, if successful, can contribute to the poverty reduction not only in Asia but also in SSA, where rainfall is low and unpredictable.

Appendix

Possibility of (Rice) Green Revolution in Sub-Saharan Africa: Lessons from Asia

1. Need fertilizer-responsive varieties
2. Need fertilizer, be it chemical or organic (organic is recommended as chemical fertilizer is often prohibitively expensive)
3. Need drought-tolerant varieties, which can be transferred from Asia, if the SGR is successful
4. Need to invest in international agricultural research

Rice Production and Imports (million tons) in Africa, 1961-2003



Possibility of NERICA (New Rice for Africa) Revolution

- NERICA is “miracle” rice, bred by cross-breeding between African and Asian upland rice varieties.
- Like MVs in Asia, NERICA is fertilizer-responsive, short maturing, and high-yielding varieties.
- Average yield of upland rice in SSA is 1.0 ton per ha.
- In Japan upland rice yield increased from 1 ton per ha in the late 19th century to 2 tons per ha in the late 20th century.
- According to FASID survey in Uganda, average yield of NERICA was 2.6 tons per ha without fertilizer. If grown after tobacco, to which a lot of chemical fertilizer was applied, yield was as high as 3.3 tons per ha.

NERICA in Uganda



Is NERICA Revolution Possible?

- NERICA is promising, but adaptive national research programs and extension systems are so weak in SSA. They need to be strengthened.
- How to maintain soil fertility is the key to the success of the NERICA Revolution, as NERICA effectively absorbs soil nutrients.
- Unlike lowland rice, upland rice cannot be grown continuously, because of the deterioration of soil fertility.
- Investments in research and capacity building are essential to realize the NERICA Revolution.

Possibility of Sustainable Yield Growth in Lowland Rice Production in SSA

- Lowland rice is much more sustainable and higher-yielding than upland rice.
- Lowland rice area is rapidly expanding in SSA, as marshy river bottom is the last and vast uncultivated areas.
- Lowland rice has been under-researched.
- Drought-tolerant technology, if successfully developed in Asia, can be transferred to SSA.



Q & A

1. Why are TVs low-yielding?
(a) photoperiod sensitive, (b) tall and thin, (c) totally unresponsive to fertilizer by nature.
2. Why are early MVs less productive than new MVs?
(a) susceptible to pests and diseases, (b) non-resistant to drought, (c) non-photoperiod sensitive.
3. Why didn't GR take place before the mid-1960s?
(a) inadequate investment in national agricultural research systems, (b) non-existence of international agricultural research centers, (c) sufficient food production without GR technology

Q & A

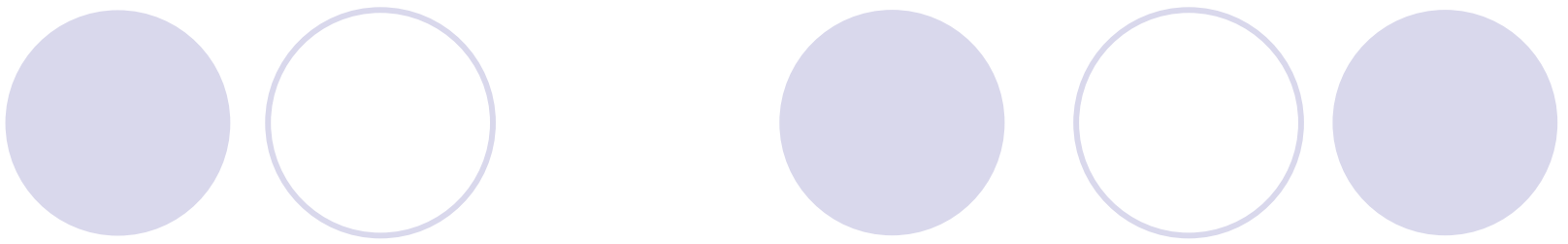
4. What would happen if there was no GR in Asia?
(a) massive deforestation, (b) widespread famine, (c) conversion of large upland areas into paddy land
5. Why has rice production begun declining recently?
(a) increasing water shortage, (b) exhaustion of the potential of Green Revolution, (c) low rice prices
6. Where are the rural poor concentrated?
(a) irrigated, (b) drought-prone, (c) deep-water areas
7. Why didn't GR take place in drought-prone areas?
(a) neglected because they occupy small areas, (b) scientific difficulty to develop drought-resistant varieties, (c) need to prevent famine by increasing rice production in more favorable areas



Q & A

8. What will be the major factors negatively affecting rice production in future?
 - (a) increasing environmental concern with pesticide use,
 - (b) decreasing farm population due to out-migration,
 - (c) increasing prices of chemical fertilizer

9. What should be IRRI's major research strategies?
 - (a) development of drought-resistant technology,
 - (b) development of water-saving technology for irrigated areas,
 - (c) development of technology useful for production environments in Sub-Saharan Africa



Thank you very much for
your attention