

# Impact of rice research on food security and poverty reduction: Lessons learned from my research at IRRI



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# Studies undertaken

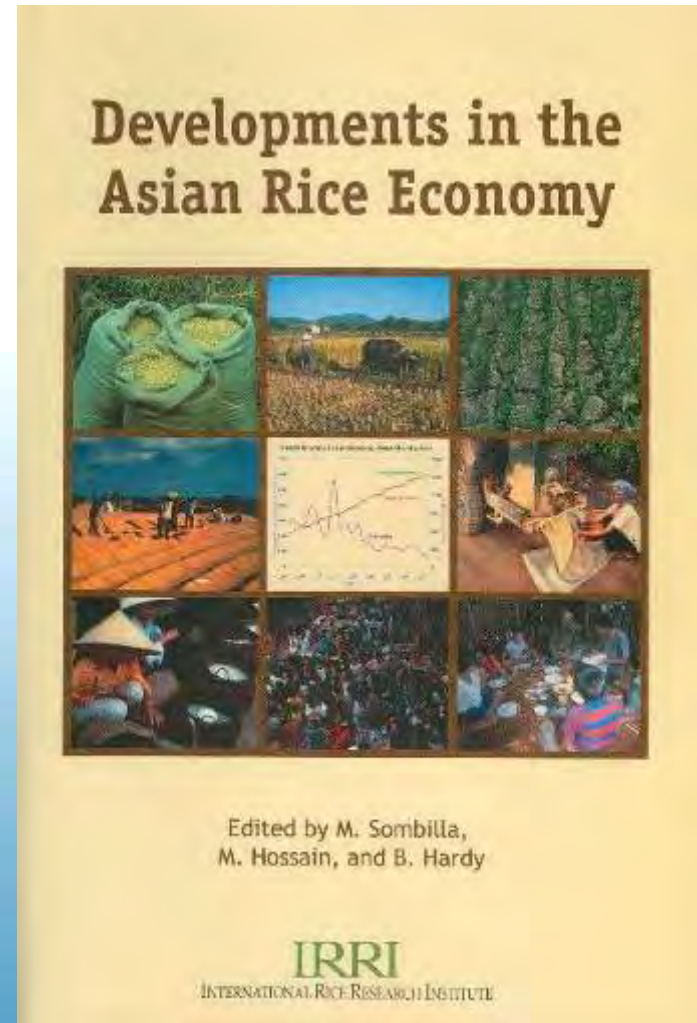
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- Ex-ante impact assessment for research strategy and priority setting
  - 1992-96: Rice supply and demand trends
  - 1994-1998: Constraints to increase in rice productivity
  - 1998-2001: Evaluation of farmers' experience with hybrid rice cultivation
  
- Understanding the context for technology impact
  - 1994 to date: Rural livelihood systems and the technology impact on income distribution and poverty
  - 2000-2004: Determinants of changes in rural livelihood systems in Bangladesh for supporting policy dialogues
  
- Ex-post impact assessment
  - 1998-2001: Impact of IRRI's crop improvement research
  - 2002-2004: Impact of rice research on poverty reduction

# Rice supply and demand trends

## Conclusions

- Growth in demand for rice will slow down substantially over the next two decades
- Growth in supply will also slow down due to pressure on natural resources and better income earning opportunities for farmers from non-rice economic activities
- Effect on the supply-demand balance and the trend in price in the world market will depend on government policies for supporting farm income



# Factors influencing demand for cereals

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- Population growth
- Level and growth of income
- Urbanization
- Changes in relative prices
- Indirect demand in livestock production



# Effect of growth in household income on per capita rice consumption



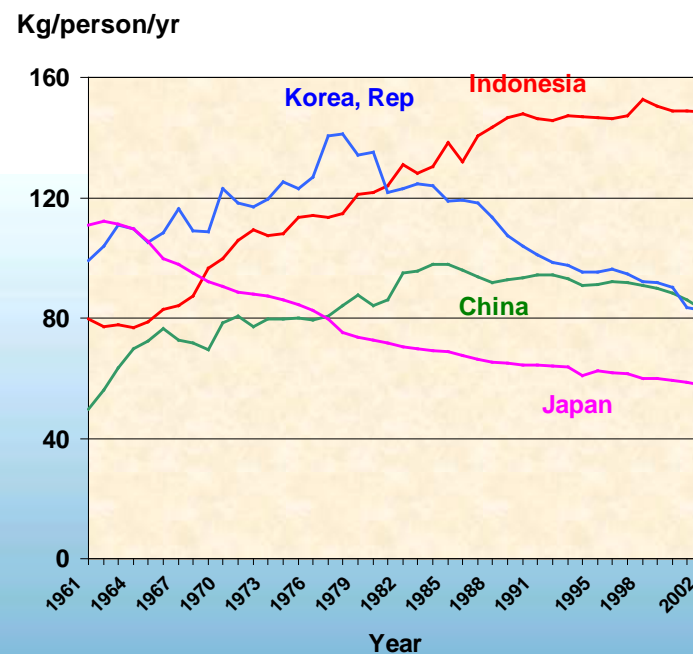
## Changes in consumption pattern South Korea, 1961-2001

(kg/person/yr)

Food item	1961	1981	2001
Rice	99	122	84
Other cereal	78	71	73
Roots & tubers	41	26	15
Oilcrops	5.8	9.4	10.9
Vegetables	76	198	230
Fruits	5.2	26	70
Meat	5.5	19	53
Milk	0.6	9.0	29
Fish	13.2	45	51
Calorie (k.cal)	2147	2926	3055
Calorie from rice	1073	1355	905

Source: FAO, 2004. Food Balance Sheet: <http://apps.fao.org>

## Trend in per capita rice consumption: Japan, Korea, China and Indonesia

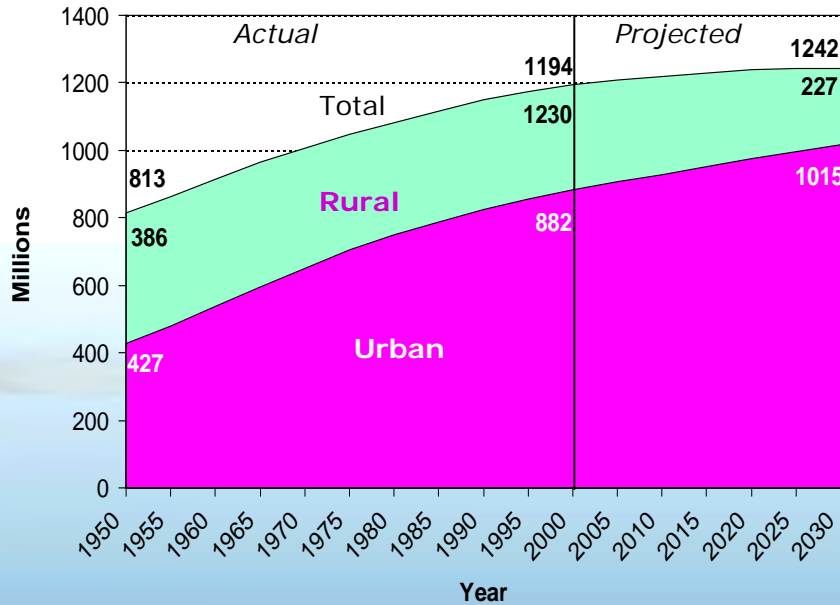


- Economic growth induces change in consumption pattern away from rice to vegetables, fruits, and livestock products
- Per capita rice consumption declines with economic growth

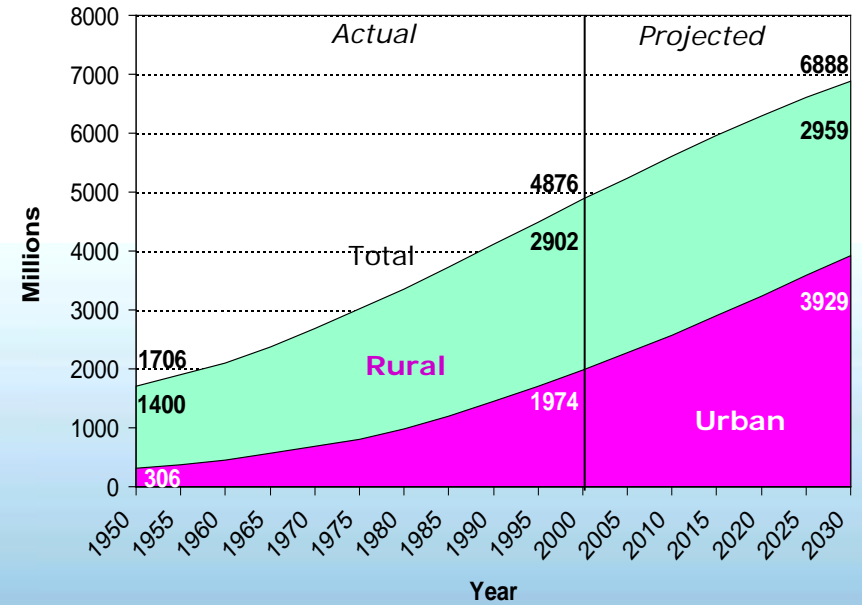


# Projection of population growth and urbanization

## More developed world



## Less developed world



- Population growth has slowed down in many developing countries
- But absolute population is projected to increase by another 2.0 billions over 2000-2030 compared to an increase of 2.2 billions over 1970-2000
- Population growth will continue to pressure on demand for some time in future

# Emerging trends in demand

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- Declining per capita consumption in middle and high-income countries in Asia
- Stagnant per capita consumption in low-income countries in Asia
- Increasing per capita consumption in West Asia, Africa and Latin America
- Slow and declining growth of population in middle- and high- income countries, in Asia and Latin America
- High but declining population growth in low- income countries in Asia
- Continuing high population growth in West Asia and Africa

# Projected increase in demand for rice, 2005-2015




■ East Asia	-3%
■ Southeast Asia	11%
■ South Asia	13%
■ Central and West Asia	36%
■ Sub-Saharan Africa	49%
■ Latin America	17%
■ World	10%





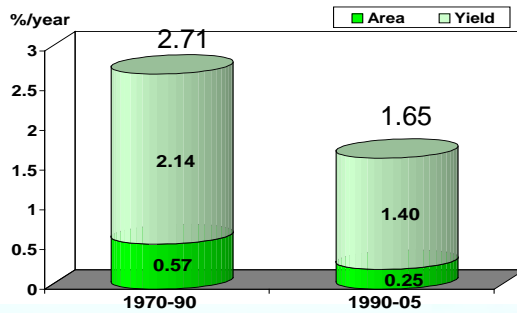
# Factors affecting production

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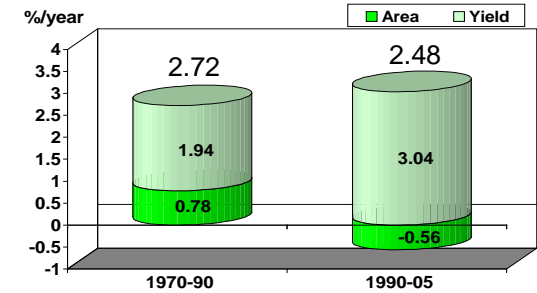
- Competing demand for land with urbanization and economic growth
  - Looming water crisis
  - Decline in soil fertility and overuse of harmful agrochemicals
  - Technological progress getting out of steam for irrigated ecosystem
  - Increase in fuel and fertilizer prices would increase cultivation cost for irrigated rice
  - Negative social perceptions for rice biotech
  - Rapid economic growth and opportunities in non-farm sector dampen farmers' incentives
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# Trend in rice production: effect of technological progress

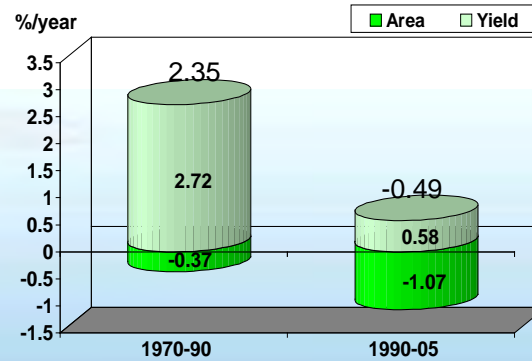
## South Asia



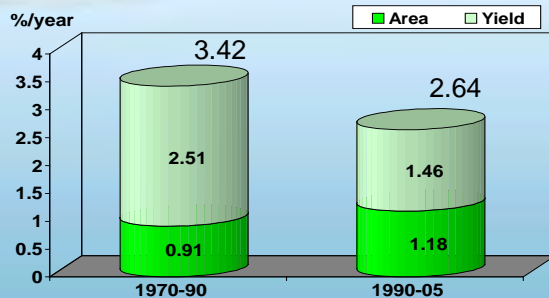
## South America



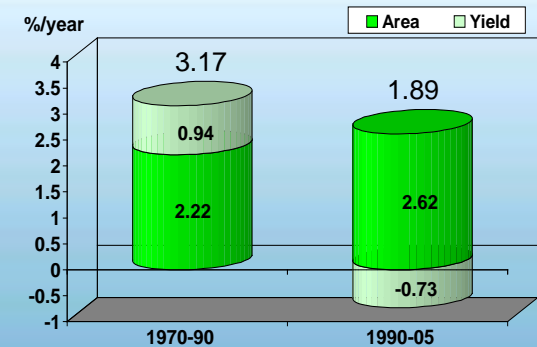
## East Asia



## Southeast Asia

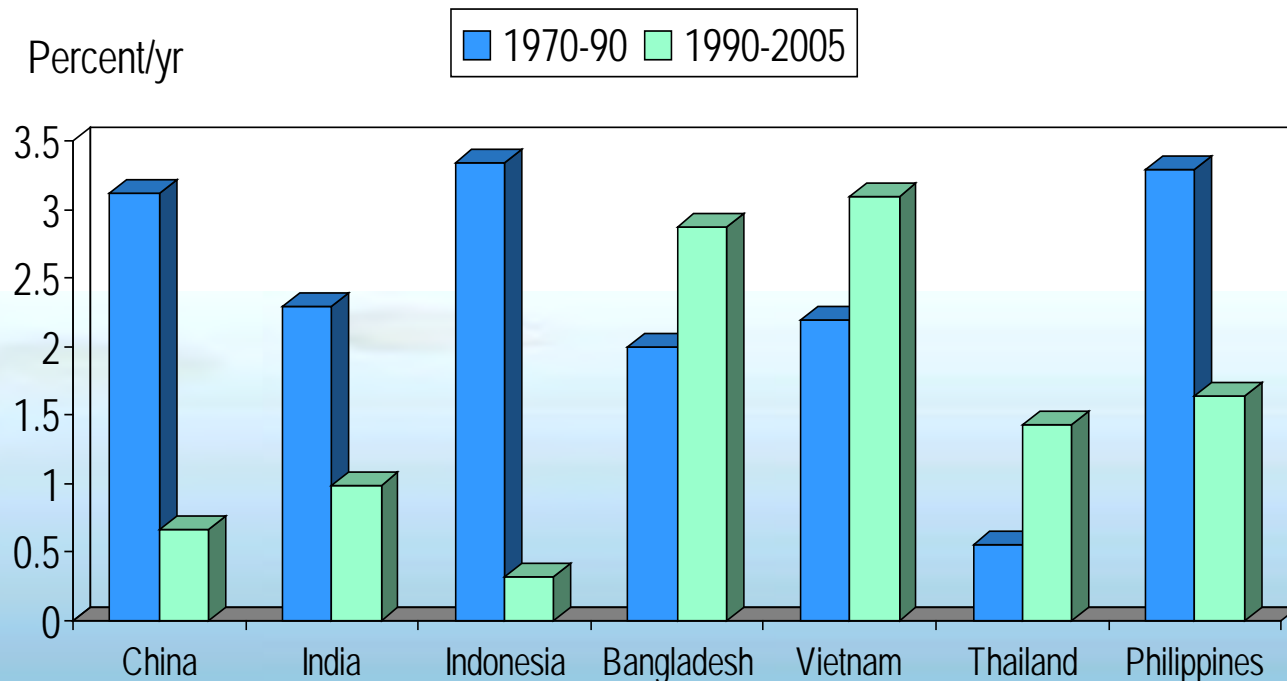


## Sub-Saharan Africa



- Production growth has slackened in all regions since the early 1990s
- A drastic fall in the growth in rice yield, due to technological progress reaching its limit
- Limited technological progress in Sub-Saharan Africa

# Trend in growth of rice yield, major rice-growing countries

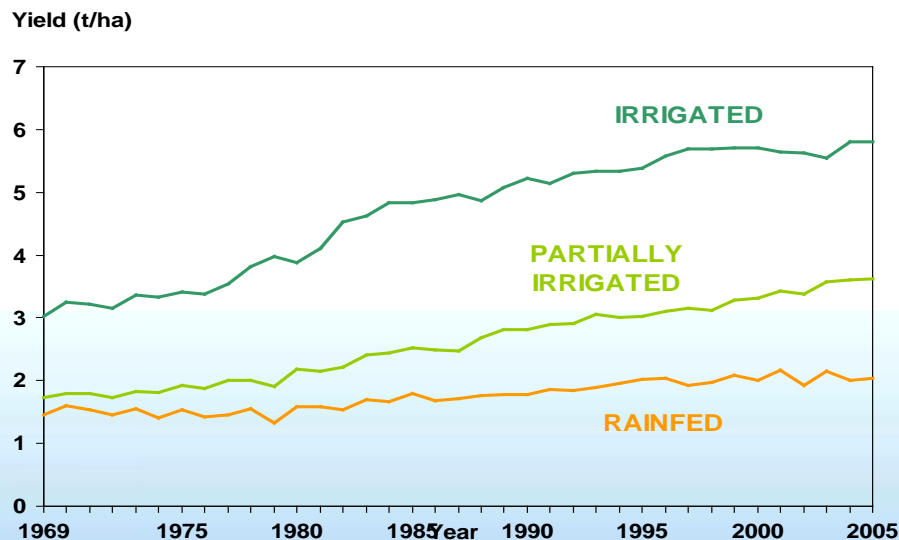


- China, India and Indonesia (contribute 60% to global rice production) have experienced a drastic fall in yield
- Countries that have increased rice yield in recent years had a predominant rainfed ecosystem earlier, but expanded irrigation coverage in the later period

# Trend in rice yield, irrigated and rainfed environments, 1969-2005



- Recent deceleration in production growth was mainly in the irrigated ecosystem
- The rainfed ecosystem has had limited increase in yield, an indication of lack of technological progress
- The yield gap between rainfed and irrigated ecosystem is large and has grown overtime



Ecosystem	No. of countries	Rice area (m. ha)	Rice yield (t/ha)			Growth in yield (%/yr)	
			1969-72	1990-92	2003-05	1970-90	1990-05
Irrigated	19	45.1	3.17	5.14	5.73	2.8	0.7
Partially irrigated	22	63.1	1.78	2.84	3.60	2.4	1.7
Rainfed	24	18.5	1.53	1.81	2.06	0.9	0.8

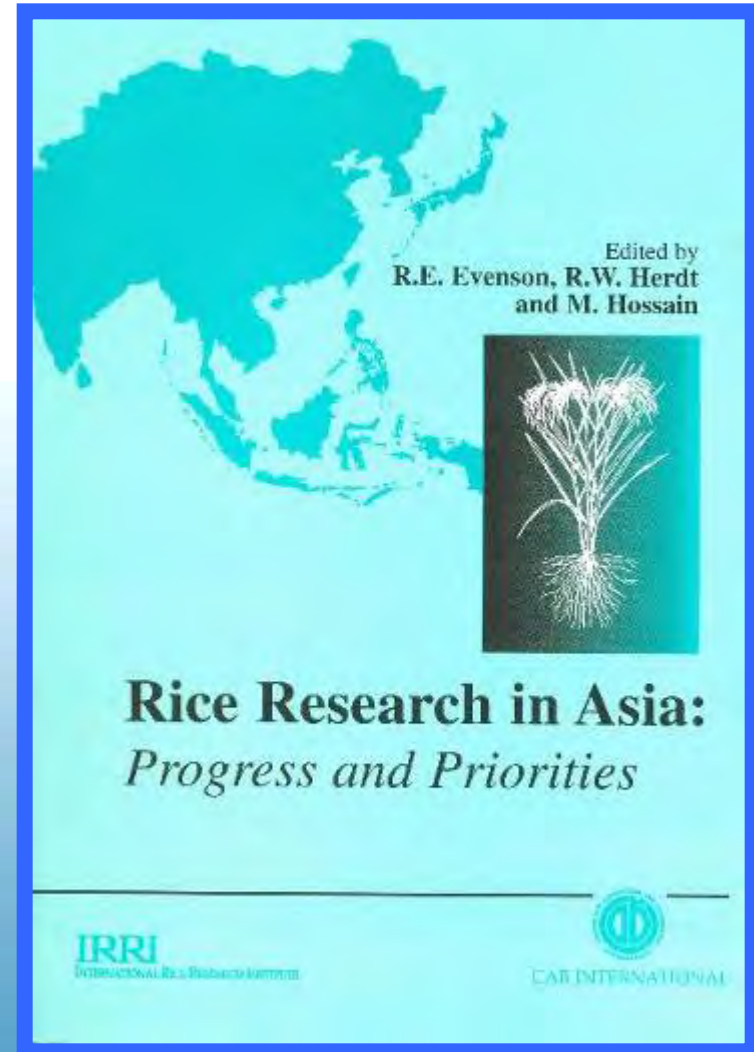
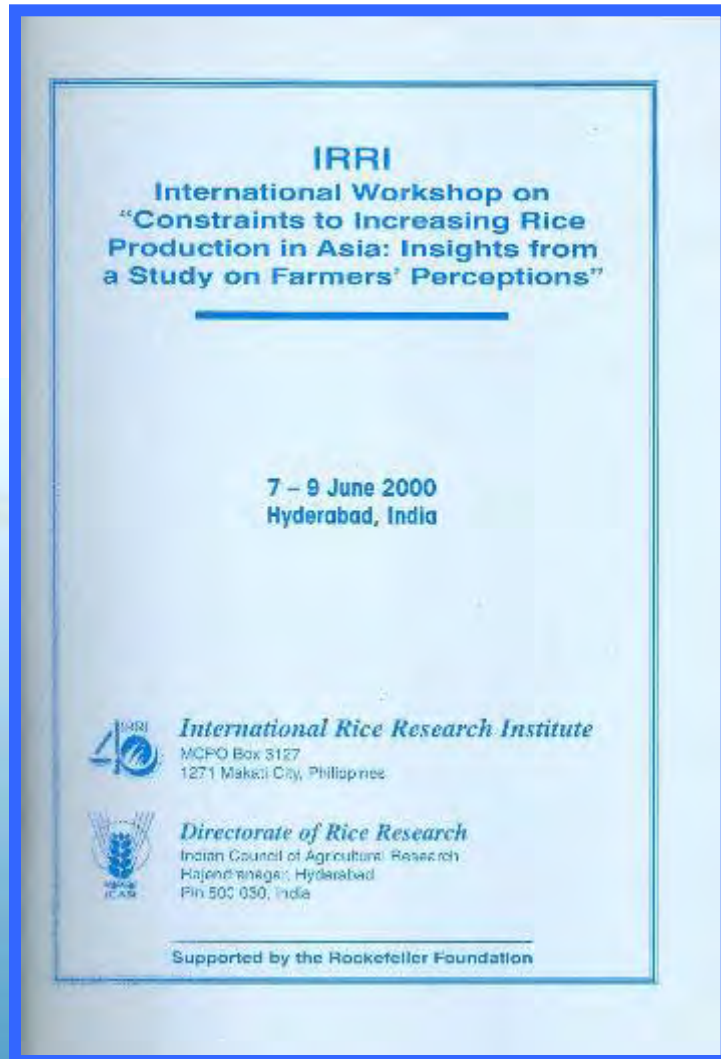
# World market will be affected by agricultural policy: The case of China

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- **Trade liberalization may lead to decline in production faster than demand**
  - Rice shortage in the domestic market may lead to an upward trend in rice imports
  - would lead to reversal of the downward trend in rice price in the world market
- **But China may decide to protect the domestic market to:**
  - Increase the profitability of rice farming
  - Help reduce rural-urban disparity in income
  - Maintain the rice supply and demand balance
- **Such a policy would leave the world rice market unaffected**

# Constraints to increase in rice production



# Yield losses from biotic and abiotic stress: Estimates from survey of farmers' perceptions



<b>Summary of key findings</b>	
No. of cases studied	14
Rice area covered by the countries/regions under study (million ha)	70.5
Average farm level rice yield for the sample (ton/ha)	3.10
Average yield for South and SE Asia (t/ha)	3.16
Estimates of yield losses from various constraints (t/ha)	1.10
Losses as percent of farm-level yield (%)	35.5
Estimates of loss in rice production (m. ton)	115
Value of yield losses (million US\$)	14,950

# Yield losses from various constraints: Estimates from the case studies



Constraint	Yield losses (kg/ha)	Percent of farm level yield (kg/ha)	Estimated production loss for South and SE Asia
Insects	182	5.9	19.1
Diseases	106	3.4	11.1
Weeds	187	6.0	19.7
Rodents/Snails	68	2.2	7.1
Drought	94	3.0	9.9
Submergence	112	3.6	11.8
Soil-related stresses	142	4.6	14.9
Other climatic factors	43	1.4	4.5
Post-harvest	165	5.3	17.3
<b>Total</b>	<b>1099</b>	<b>35.5</b>	<b>115.4</b>

Source: IRRI 2000 DRR. International Workshop on "Constraints to Increasing Rice Production in Asia: Insights from a Study on Farmers' Perception. Hyderabad, India, 7-9 June, 2000



# Constraints in order of importance



Type of constraint	Yield losses in kg/ha
Insect pests	Stemborer (46), Rice bugs, (35) Brown planthopper (26), Leafhopper (20), Army worm (15), Green leafhopper (13), Gall midge (10), Thrips (10), Rice hispa (9)
Diseases	Bacterial blight (39), Blast (28), Sheathblight (18), Tungro (14), Brown spot (8), Ufra (2)
Other biotic stresses	Weeds (187), Rodents (58), Snails (10)
Climatic stresses	Submergence (112), Drought (94), Winds (37), Cold temperature (6)
Soil-related stresses	Organic matter deficiency (52), Zinc deficiency (39), Sulfur deficiency (27), Soil salinity (23), Acidity (14), Iron toxicity (5)

Source: IRRI 2000 DRR. International Workshop on "Constraints to Increasing Rice Production in Asia: Insights from a Study on Farmers' Perception. Hyderabad, India, 7-9 June, 2000

# Major insects and disease problems, by region

Region/ country	Major problem area (yield loss in kg/ha)
Eastern India	Rice bugs (78), Stem borer (65), Blast (54), Bacterial blight (52), Brown planthopper (43)
Rest of India	Stemborer (57), Bacterial blight (49), Blast (42), Leaffolder (37), Rice bugs (31)
Bangladesh	Stemborer (62), Brown planthopper (19), Rice hispa(31), Bacterial blight (17), Blast (16)
Myanmar	Army worm (30), Stemborer (14), Bacterial blight (19), Ufra (13), Leaffolder (14)
Vietnam	Sheath blight (80), Tungro (37), Leaffolder (35), Stemborer (32), Army worm (26), Blast (14)

Source: IRRI 2000 DRR. International Workshop on “Constraints to Increasing Rice Production in Asia: Insights from a Study on Farmers’ Perception. Hyderabad, India, 7-9 June, 2000

# Constraints of international importance

Type of constraint	
Insect pests	Stemborer, Brown planthopper, Leaffolder, Rice bugs
Diseases	Bacterial blight, Blast, Sheathblight
Soil-related stresses	Organic matter deficiency, Zinc deficiency
Other biotic stresses	Weeds, Rodents, Drought, Submergence

# Constraints of national importance

Constraint	Region/country
Rice hispa	Bangladesh, West Bengal, Myanmar
Thrips	Sri Lanka, Tamil Nadu, South Vietnam
Tungro	Uttar Pradesh, Tamil Nadu, Philippines
Ufra nematode	Bangladesh, Myanmar
Cold temperature	West Bengal, Bihar, Uttar Pradesh
Sulfur deficiency	Bangladesh, West Bengal, Uttar Pradesh
Iron toxicity	Tamil Nadu, Sri Lanka
Soil salinity	Tamil Nadu, Bangladesh, South Vietnam



# Farmers' experiences with hybrid rice in the tropics



Hybrid rice



# Summary of findings

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- **Hybrids do have yield advantage over inbreds**
- **Yield gain however is not stable due to pest pressure**
- **Price disadvantage due to poor grain quality**
- **Seed cost accounts for an additional six percent of gross value**
- **Little profitability gains, so commercial farmers not interested in hybrid cultivation**
- **Subsistence farmers more interested in hybrids**
- **Breeding strategy must target quality improvement and pest resistance**



# Performance in South Asia



Indicator	India, 197/98 <sup>a</sup>			Bangladesh, 1999 <i>boro</i> <sup>b</sup>		
	Hybrid	HYV	% diff	Hybrid	HYV	% diff
Yield (t/ha)	6.91	5.95	16	6.46	5.63	15
M. Price (US\$/t)	105	118	-11	126	122	3
Gross return (US\$/ha)	758	739	3	853	735	16
Total cost (US\$/ha)	283	239	19	469	382	23
Net return (US\$/ha)	475	500	-5	384	353	9

Source: a Janaiah & Hossain, 2000; b Husain et al., 2001

# Performance in Southeast Asia

Indicator	Philippines, 2000			Vietnam, 2000		
	Hybrid	HYV	% diff	Hybrid	HYV	% diff
Yield (t/ha)	5.41	4.62	17	6.33	5.25	21
M. Price (US\$/t)	173	181	-4.4	125	129	-3.3
Gross return (US\$/ha)	936	836	12	789	676	17
Total cost (US\$/ha)	371	276	34.4	495	433	14
Net return (US\$/ha)	565	560	1	294	243	21

Source: a Janaiah & Hossain, 2000; b Husain et al., 2001




# Farmers' assessment of constraints

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- ✓ Inferior grain quality
- ✓ Higher risks from pests and diseases
- ✓ Higher seed cost
- ✓ Unstable yield
- ✓ Sterile/chaffy grains in the productive tillers
- ✓ Poor quality in terms of keeping, eating and taste
- ✓ Lower head rice recovery after milling
- ✓ Crop lodging and grain shedding (Bangladesh)

*Hossain, et al. 2001*





# Understanding rural livelihoods

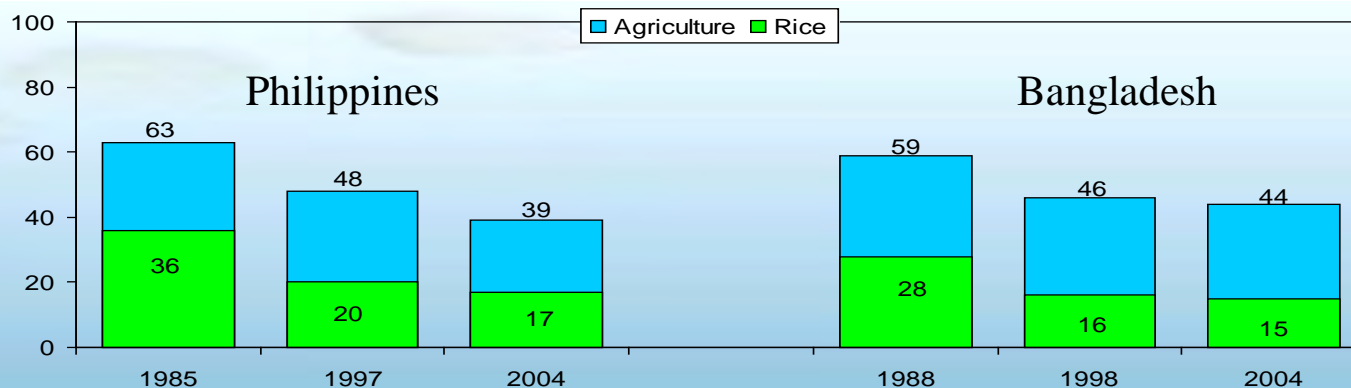
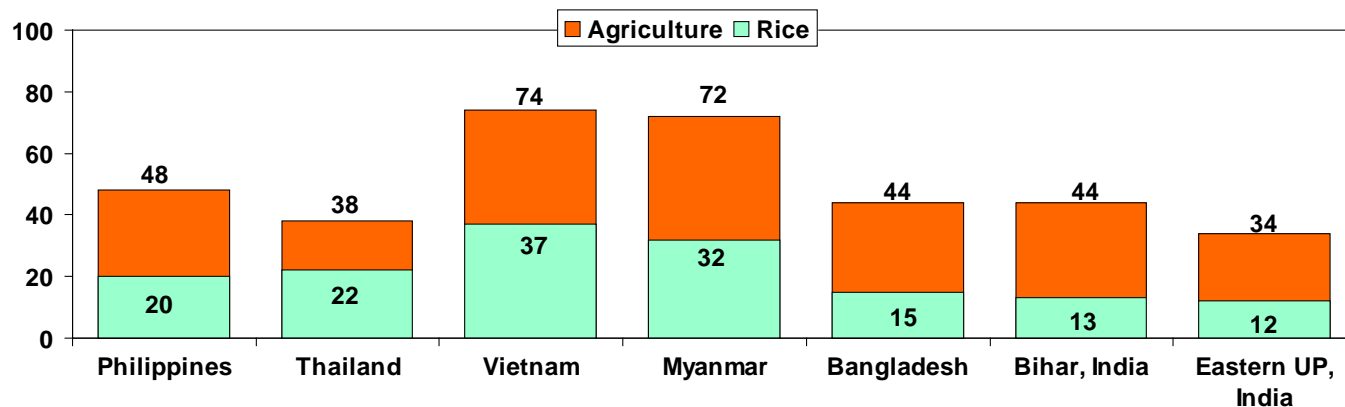
## Income Distribution and Poverty in Rural Asia

Insights from Village Studies

Papers presented  
at the Third Conference of the Asian Society  
of Agricultural Economists at Jaipur, India,  
October 18-20, 2000

Reprinted from  
*Economic and Political Weekly*, Mumbai (India),  
Vol XXXV, Nos 52 and 53,  
Review of Agriculture, December 30, 2000

# Changes in the share of agriculture and rice in household income



- The importance of crop sector within agriculture and the importance of agriculture within rural economy decline with economic progress
- The faster the economic growth, the more dramatic is the transformation within agriculture and the rural economy

# Does technological progress in agriculture worsen income inequality?



Country	Coefficient of concentration of income	Share of rice	Share of non-agriculture
Bangladesh	0.43	0.18	0.22
Vietnam	0.43	0.17	0.19
Thailand	0.53	0.07	0.39
Philippines	0.45	0.09	0.33
Bihar, India	0.37	0.13	0.19
Chattisgarh, India	0.34	0.20	0.11

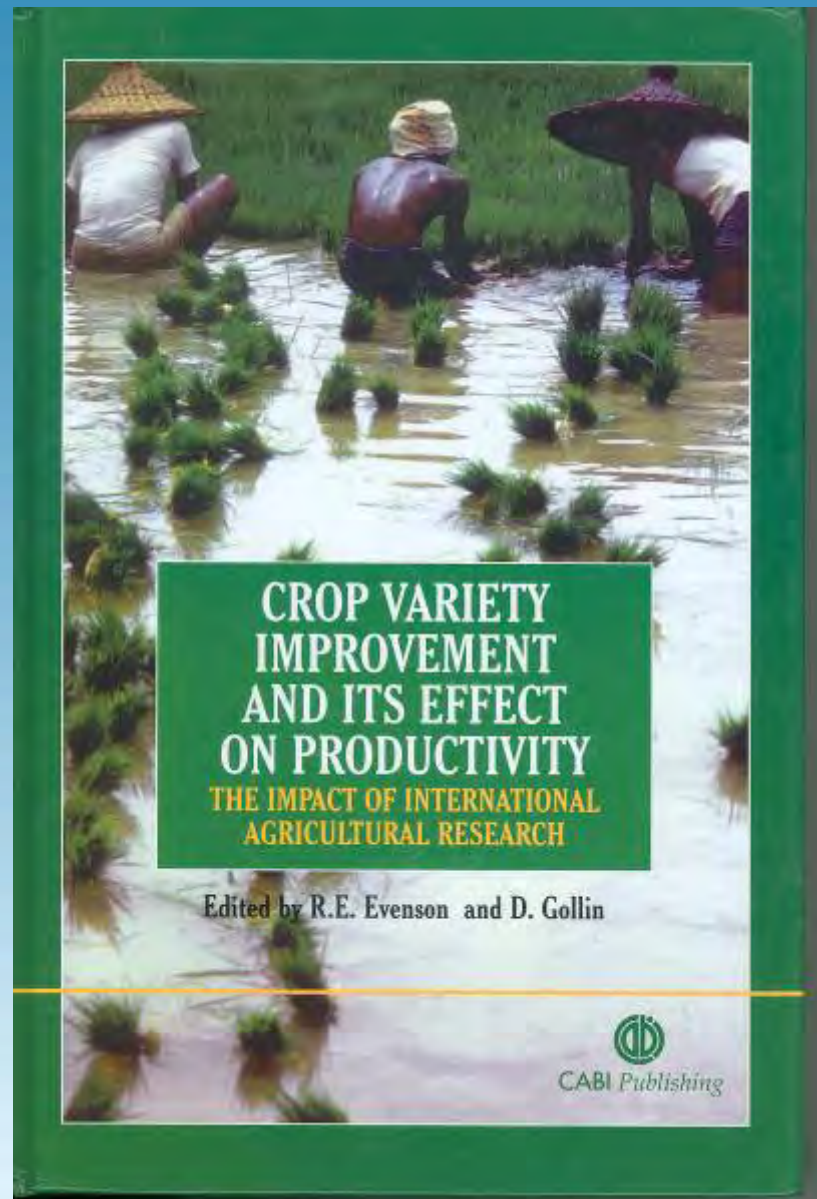
Source of income	Share of income		Contribution of income concentration coefficient	
	1988	2004	1988	2004
Agriculture	59	44	0.18	0.15
Rice farming	28	15	0.13	0.05
Non-rice crops	9	11	0.03	0.06
Non-crop agric.	12	12	0.03	0.04
Agric. Wage	11	6	-0.002	-0.005
Non-agriculture	41	56	0.21	0.27
Business & trade	13	19	0.06	0.10
Services & remittance	21	30	0.13	0.16
Other non-agric.	7	7	0.02	0.02
Total	100	100	0.39	0.41

Source: Hossain et. al. 2007

- It was argued that green revolution will bypass small and marginal farmers and contribute to worsening rural income distribution
- Rice and crop farming account for less than half of the concentration in rural incomes
- Income from rural non-farm activities are more unequally distributed than income from crop farming
- Growth in non-farm activities contribute more to worsening income than technological progress in agriculture



# Impact of crop improvement research



# Investment in rice research

Region	<u>No of rice scientists</u>		<u>Investment</u> <u>(million US\$)</u>
	1983	1999	1999
NARS:			
Southeast Asia	333	840	18.3
South Asia	733	880	17.9
IRRI	173	251	34.0
Total	1239	1971	70.2

Source: Hossain et al. 2003

# Rice varieties released 1970-99



Region	No. of varieties	Rice area (million ha)	No. of varieties/ million ha
Southeast Asia	624	42.0	15
South Asia	883	58.5	15
Total	1507	100.5	15

Source: Hossain et al. 2003

# IRRI's contribution to production of varieties



IRRI crosses released as varieties	11%
Released varieties with an IRRI parent	31%
Released varieties with IRRI materials in previous ancestors	8%

Source: Hossain et al. 2003



# Released varieties linked with IRRI materials

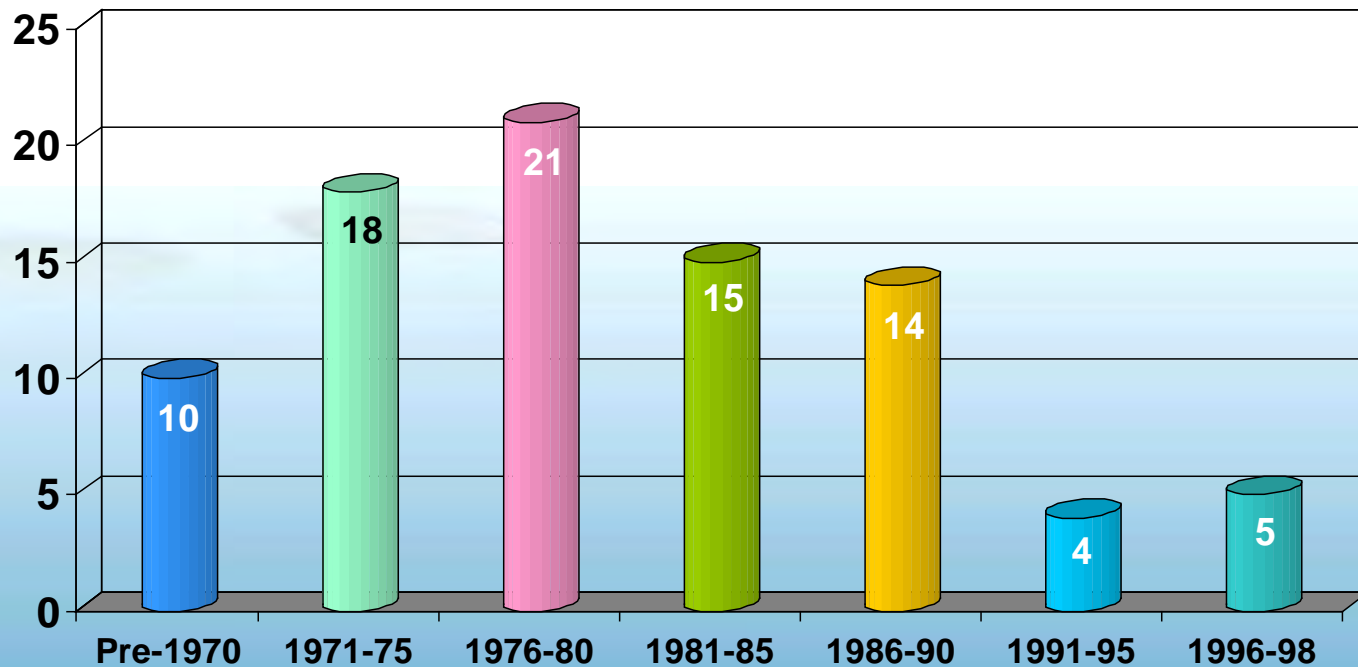
Country	Released varieties with IRRI materials (%)	of which direct release (%)
Bangladesh	65	11
Cambodia	31	24
India	48	5
Indonesia	68	10
Laos	43	5
Malaysia	48	5
Myanmar	45	24
Pakistan	47	22
Philippines	70	27
Sri Lanka	55	3
Thailand	16	0
Vietnam	53	21

Source: Hossain et al. 2003

# IRRI crosses released as varieties, as percent of total releases, IRRI, 1999



Percent

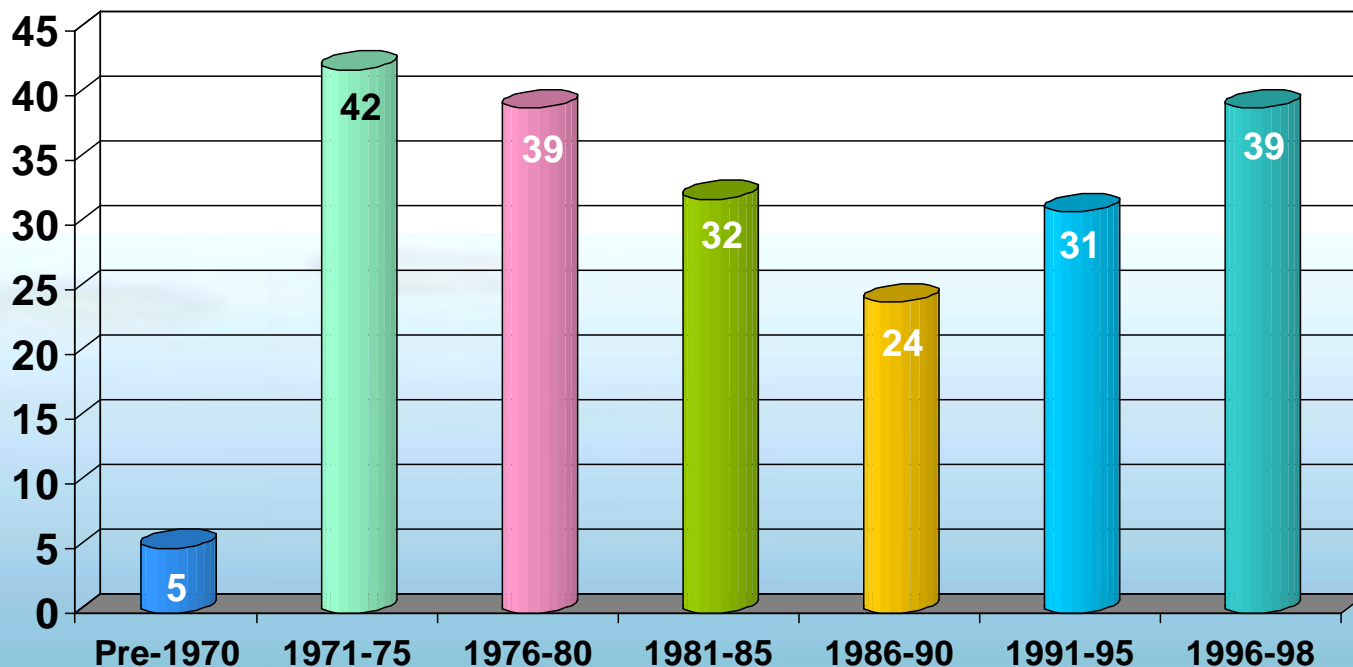


Source: Hossain et al. 1999

# Releases with IRRI parents, as percent of total releases, IRRI, 1999



Percent



Source: Hossain et al. 1999

# Trend in adoption of modern varieties (% of rice area)



<u>Year</u>	<u>Southeast Asia</u>	<u>South Asia</u>
1966	5	2
1976	25	31
1981	36	44
1986	50	52
1991	58	61
1999	71	71

Source: Hossain et al. 2003

# Net gains from the adoption of MVs



Yield of modern varieties (t/ha)	4.38
Yield of traditional varieties (t/ha)	2.28
Yield gains (t/ha)	2.20
Cost of cultivation, TVs (t/ha)	1.52
Cost of cultivation, MVs (t/ha)	2.68
Additional cost associated with adoption of MVs (t/ha)	1.16
Net gains from adoption (t/ha)	0.94
Area under MV rice (million ha)	71
Additional production from adoption (million ton)	67
Value of production (US\$ billion)	6.7

# Impact of technological progress on poverty reduction





# Who are the poor?

Incidence of poverty among landownership groups, Bangladesh, 2000

- Landless agricultural laborers
- Transport and construction workers
- Fishermen and rural artisan
- Marginal farmers
- Urban manual workers

Land ownership group (ha)	Percent of households in the group	Extreme poor (% of the group)	Extreme & moderate poor (% of the group)
No land	34.5	25	77
Up to 0.20	15.8	15	60
0.21 – 0.40	15.1	4	30
0.41 – 1.00	19.3	1	11
1.01 – 2.00	10.1	Nil	2
2.01 – 3.00	2.4	Nil	---
3.01 & above	2.8	Nil	---
<b>Total</b>	<b>100.0</b>	<b>12</b>	<b>43</b>

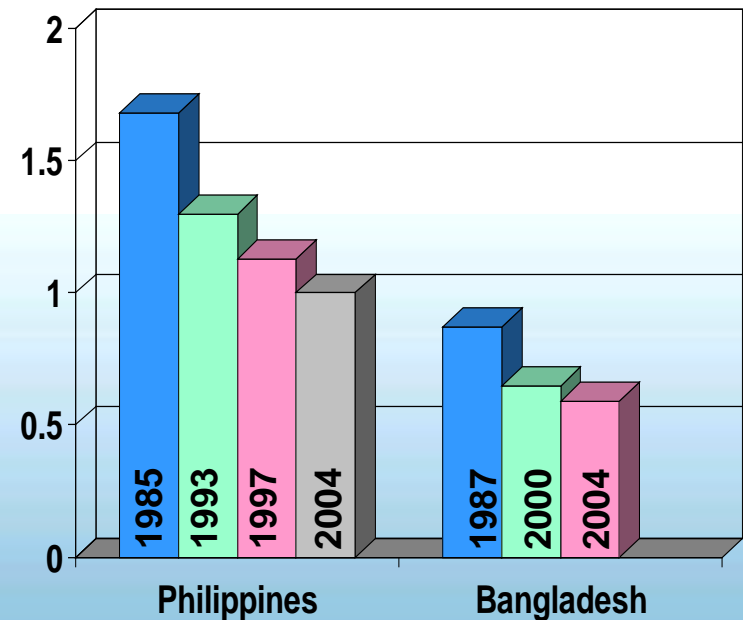
IRRI-BIDS survey, 2001

# Land as a source of livelihood

## Endowment and access to land

Country/ region	Landlessness (% of rural households)	Size of farm (ha)	Area under tenancy (% of cultivated land)
Philippines	51	1.10	48
Thailand	5	4.73	36
Vietnam	Nil	0.78	Nil
Myanmar	50	2.14	Nil
Bangladesh	37	0.58	39
Bihar, India	33	0.89	12
Eastern UP, India	37	0.60	10

## Changes in farm size (ha)



- A third to one-half of rural households are landless
- Average farm size is small and declining despite rapid rural-urban migration of population
- Access to land through the tenancy market is limited
- Unfavorable terms of tenancy: *The tenant gets return only from labor*



# Direct impact of technological progress on the poor



- **Agricultural productivity growth does not directly benefit the poor**
- **Size of the tenancy market is small and terms unfavorable for tenants**
- **Benefit through agricultural labor market is limited**
  - **Size of labor market is small**
  - **Adoption of farm mechanization reduces demand for labor**



# Share of food and rice of consumer basket, Bangladesh 2000



Item	Poor (Bottom 40% of the households in income scale)		Rich (Top 10% of the households in income scale)	
	Rural area	Urban area	Rural area	Urban area
Rice	35	25	13	6
Food & drinks	68	61	44	29

*Source: Bangladesh Bureau of Statistics: Household Income and Expenditure survey 2000.*

- Rural and urban poor spend a substantial portion of their income on staple food



# Indirect impact on poverty reduction

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- **The effect is through prices of staple food**
- **Food entitlement of the poor improves, if prices kept within affordable limits**
- **Supply of staple food must increase at a rate at which demand has been growing to check upward trend in prices**
- **Reduction in unit cost provides farmers incentives to sustain production growth at low prices**



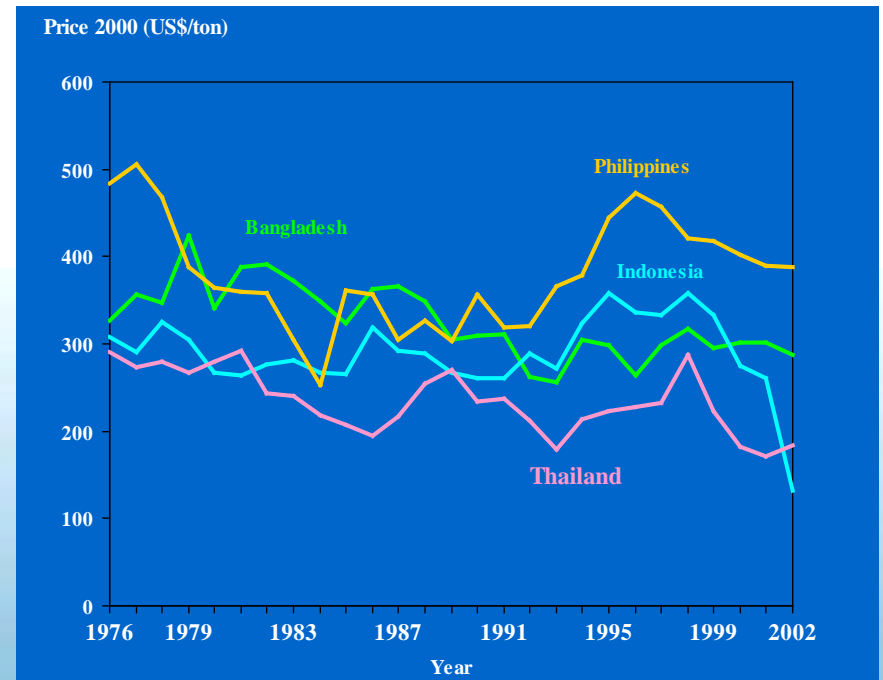
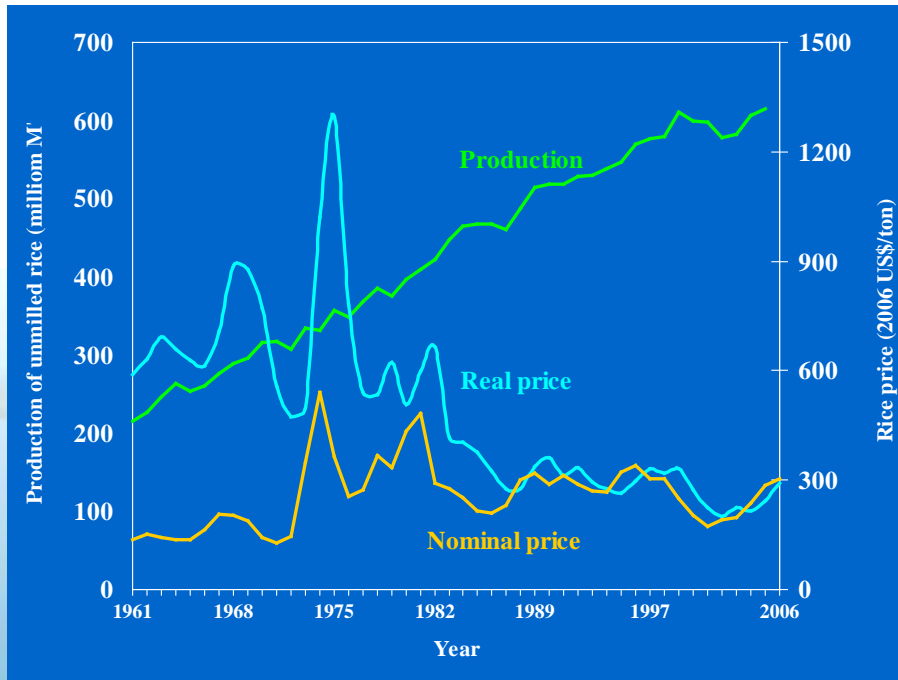
# Impact of technology on unit cost

Country/region	Modern variety (MV) (US\$/ton)		Traditional variety (TV) (US\$/ton)	Reduction (%) in unit cost	
	Irrigated	Rainfed		Irrigated MV over TV	Rainfed MV over TV
Bangladesh	129	125	147	-13	-15
India: Bihar	81	95	112	-28	-15
India: Chhatisgarh	96	102	138	-31	-26
Philippines	167	221	224	-25	-2
Thailand	71	*	98	-29	*
Vietnam	100	125	140	-20	-11

- Technological progress helped reduce unit cost of rice cultivation up to 30 percent
- Farmers can maintain their profits if rice price is reduced by this margin



# Trend in real (adjusted for inflation) rice prices



Source: Production: FAOSTAT Electronic Database, FAO.20Apr2006 update.

Rice Price: Relate to Thai rice 5%-broken deflated by G-5 MUV Index deflator (adjusted based on 1 March 2007 data update)

Source: www.,WorldBank.org

Note: Wholesale price of rice deflated by general price index for individual countries. Domestic currency values were converted into US\$ using 2000 nominal exchange rate.

Source: 1976-1998: World Rice Statistics database.

1998-2002: Websites of national statistical organizations



# “Walking on two legs” for reducing poverty



- **Increasing nominal incomes for the poor**

- Improvement in education
- Access to financial capital
- Development of rural infrastructure

- **Providing food at affordable price**

- Increasing rice supply at a rate at which demand has been growing
- Reducing unit cost of production to sustain farmers' incentives to increase production



# Implications for rice research strategy

## ◆ Middle and high-income countries

- ◆ Further increase in yield will generate rice surplus that will be difficult to market
- ◆ Research for food safety, environment protection, and diversification in the end use of rice

## ◆ Low income countries with excess capacity

- ◆ Improvement in grain quality to capture the growing market for quality rice
- ◆ Mechanization, precision farming, and post-harvest research to reduce unit cost and add value

## ◆ Low income countries with growing demand for rice

- ◆ Shifting yield frontier for the irrigated system
- ◆ Reducing yield gaps with improved varieties tolerant to abiotic stresses
- ◆ Systems approach to rice research to fit non-rice crops in rice-based systems





# Role of IRRI





# Role of IRRI

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- Enhance rice research capacity of NARS
- Lead research for development of technologies with abiotic stress tolerance
- Collaborate with NARS for maintenance breeding for the irrigated system
- Facilitate transfer of knowledge and technologies from ARIs to young NARS
- Maintain genetic resources and explore new traits



# Acknowledgment



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V. Cabanilla

## NARES

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