Agricultural R&D and Food Security?

- **50**% increase in world population by 2050 (3 billion more people), almost all in LDCs
- Little **new land** to bring into production
- Maintain **high crop yields** (historically unprecedented), and increase upon them
- Worrying trends in agricultural R&D **investments**
- General lack of investment in science for poor countries
- Many worried about **IPRs** and **GMOs** (rich-country concerns?)
- Nature of science and who does it – pressures for increasing **self-reliance** by LDCs?

The **biggest** risk

Science and technology will bypass poor people ??

(scientific *apartheid*)

Research must focus on *agricultural engineering* relevant to small farmers and poor consumers in developing countries

Characteristics:

- Small holders
- Low risk bearing capacity
- Lack of awareness / Illiteracy
- Limited access to resources
- Diminishing natural resources

Current Situation of Agricultural Engineering in some key member countries of APCAEM

April 27, 2007

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International Seminar on Restructuring and Strengthening R&D for Agricultural Engineering

United Nations ESCAP; APCAEM; CAAMM; CAAE; CAU; DLG e.V.; DMAG; HFS

21st Century Hotel; Beijing (PR China) 27-28 April 2007

The World, We Are In…

The potential size of cultivable land in the world is no more than 3 billion hectares, only **22**% of the world's land mass.

Less than half is used productively

26.7 million tractors are moving round the world (2002)

Concentrated in:

Europe – 43%
US – 27%

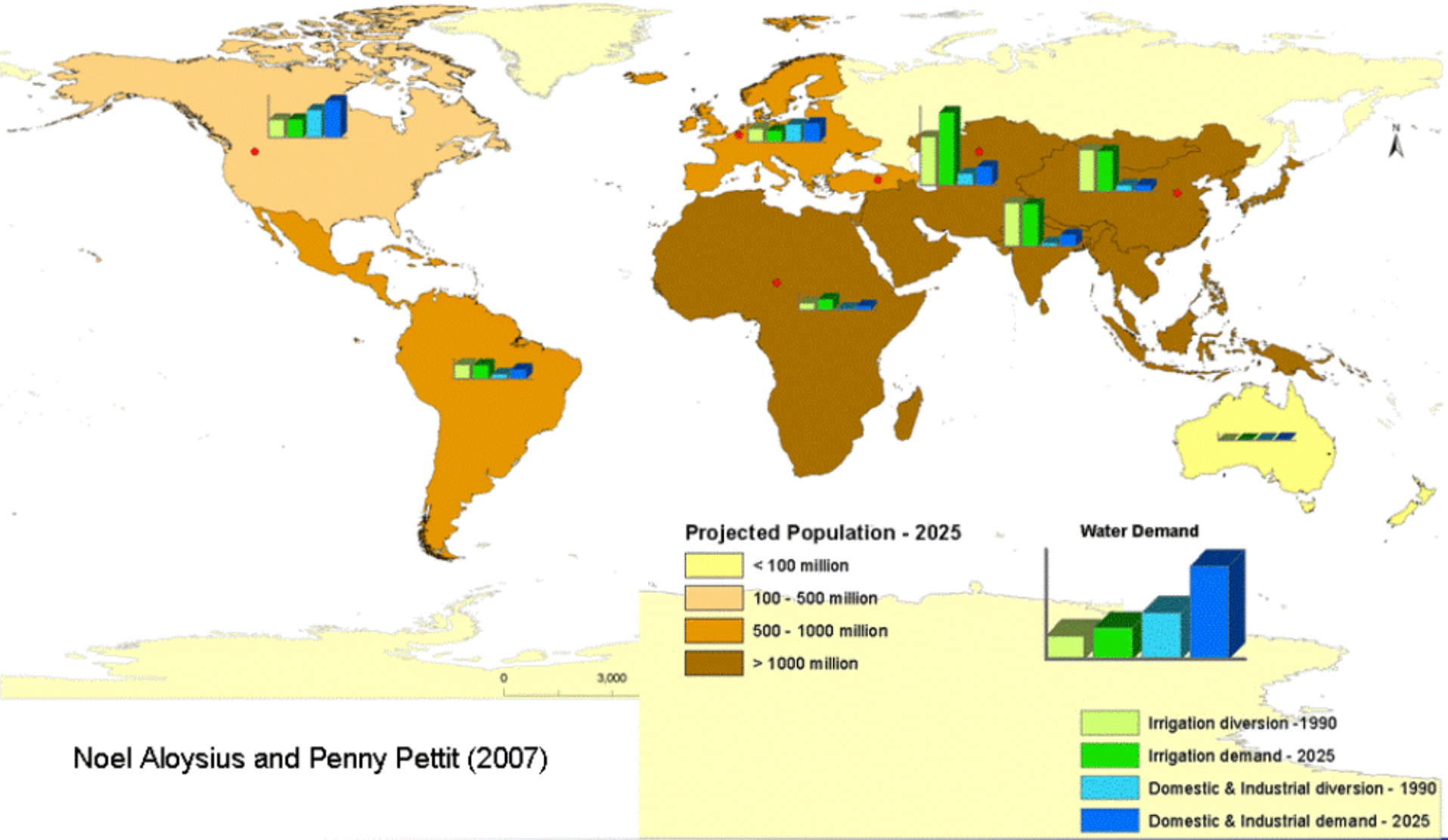
Asia – 26%
Africa – 2%
Oceania – 2%

Demographic differences in agriculture…

Number of agricultural labor per sq. km of arable land:

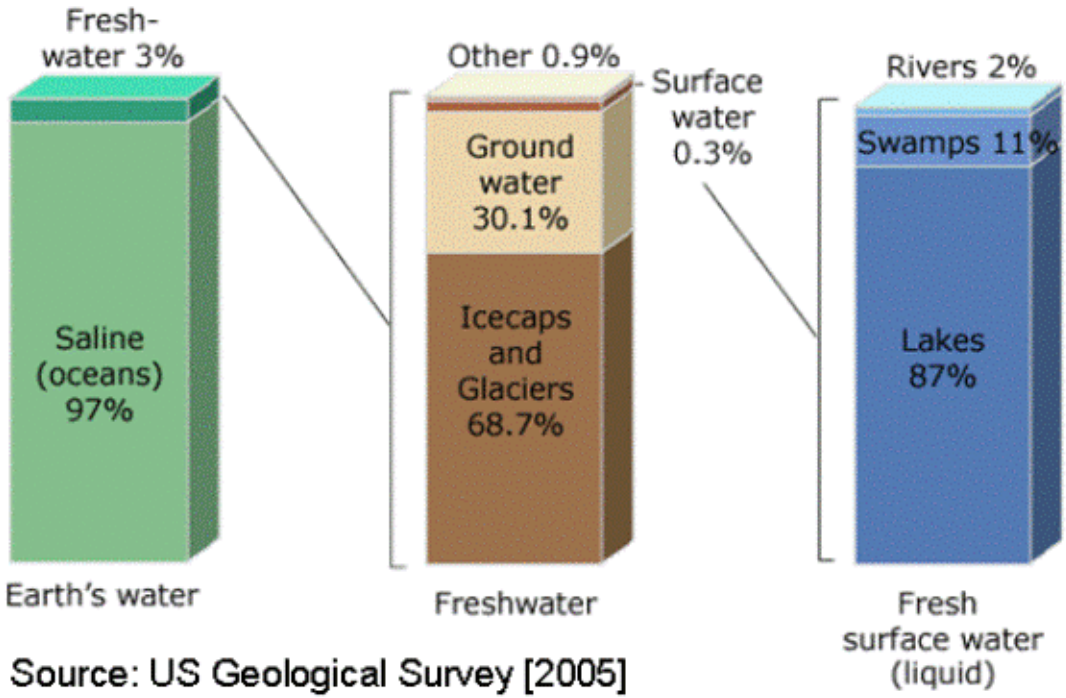
US – 2
Europe – 16
Africa – 88
Asia – 216

Some Facts to Know!



Noel Aloysius and Penny Pettit (2007)

Distribution of Water on Earth



Source: US Geological Survey [2005]

Freshwater constitutes only **3**% of earth's total water.

Various uses of Freshwater (Shiklomanov, 1999)

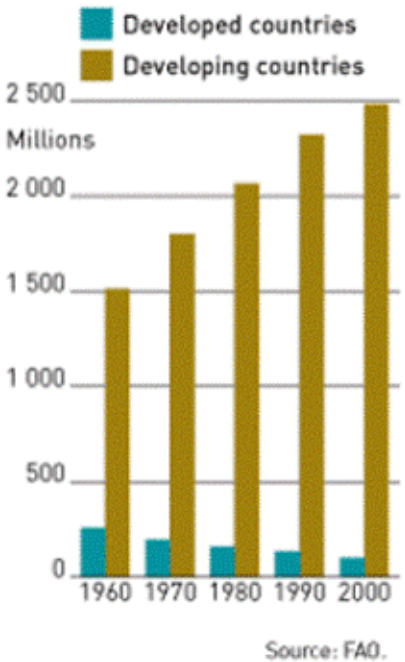
Sector	Water Withdrawals	Water Consumption
Agriculture	66 %	93 %
Industry	20 %	4 %
Domestic use	10 %	3 %
Evaporation from reservoirs	4 %	

Water A Growing Constraint

- Farmers use ~**70**% of the fresh water used in the world. They are both the largest **users** and the largest **wasters** of water.
- Water is priced at **zero** to most farmers, signaling that it is much more abundant than in reality. Anything priced at zero will be wasted.
- With rapid **urbanization**, cities are likely to outbid agriculture for available water.
- The world's farmers need to more than **double** food production using less water than today.

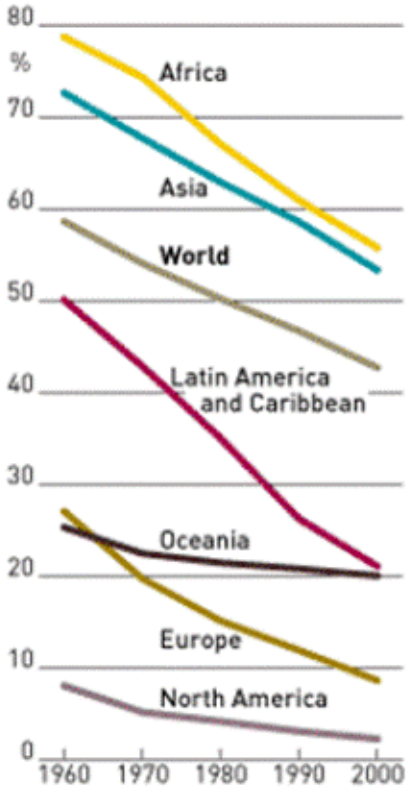
Farming

POPULATION ENGAGED IN AGRICULTURE Actual numbers



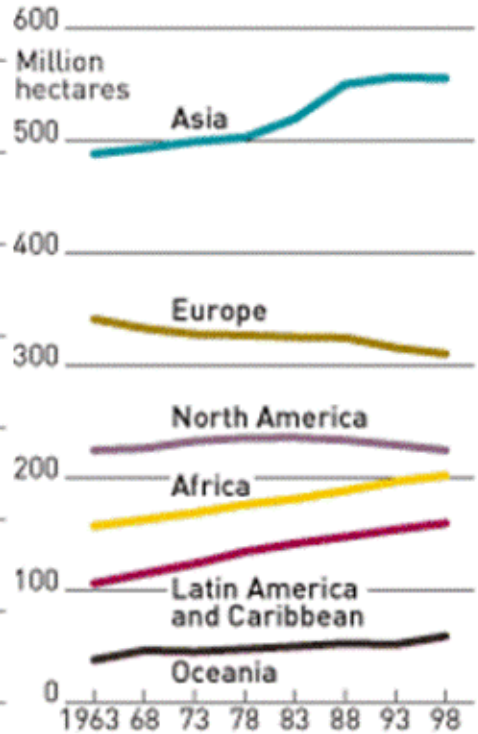
Source: FAO.

PROPORTION OF POPULATION ENGAGED IN AGRICULTURE



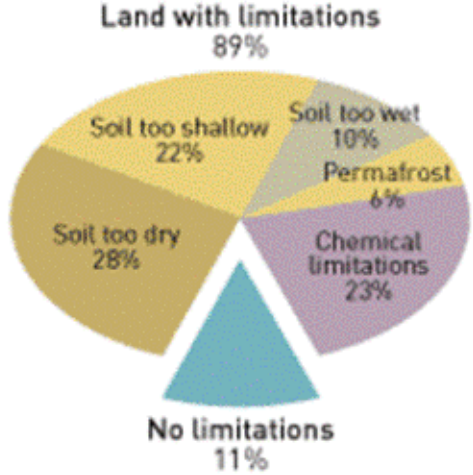
Source: FAO.

WORLD ARABLE AND CROPLAND By region

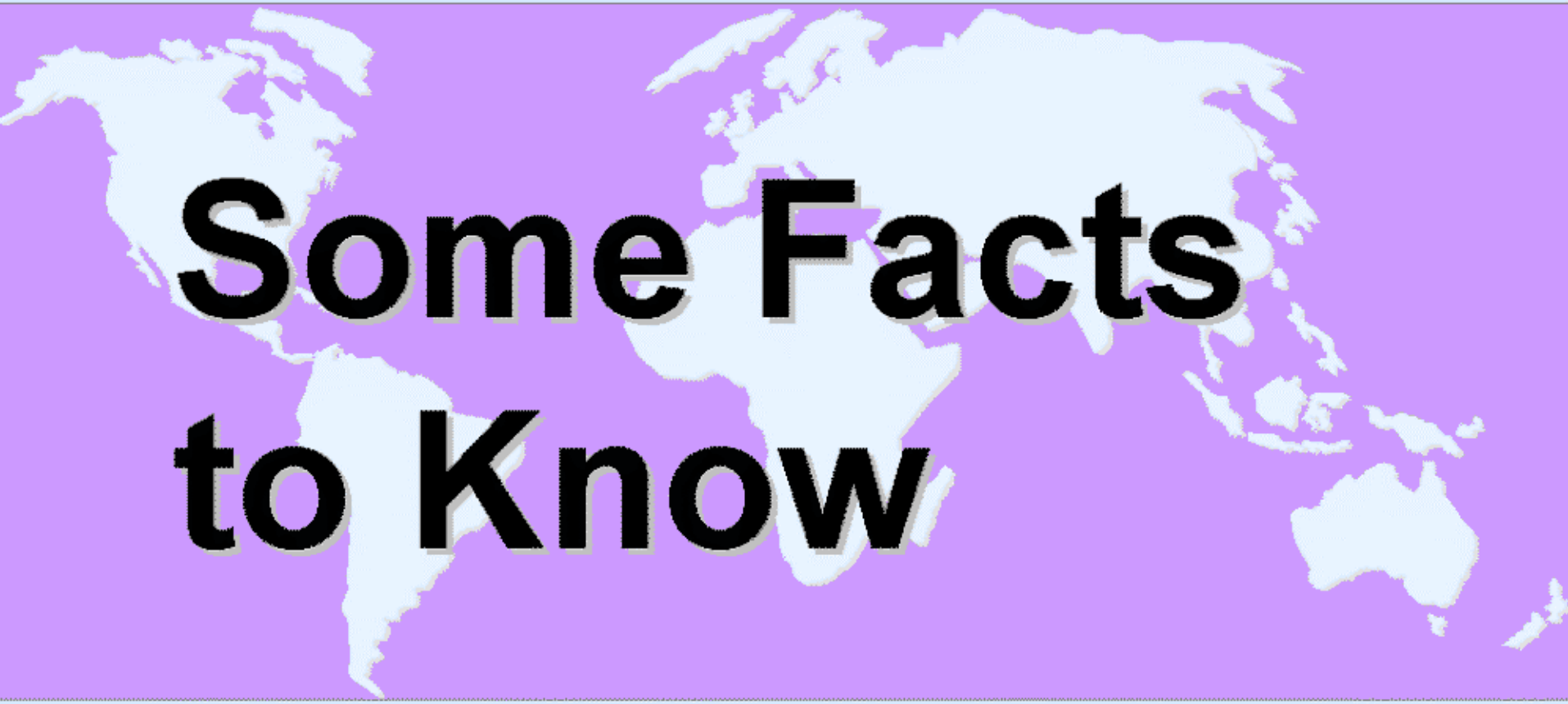


Source: FAO.

GLOBAL SOIL LIMITATIONS TO AGRICULTURE



Source: FAO.


Some Facts
to Know

The World As 100 People

If the world were 100 people there would be…

57 Asians, **21** Europeans, **14** from North and South America, **8** Africans

52 would be female, **48** would be male

70 would be nonwhite, **30** white

59% of the entire world's wealth would belong to only **6** people and all **6** would be citizens of the United States

80 would live in substandard housing

70 would be unable to read

50 would suffer from malnutrition

1 would be near death

1 would be near birth

6 would have a computer

Only **1** would have a college education

Steven Sanders (2002)

Land Productivity in Developed and Developing Countries, 2000

Country	Average Grain Yield (kilograms per hectare)	Population (million)
United Kingdom	6,975	60
Japan	5,971	127
United States	5,794	278
Indonesia	3,915	207
Bangladesh	2,786	128
Mexico	2,640	97
Brazil	2,660	168
India	2,293	998
Pakistan	2,255	135
Nigeria	1,208	124
Congo	781	50

Source: World Bank (2001). World Development Indicators

Distribution of Farms and Farmland by Operational Farm Size in Selected Developing Countries in Asia and Latin America

Average Country	Average Operational Farm Size (hectare)	Percentage of Farms and Farmland			
		Below 5 Hectares		Above 50 Hectares	
		Farms	Area	Farms	Area
Asia					
Bangladesh	1.6	90.6	67.6	n.a.	n.a.
India	2.3	88.7	46.7	0.1	3.7
Indonesia	1.1	97.9	68.7	0[c]	13.6
Nepal	1.0	97.2	72.1	0[c]	0.8
Philippines	3.6	84.8	47.8	0.2	13.9
Thailand	3.7	72.3	39.4	0	0.9
Latin America					
Brazil	59.7	36.8	1.3	16.3	84.6
Costa Rica	38.1	48.9	1.9	14.5	79.7
Colombia	26.3	59.6	3.7	8.4	77.7
Peru	16.9	78.0	8.9	1.9	79.1
Uruguay	214.1	14.3	0.2	37.6	95.8
Venezuela	91.9	43.8	0.9	13.6	92.5

Source: Otsuka, K., Chuma, H., and Y. Hayami (1992). Land and labor contracts in agrarian economies: Theories and facts. Journal of Economic Literature.

The Important Role of Women

- Women provide **60-80**% of agricultural labor in Africa and Asia, and 40% in Latin America
- Women work **longer** hours than men
- Government assistance programs tend to reach men, **not women**

Food Resources - Figures

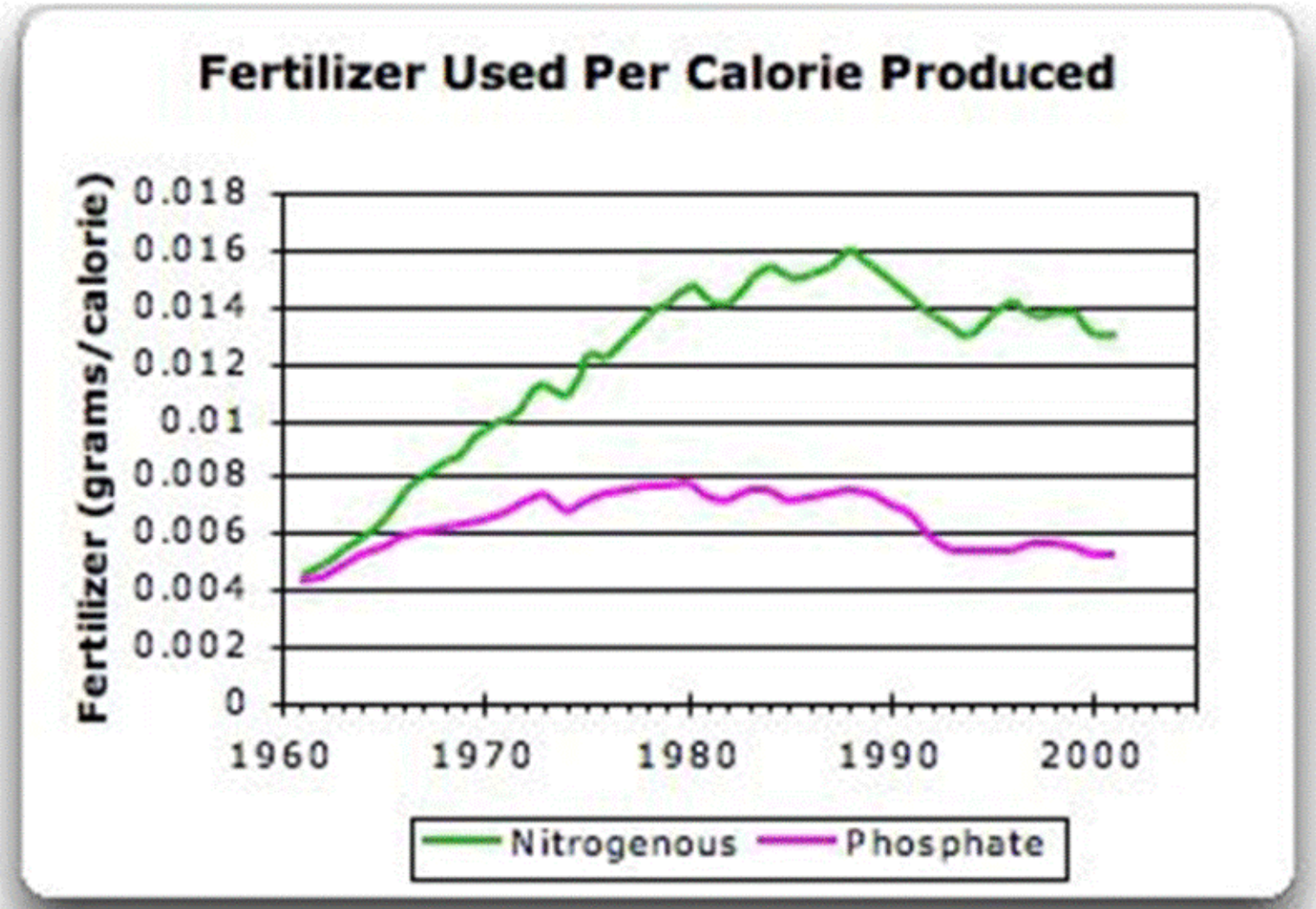
Over the past 20 years World food production has increased by **2.1**% per year.

In the developing countries of the world **1 in 5** people do not have enough food to meet their daily requirements.

There is enough food globally to give everyone **2,700** calories per day. The minimum requirement is 2,100 calories per day and malnourishment is considered to be anything lower than 1,800 calories per day.

How Many People Could We Feed With Today's Production?

- **Poverty**, not inadequate food supply, cause of hunger today; we produce more than enough for the 6 billion people alive today
- but 840 million (1/7) are undernourished
- 10 billion possible with today's production
  —if everyone were vegetarian
  —if no food were wasted
  —if food were equally distributed



http://homepage.mac.com/williseschenbach/.Pictures/fertilizer%20per%20calorie.jpg

Looking at the food system as a whole: {energy used to grow, store, process, package, transport, refrigerate and cook}

about **10** units of energy of nonrenewable fossil fuel energy are needed to put **1** unit of food energy on the table.

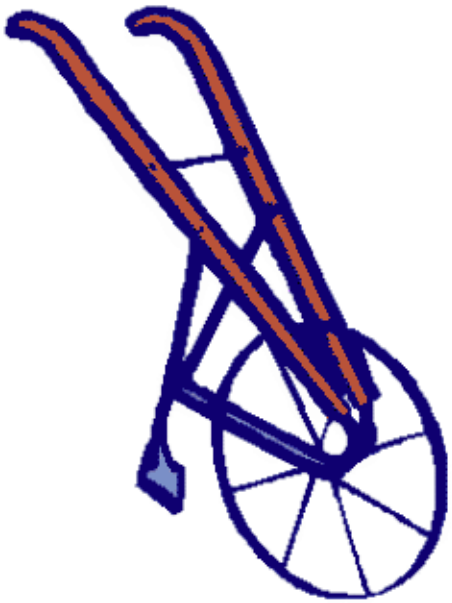
Steven Sanders (2002). Propositions of an Eco-Logical Economic Revolution. Wilcox HS

In a nut-shell…

Almost all the increase in world food demand will take place in developing countries

The world's farmers will have to produce 40% more grain in 2020, most of which will have to come from yield increases and reduced losses

HOW?



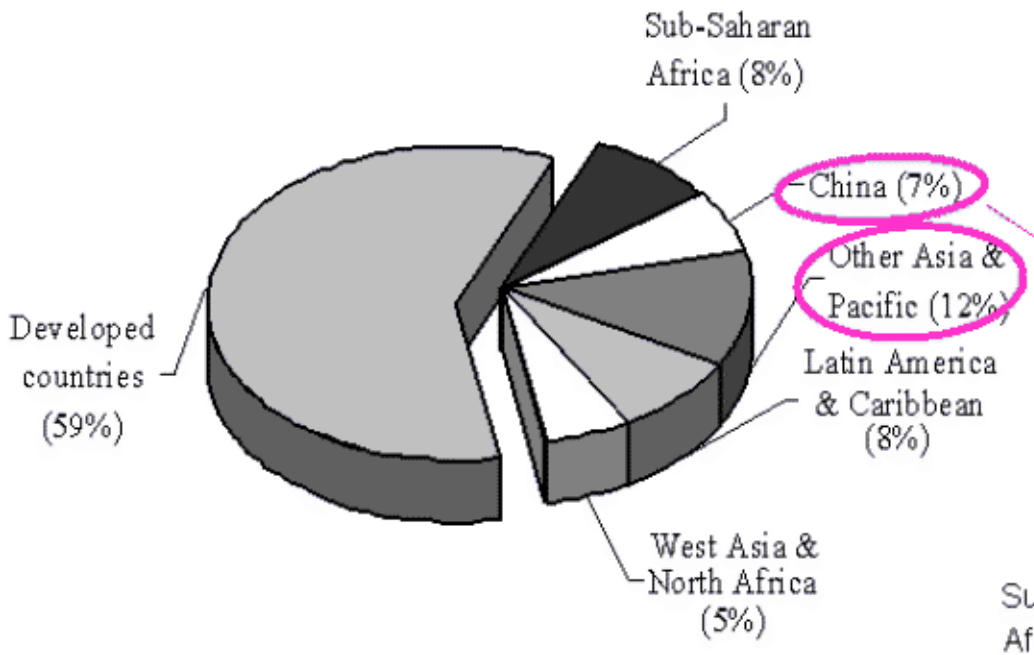
Agricultural Engineering

Investments in Agricultural R&D

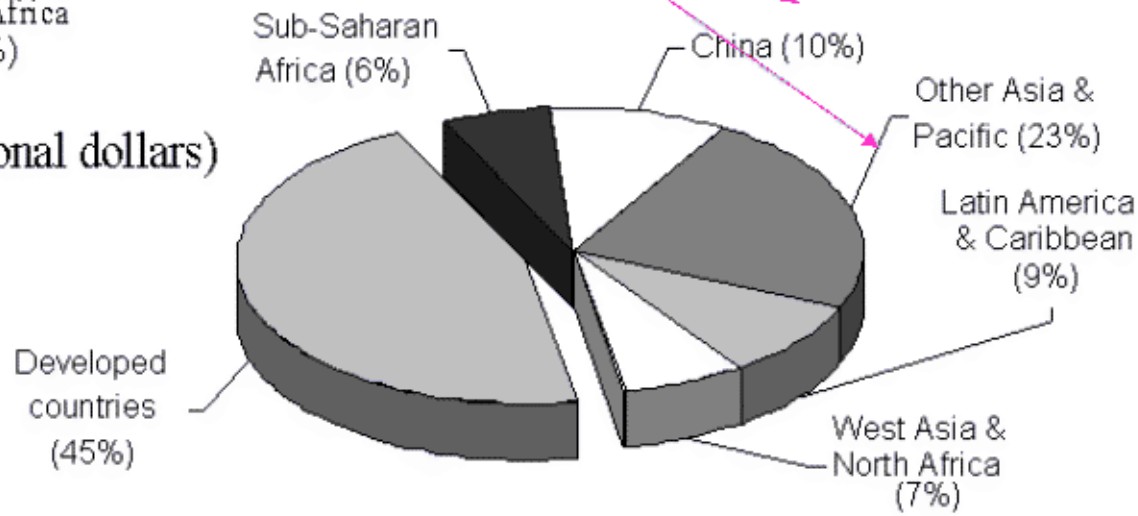
Need to Restore Public Research Funding

- Green Revolution was the result of "**public goods**" research and investment
- Biotechnology/Mechanization-research is primarily driven by the **private** sector
- Maintaining a **balance** between public and private research is essential and healthy
- Public institutions focus on problems of the poor, help prepare future scientists, and help assure that the public interest is protected.

Global Public Agricultural Research Expenditures, 1976–95



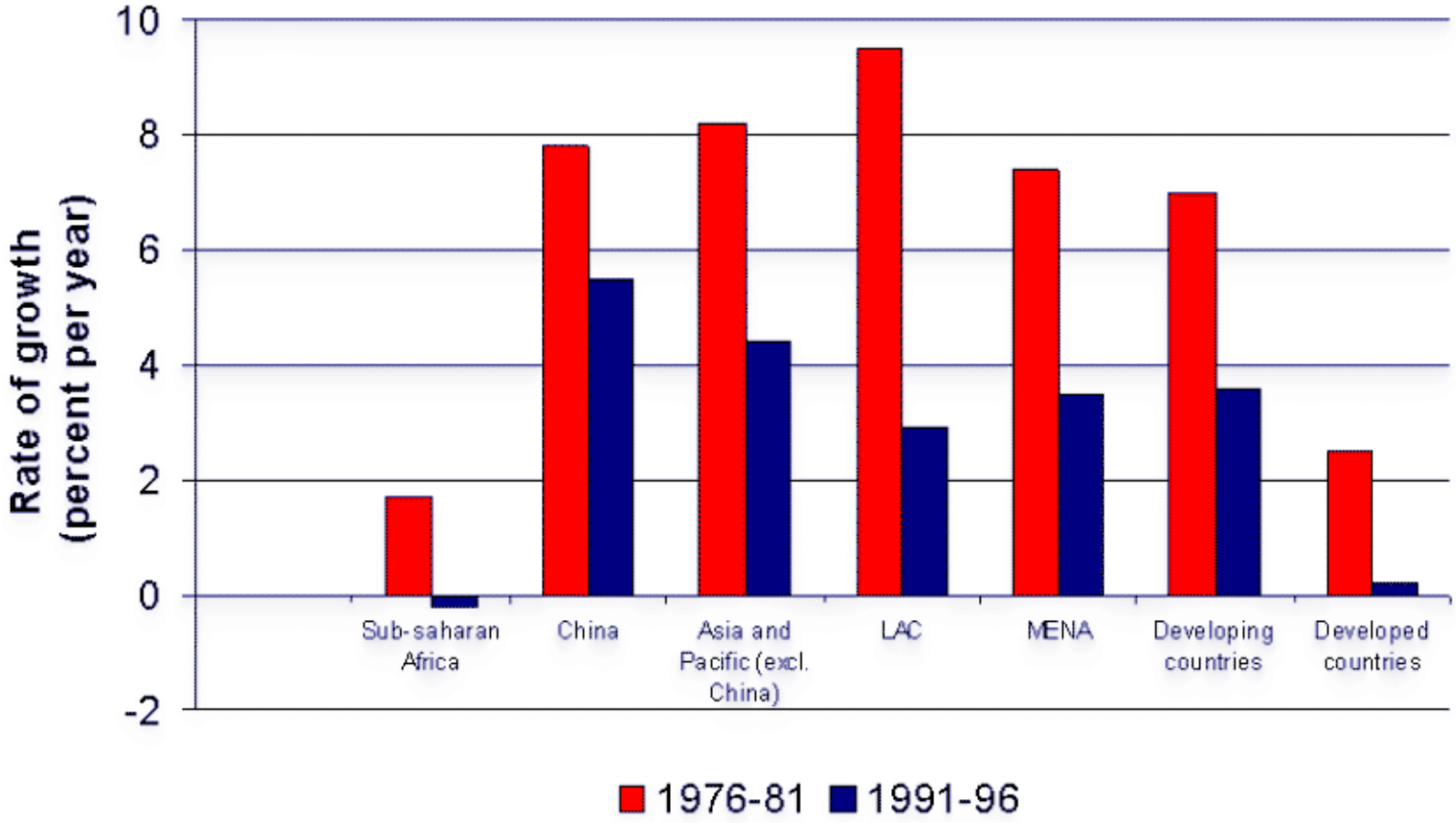
1976: $11.8 billion (1993 international dollars)



1995: $21.6 billion (1993 international dollars)

Source: Pardey and Beintema (2001)

Public R&D Spending Slowdown



Source: Philip G Pardey (2004), Columbia University

Private research intensities in developing countries are even lower

Private agricultural R&D expenditure in selected countries as a percentage of agricultural GDP (%) in 1995

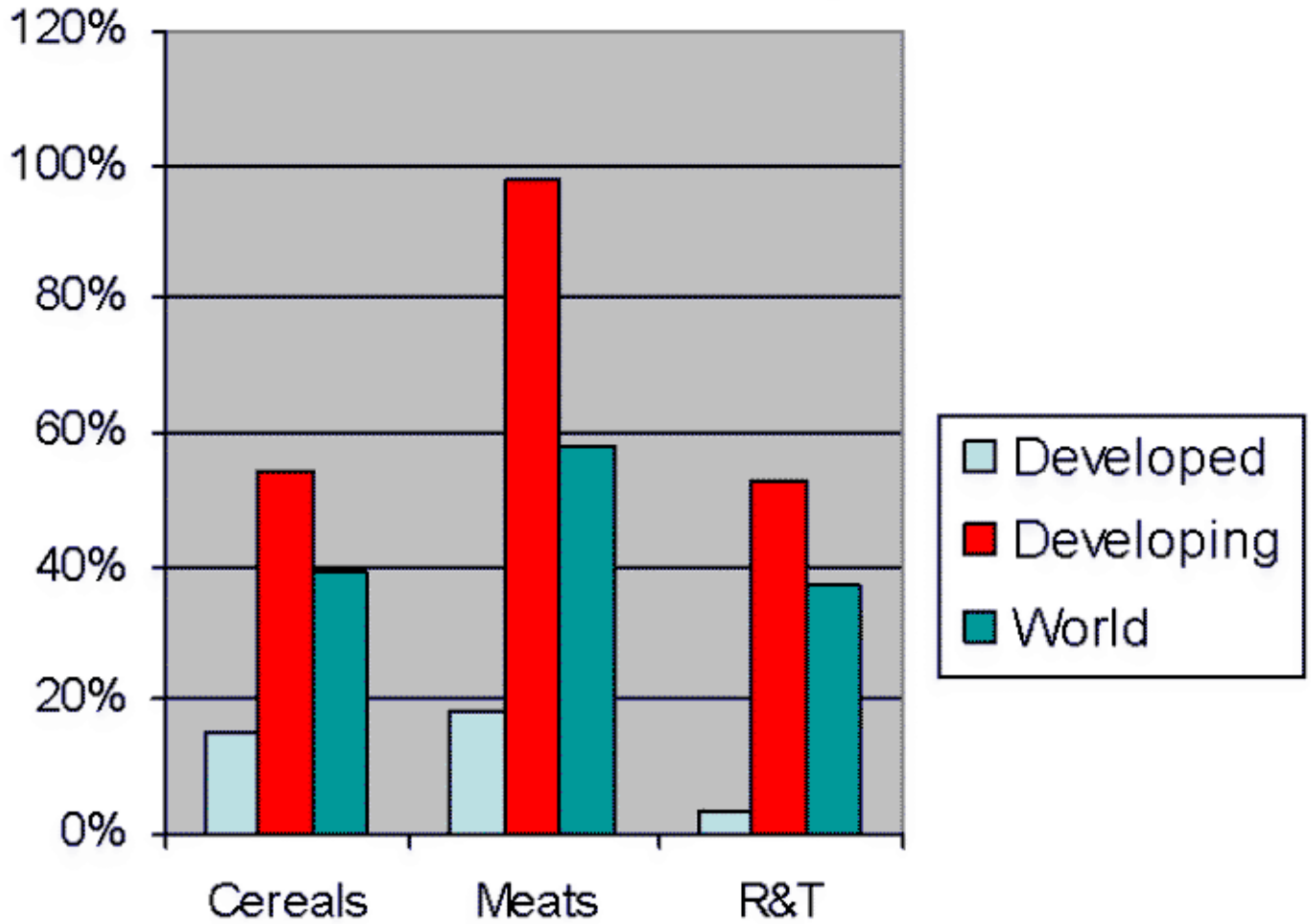
Country	Private ag. R&D as a fraction of ag. GDP (%)
United Kingdom	3.71
United States	2.67
Australia	0.49
Colombia	0.41
Malaysia	0.15
Thailand	0.10
Philippines	0.06
India	0.03
Indonesia	0.01
Chile	0.01

Source: Kremer and Zwane (2002), who cite Pray and Umali-Deininger (1998); expenditure per unit of agricultural GDP based on data from World Bank (1999).

Growing Food Demand:

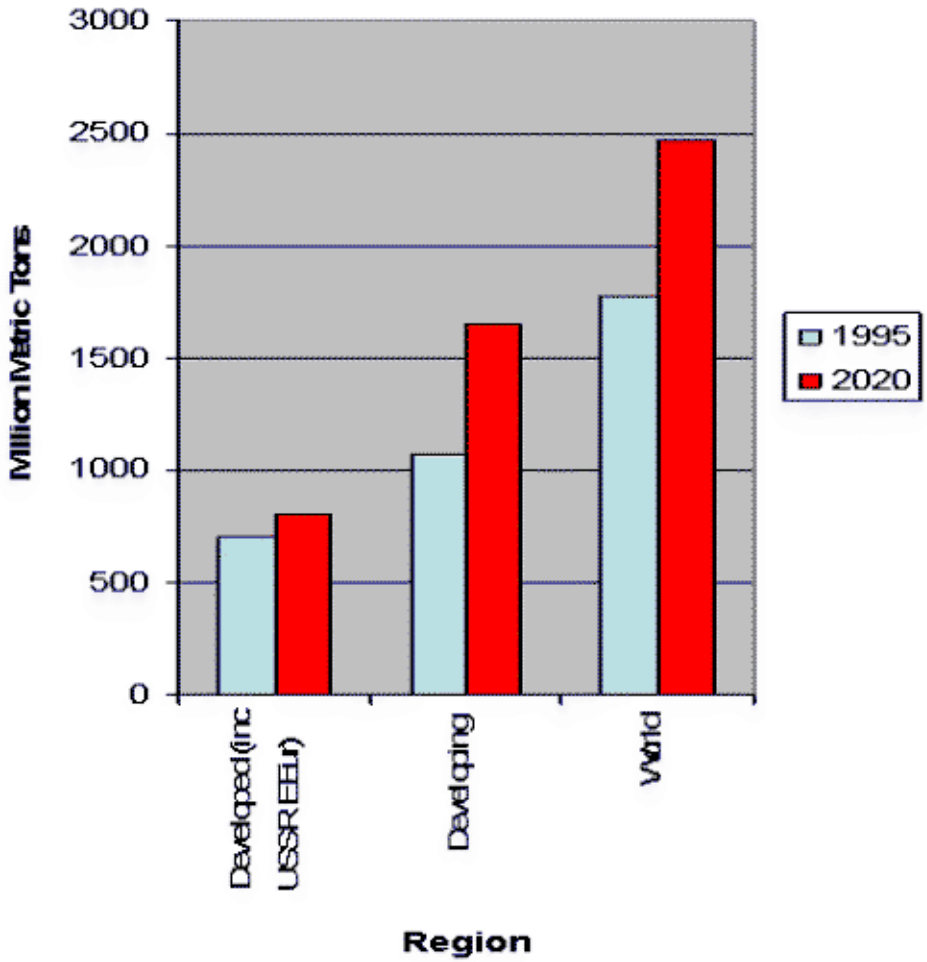
What Projection Trends Say…

Commodity Demand Increases, 1995 to 2020



Source: International Food Policy Research Institute(IFPRI), (2000)

Cereal Demand, 1995 to 2020

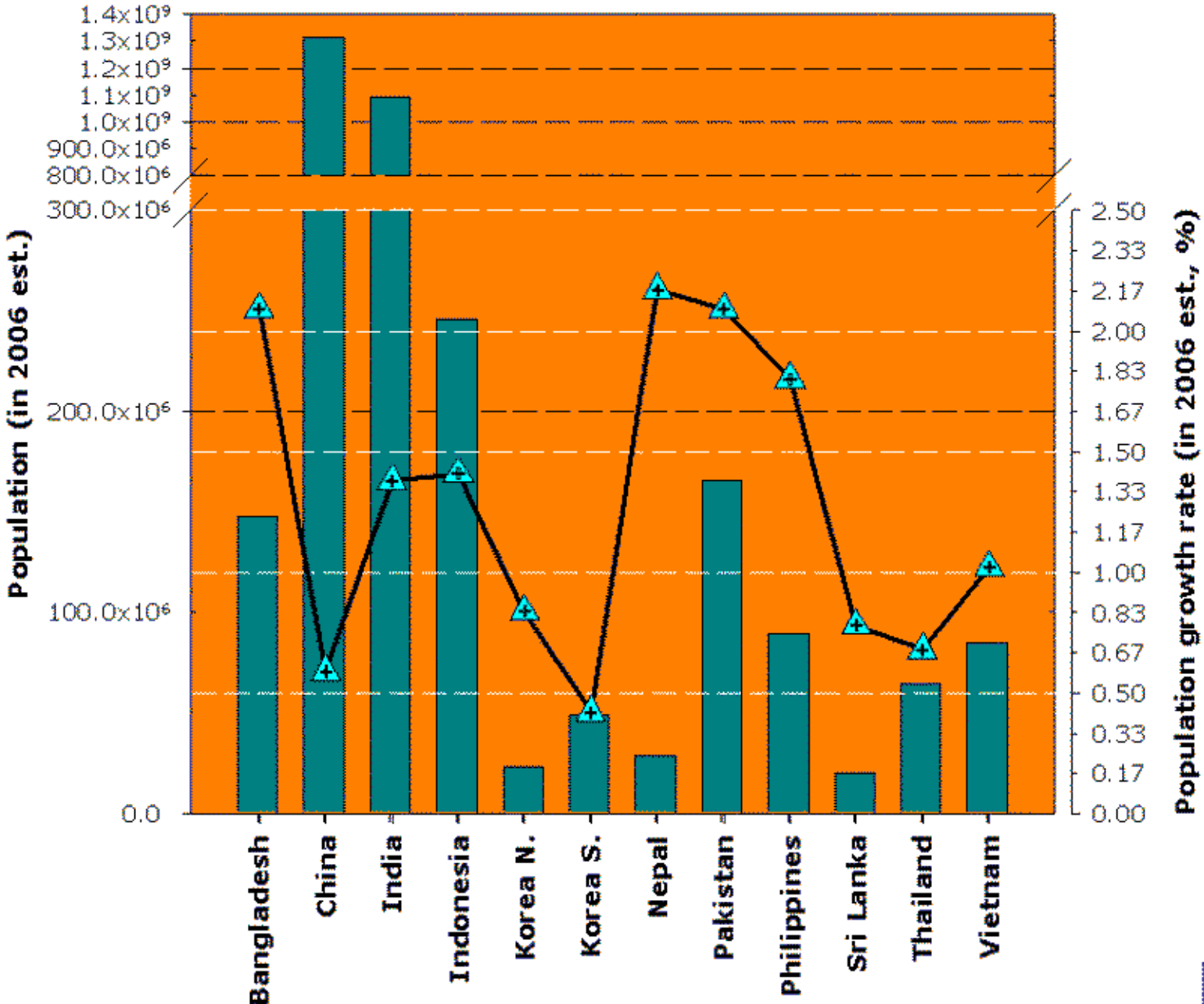


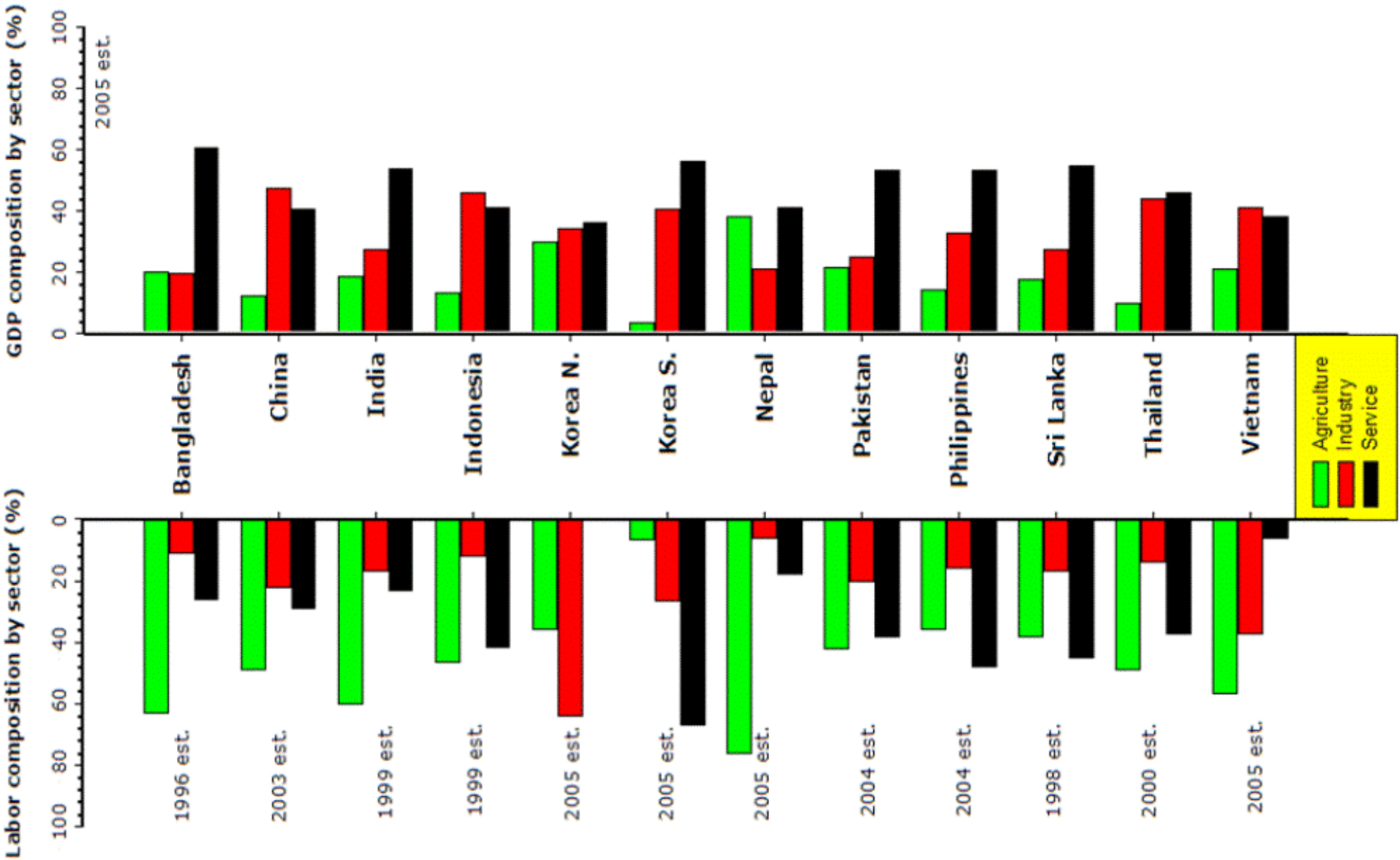
- Global cereal demand will increase by **39**% (690.1 mmt) from a base demand of 1776.2 mmt in 1995
- Demand in developing world will increase **54**% (583.3 mmt)
- Demand in developed world will increase **15**% (106.8 mmt)

Source: International Food Policy Research Institute(IFPRI), (2000)

Profile of Developing Countries in ASIA

Population and its growth rate during 2006 (Compiled after CIA, 2006)

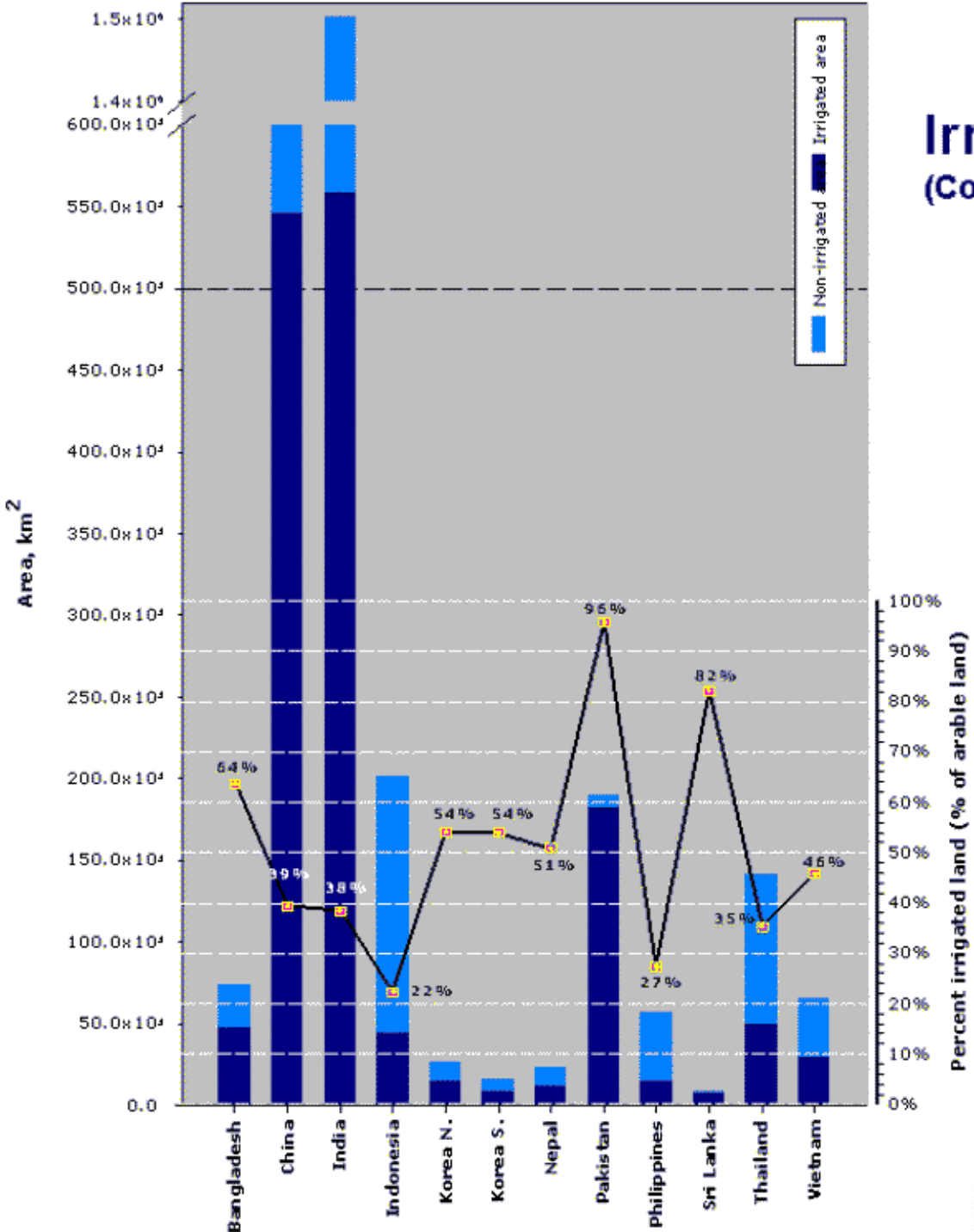




Sectoral composition of labor and GDP (Compiled after CIA, 2006)

Irrigated area during 2003

(Compiled after CIA, 2006)



Food production indices during 2000-2005

(in percent of 1999-2001 average total production)

	Year					
	2005	2004	2003	2002	2001	2000
Region (total, in million)						
World	111.1	110.4	106.5	103.5	101.6	100.2
Developed countries	103.4	105.1	99.9	100.0	99.6	100.6
Developing countries	115.5	113.4	110.2	105.5	102.6	100.0
Country (individual, in thousand)						
Bangladesh	109.3	108.8	106.8	103.0	100.4	102.9
China	122.1	118.2	112.6	109.1	103.5	100.2
India	105.5	105.3	104.7	97.9	102.4	99.1
Indonesia	122.7	122.4	115.6	108.8	102.3	100.5
Korea, N.	112.8	110.9	110.6	108.5	106.2	95.8
Korea, S.	96.3	98.5	91.7	94.3	100.9	100.3
Nepal	113.1	111.7	111.8	106.6	103.3	100.3
Pakistan	113.6	109.9	105.9	101.5	99.2	102.0
Philippines	114.4	117.3	111.8	109.4	104.2	99.8
Sri Lanka	107.0	98.5	104.0	100.3	98.7	101.7
Thailand	103.6	103.1	110.0	104.5	103.9	100.6
Viet Nam	125.8	123.9	117.5	112.8	103.9	100.4

Sources: WRI (2006); FAOSTAT (2006)

Comparative use of tractor during 1995-2003

	Year								
	2003	2002	2001	2000	1999	1998	1997	1996	1995
Region (total, in million)									
World	27.6	27.2	26.9	26.9	26.7	26.6	26.4	26.3	26.2
Asia*	7.1	6.7	6.5	6.5	6.2	6.0	5.9	5.7	5.5
Europe	10.8	10.9	10.9	10.9	11.0	11.2	11.2	11.4	11.5
Developed countries	19.3	19.3	19.4	19.3	19.4	19.6	19.7	19.9	20.1
Developing countries	8.4	7.9	7.7	7.7	7.3	7.1	6.9	6.5	6.3
Country (individual, in thousand)									
Bangladesh	5.5	5.5	5.5	5.5	5.5	5.4	5.4	5.4	5.3
China	995.4	926.0	844.2	989.1	798.5	738.5	703.1	684.3	685.2
India	2,528.1	2,176.1	2,058.8	1,941.5	1,824.2	1,706.8	1,589.5	1,472.2	1,354.9
Indonesia	94.6	94.3	88.4	101.0	93.4	85.8	79.4	69.5	60.0
Korea, N.	64.2	64.3	64.3	64.7	65.1	65.5	65.9	66.3	66.7
Korea, S.	211.6	206.4	201.1	191.6	176.1	157.9	131.4	113.3	100.4
Nepal	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6
Pakistan	320.5	320.5	320.5	320.5	320.5	320.5	320.5	320.4	305.0
Philippines	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5
Sri Lanka	10.5	10.5	9.7	8.8	8.0	7.4	6.7	7.0	7.4
Thailand	220.0	220.0	220.0	220.0	220.0	220.0	218.2	183.7	148.8
Viet Nam	163.0	163.0	163.0	162.7	145.9	123.0	115.5	109.5	97.8

* Excluding Middle East
Source: FAOSTAT (2006)

Fertilizer use intensity during 2000-2002 (in kg/ha)

	Year		
	2002	2001	2000
Region (average)			
World	91.9	89.5	88.2
Asia (excluding Middle East)	145.7	138.7	137.9
Developed countries	78.7	79.3	77.5
Developing countries	102.3	97.9	96.7
Country(individual)			
Bangladesh	168.9	170.8	155.6
China	256.6	227.8	230.2
India	95.0	102.2	98.4
Indonesia	88.8	78.5	74.2
Korea, North	91.8	100.5	91.4
Korea, South	370.3	379.4	408.4
Nepal	35.9	29.3	30.1
Pakistan	133.0	132.9	134.9
Philippines	67.6	73.0	69.0
Sri Lanka	148.3	127.7	129.3
Thailand	87.8	87.2	81.1
Viet Nam	224.1	215.6	278.6

Source: FAOSTAT (2006)

Water use efficiency during 2000 (in m^3/ha/year)

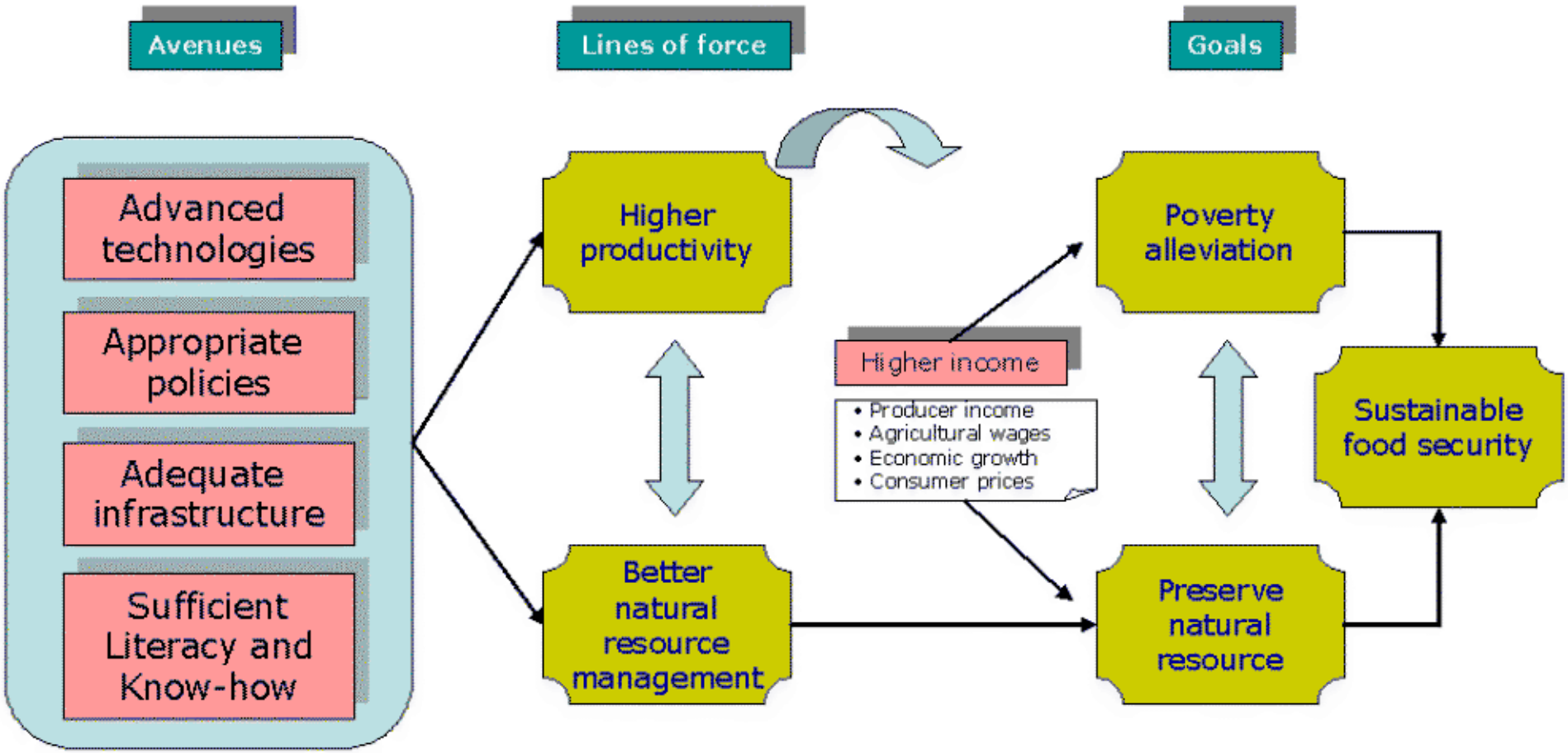
	2000
Cambodia	8,999.3
China	2,871.4
India	3,289.4
Indonesia	2,250.0
Korea, N.	1,771.4
Korea, S.	4,650.7
Myanmar	4,042.8
Pakistan	7,406.6
Philippines	1,981.2
Sri Lanka	6,282.7
Thailand	4,299.8
Viet Nam	5,974.4

Source: FAOSTAT (2006)

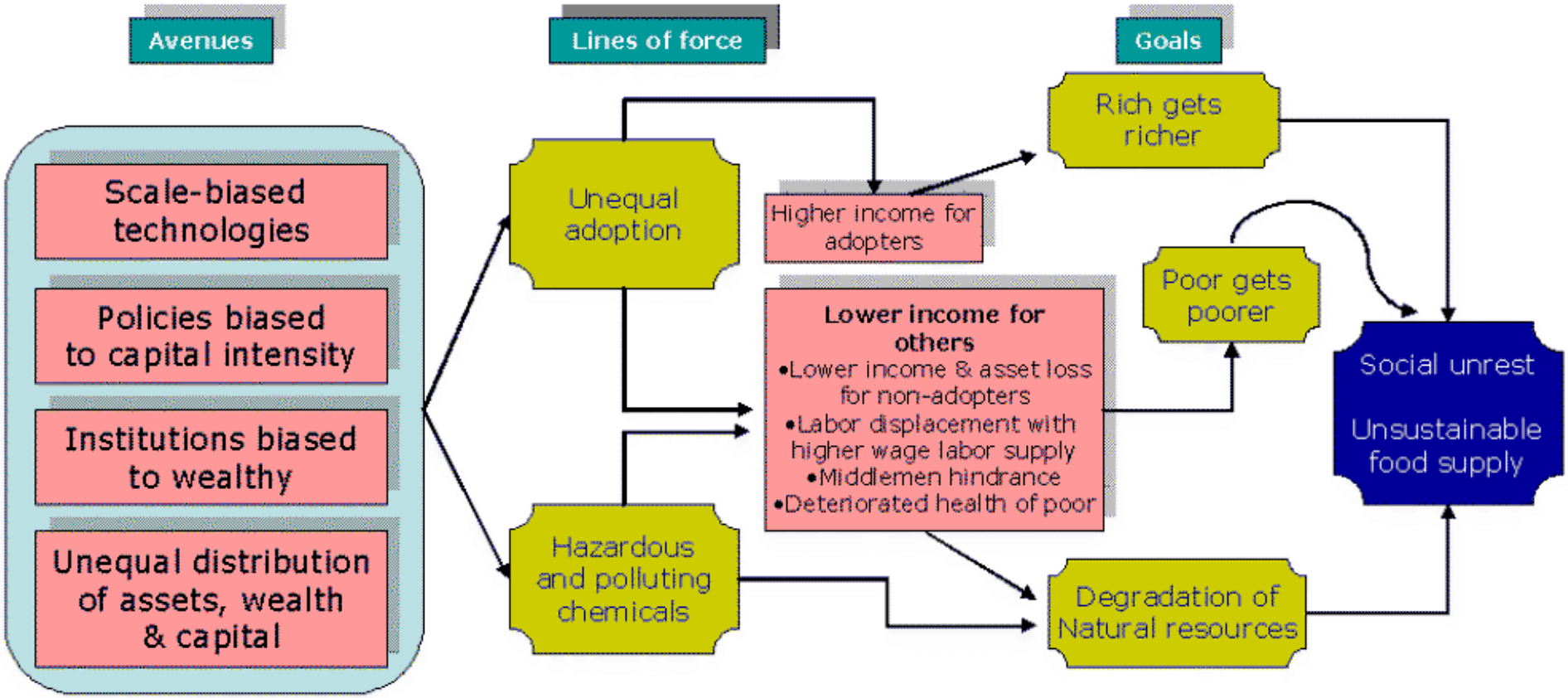
Evolution of Agricultural Research in ASIA

Positive Impact…

Contribution of agricultural research to poverty alleviation



Negative Impact…



Status of Small Farms Mechanization in Asia

Average operational farm size in Asia: **1 – 3.7** ha

Research expenditures (of GDP) for agriculture:

0.4% low-income countries
2% middle-income countries
2.5% high-income countries

Share of the Asian and Pacific region in the global agriculture machinery consumption is only **10**% compared with Europe, which has the highest share of **80**%.

As of 2002, **Japan** had the highest number (1.042 million units) of harvesters-threshers in use, followed by China (0.197 million unites), while **Sri Lanka** had the lowest number of only 10 units of harvester-threshers (FFTC, 2006).

Comparative yield of cereals during 2000-2005 (kg/ha)

	Year					
	2005	2004	2003	2002	2001	2000
Region						
World	3,263	3,349	3,106	3,078	3,115	3,056
Asia[#]	3,467	3,463	3,317	3,327	3,308	3,247
Europe	3,509	3,816	3,150	3,487	3,419	3,162
Developed countries	3,934	4,133	3,609	3,579	3,679	3,580
Developing countries	2,929	2,938	2,850	2,816	2,817	2,786
Country						
Bangladesh	3,551	3,517	3,531	3,393	3,311	3,384
China	5,171	5,177	4,878	4,890	4,802	4,756
India	2,367	2,424	2,382	2,310	2,423	2,294
Indonesia	4,312	4,275	4,248	4,174	4,045	4,026
Korea, N.	3,426	3,450	3,347	3,199	3,020	2,371
Korea, S.	6,283	6,688	5,729	6,087	6,561	6,436
Nepal	2,282	2,279	2,293	2,171	2,177	2,136
Pakistan	2,563	2,431	2,320	2,261	2,231	2,408
Philippines	3,023	2,992	2,823	2,731	2,668	2,581
Sri Lanka	3,438	3,564	3,283	3,405	3,425	3,338
Thailand	2,723	2,706	2,747	2,707	2,727	2,719
Viet Nam	4,780	4,665	4,508	4,442	4,168	4,113

Sources: WRI (2006); FAOSTAT (2006)

Tractor use intensity during 1995-2003 (ha/tractor)

	Year								
	2003	2002	2001	2000	1999	1998	1997	1996	1995
Region									
World	55.8	56.6	57.2	56.9	57.3	57.6	57.8	58.2	58.3
Asia*	70.4	75.2	77.6	76.0	78.2	79.9	81.9	84.5	87.4
Europe	27.8	27.8	27.8	28.0	27.9	27.7	27.8	27.3	27.0
Developed countries	33.3	33.3	33.5	33.8	33.5	33.8	33.8	33.7	33.4
Developing countries	107.5	113.4	116.8	115.2	120.6	123.8	126.2	132.7	137.7
Country									
Bangladesh	1,522.4	1,524.2	1,534.4	1,534.2	1,548.6	1,543.0	1,526.1	1,531.8	1,537.4
China	155.6	166.7	183.8	150.3	181.5	186.7	192.5	197.4	196.6
India	67.1	78.0	82.4	87.4	93.0	99.4	106.7	115.2	125.3
Indonesia	363.7	357.4	380.0	332.5	350.6	370.1	393.6	445.8	506.5
Korea, N.	45.2	45.1	43.5	43.3	43.0	42.0	41.0	39.2	39.0
Korea, S.	8.7	9.0	9.4	10.0	10.8	12.1	14.6	17.2	19.8
Nepal	444.6	442.9	442.0	433.8	431.4	430.2	429.3	428.4	428.4
Pakistan	62.8	69.5	69.1	68.5	68.3	68.5	68.6	67.7	70.7
Philippines	930.4	930.4	930.4	926.1	921.7	917.4	887.0	869.6	860.9
Sri Lanka	182.5	182.5	197.0	217.0	238.1	256.8	283.0	268.5	254.3
Thailand	80.4	88.0	87.8	87.5	87.4	87.5	90.0	109.2	137.1
Viet Nam	55.1	54.1	54.2	50.0	53.3	60.3	62.4	64.0	69.0

Source: FAOSTAT (2006)

Irrigated land as percent of total agricultural area during 1995-2003 (%)

	Year								
	2003	2002	2001	2000	1999	1998	1997	1996	1995
Region (average)									
World	5.6	5.6	5.5	5.6	5.5	5.5	5.4	5.4	5.3
Asia*	15.1	15.1	14.8	15.2	15.1	15.1	15.0	14.8	14.6
Europe	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.4	5.4
Developed countries	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.7	3.7
Developing countries	5.9	5.9	5.8	5.9	5.9	5.8	5.8	5.7	5.7
Country (individual)									
Bangladesh	52.4	50.9	48.7	46.1	44.1	43.1	42.4	42.6	42.9
China	30.9	31.0	30.2	31.4	31.2	30.4	30.5	29.6	29.3
India	9.9	10.0	10.0	10.0	10.1	10.3	10.4	10.5	10.5
Indonesia	49.5	49.5	51.2	51.2	51.2	52.1	53.1	55.1	55.1
Korea, N.	46.2	45.9	45.3	44.6	44.9	44.7	44.5	44.3	44.3
Korea, S.	27.7	27.7	27.6	27.1	27.2	27.2	27.3	27.3	27.3
Nepal	72.5	65.9	65.6	67.1	66.8	66.7	66.1	65.9	64.8
Pakistan	12.7	12.7	12.7	12.8	12.9	12.9	13.3	13.6	13.8
Philippines	31.5	27.1	25.4	28.3	28.2	28.0	25.8	24.5	24.5
Sri Lanka	27.0	24.7	24.8	24.9	24.7	23.9	23.2	22.6	21.9
Thailand	31.2	31.7	31.6	34.2	35.7	37.2	38.2	39.1	42.4
Viet Nam	3.18	3.20	3.15	3.38	3.51	3.64	3.71	3.77	3.86

Sources: WRI (2006); FAOSTAT (2006)

Problems, Issues & Constraints

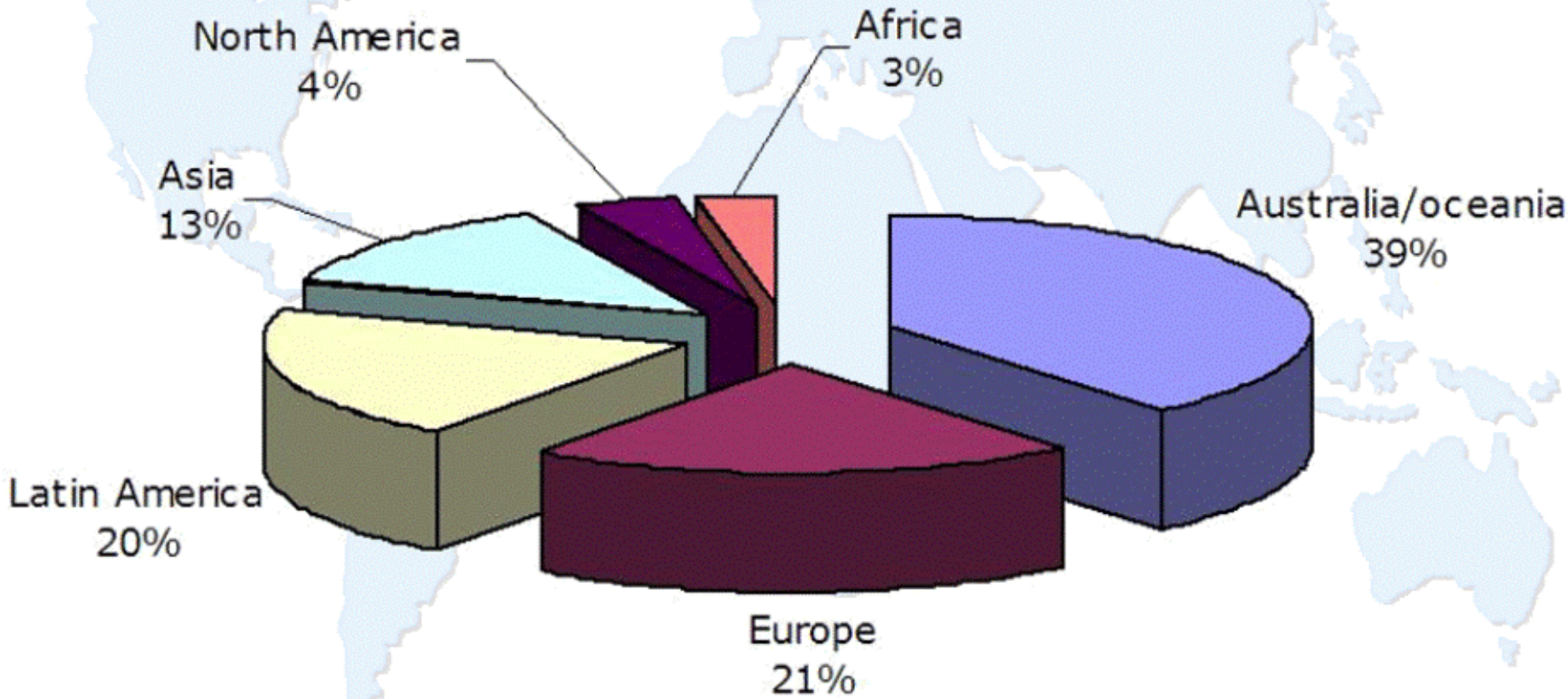
The barriers that impede the growth and sustainability of agricultural engineering in the region can be classified into:

- Technological Constraints
- Socio-economic and Behavioral Barriers
- Financial and Economical Problems
- Environmental Issues
- Land holding
- Miscellaneous

agricultural v/s environmental research: Conflicting agenda

Agricultural research + Environmental research = Sustainable research	
Agricultural research	**Environmental research**
Product-oriented	Process-oriented
Disciplinary	Multidisciplinary
Comparatively market-driven	Market failure assumed
Accepting of production as an end	Critical of production as an end
Resource optimism because of technology	Resource pessimism in spite of technology
Food valued highly relative to environment	Environment valued highly relative to food

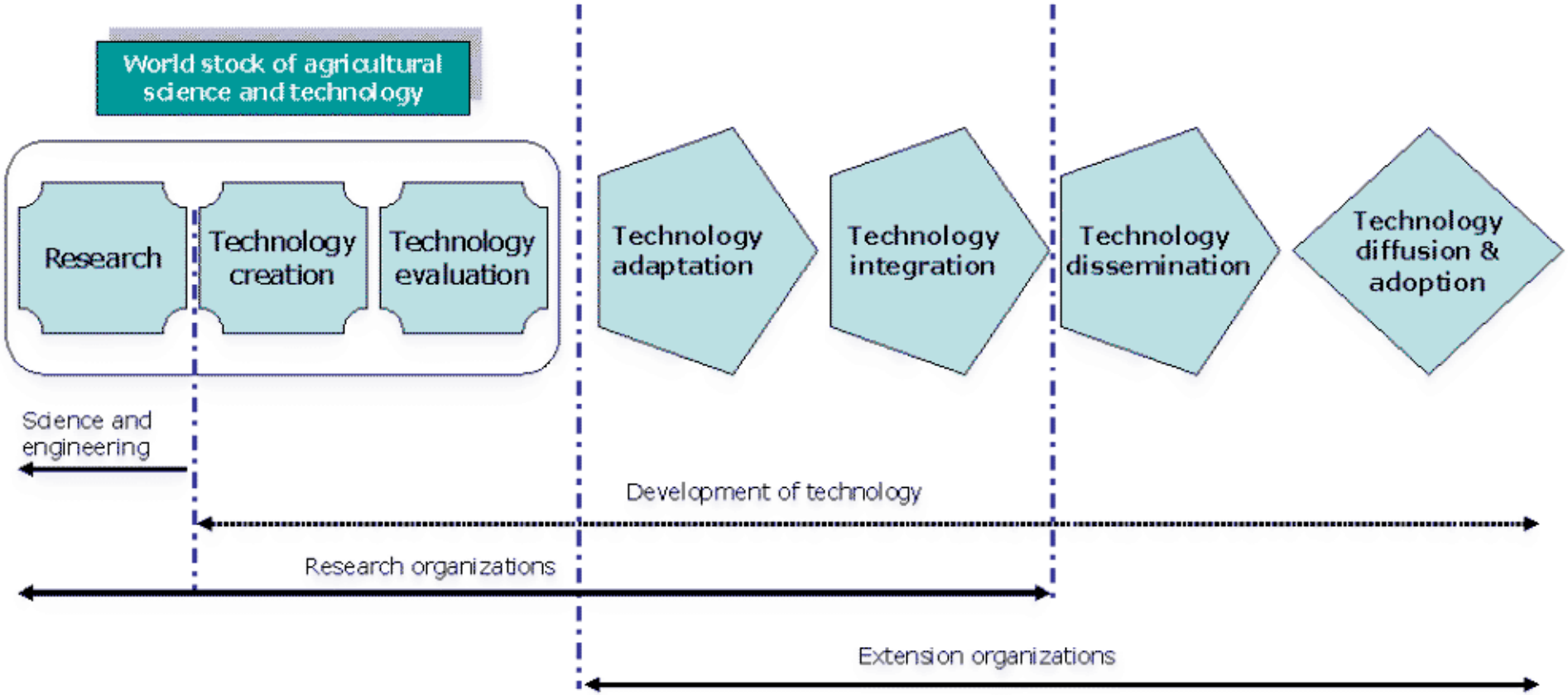
Area under organic management: Percent share per continent (During 2005-2006)



Research Extension in Challenging Scenario

- **Environmentally sustainable** diversification and intensification of agriculture
- **Location specific** technologies tailored to local needs
- Disadvantaged and risk-prone areas and small and marginal farmers and women
- Agricultural practices that increase productivity while **preserving the natural resource base**
- **Value addition** to agricultural produce through improved postharvest techniques, agro-processing and access to market and market information
- Creation of an enabling environment that encourages greater participation of the **non-governmental sector**

The technology innovation process



Agricultural R&D in Asia

Between 1985-87 and 1995-98, private R&D grew in most of the Asian countries.

In India, Pakistan, Indonesia, and China, research funding more than **doubled** within 10 years.

In the Philippines and Thailand, research funding grew between **60** and **70**%.

The largest amount of private agricultural research was in **India**, where investment was about US$ **55** million per year in the mid-1990s.

The next largest amounts of private research expenditure were recorded by **Thailand, Malaysia, and China** (US$ 15 - 20 million per year for agricultural research. They were followed by the **Philippines** (US$ 10 million), and **Indonesia** (US$ 6 million) and **Pakistan** (US$ 6 million).

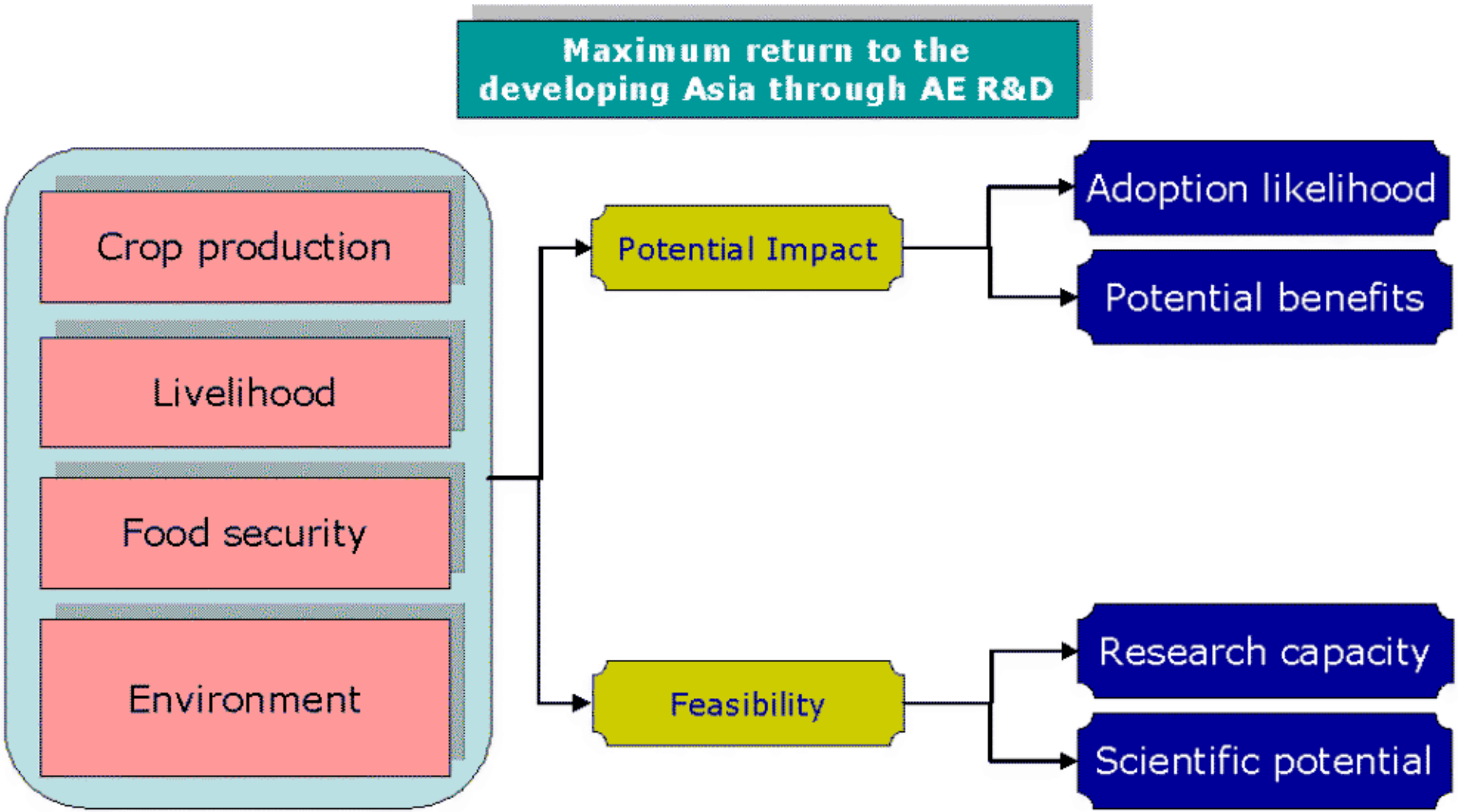
Agricultural Research Priorities in ASIA

Assessing Research Priorities

Mutually exclusive and independent portfolio criteria:

- Potential Benefits
- Adoption Likelihood
- Scientific Potential
- Research Capacity

Conceptual framework for assessing AE R&D priorities

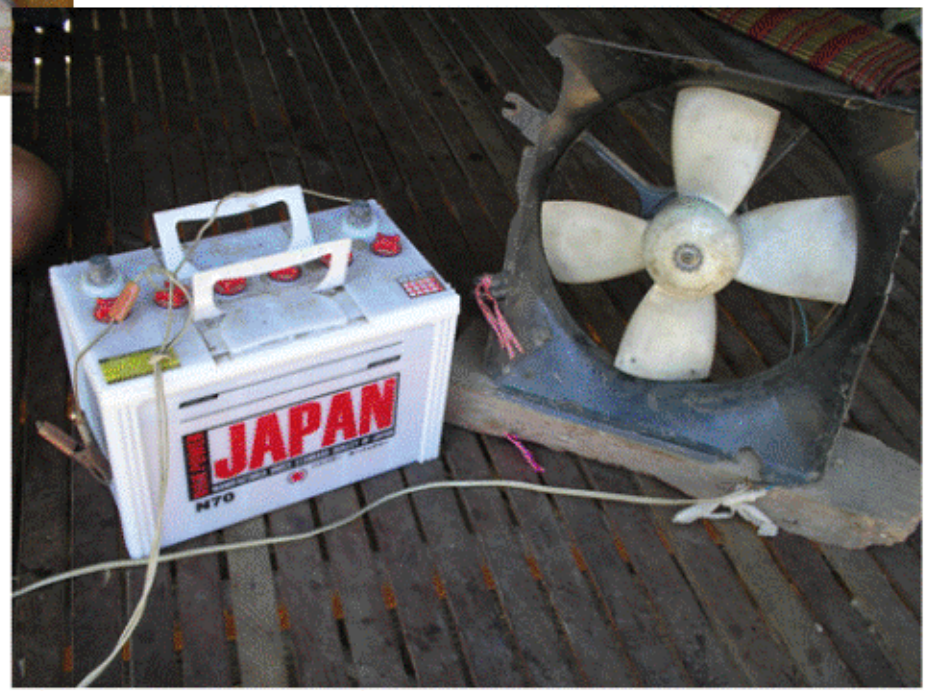


Major research issues and broad research topics in crops sub-sector

Research Issues	Research Topics
Value addition	Post-harvest operations, processing, storage, packaging, transportation, and quality improvement
Agricultural Market	Size of demand, quality & quantity, responses, processes, efficiency, market studies
Sustainable Agriculture	Resources degradation, soil & water management, use of pesticides & fertilizers, nutrient management
Plant Genetics	Conservation, utilization, management, improvement, breeding, increased yield, off-season production
Drought & Salinity Tolerance	Soil, water and crop management, variety tolerance to environmental stress
Pest and Diseases	Resistance or tolerance of chemical, integrated pest management, biological control, plant derived pesticides
Accessibility & Utilization	Prolonged production, seasonality, controlled environment agriculture
Integration among Sub-sectors	Integration of crops, livestock, aquaculture, poultry; Systems approach

Agricultural Engineering in ASIA

Agricultural Engineering!!



Irrigation

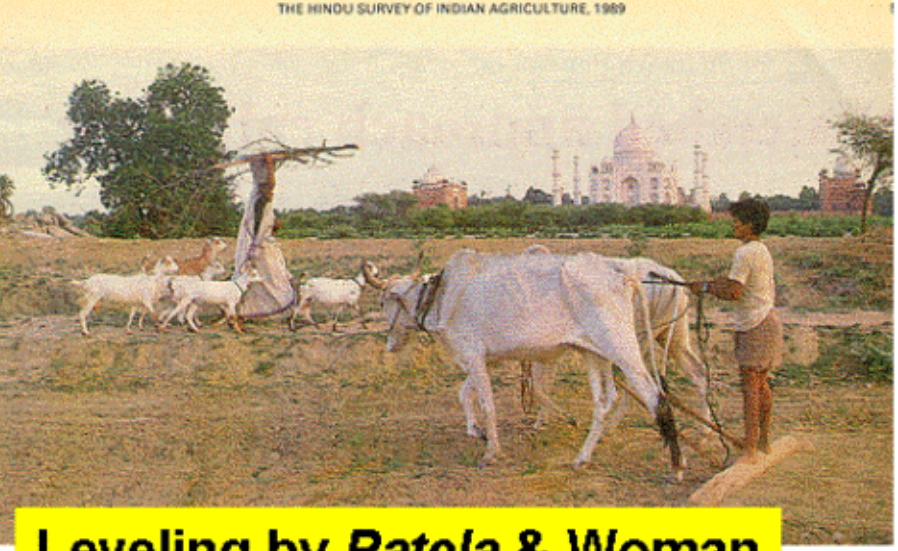
Harvesting

Threshing

Rural Transportation

Repair & Maintenance

Support service



Leveling by *Patela* & Woman Carrying wood on head

Manual Transplanting of Paddy

Manual Weeding

Manual Threshing of Paddy


Conclusions

CONCLUSIONS…

Asian agriculture is **rapidly growing** with intense farm-mechanization support in most Asian developing countries

Demand of Ag m/c will undoubtedly be increasing, but rate of increase differ from region to **region, type, size** and **make** of machinery

Though *agricultural engineering*, in the region is marking its presence in various forms; yet it is still mainly considered in terms of *farm mechanization*.

Agricultural Engineering will continue to serve the region, even with higher impetus, in the near future. A lot more faces of AE are yet to be practiced in the region.

Be the change you want to see in the world

Thank you

...for your attention

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