Feeding the 9 Billion

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Hunger & Food Insecurity Widespread

- About 1 billion people (1 out of every 7 people in the world) suffer hunger*.
- 1.4 billion people live on less than $1.25 per day,
- 2.6 billion (almost 40%of the world's population) live on less than $2.00 per day.
- Hunger is due mainly to poverty .
- The rich in no country go hungry except in times of war, natural disaster or politically-imposed famine.
- To solve the world's hunger problem, the world poverty problem must be solved.
- 70% of the extreme poor live in rural areas, and most are farmers.

*Defined operationally by the FAO as not having enough purchasing power to access 1,800 calories per day.

Malnutrition Has a High Cost

- While 1 billion people suffer calorie deficit, over 2 billion suffer nutritional deficiencies.
  - Most common: vitamin A, iron, iodine, zinc
- Malnutrition from -9 to +24 months can cause permanent stunting of a child's mental and physical development.
- Malnutrition reduces the learning capacity of school-age children and adults' labor productivity and earning potential.
- Malnutrition increases people's susceptibility to diseases caused by pathogens.

Higher Food Prices Increase the Incidence of Hunger

- Low income people spend a large fraction of their incomes on food, so higher food prices reduce the purchasing power of their meager incomes.
- The 2008 price spike increased number of people suffering hunger from 925 million to over 1 billion and precipitated political crises in many countries.
- The need for emergency food aid exploded, but higher grain prices meant that the amount that could be procured by food aid agencies, which operate on fixed annual budgets, dropped.

Share of Food* Expenditures in Total Expenditures (Percent)

Quintile	Bangladesh	India	Indonesia	Philippines
1st	69.3	62.0	63.3	64.6
2nd	66.9	59.4	58.1	59.2
3rd	63.2	56.2	54.1	54.1
4th	58.7	50.8	49.0	47.7
5th	45.2	36.4	37.9	35.4

*"Food" in low income countries has much less value-added after the farm gate than in high income countries. Source: Asian Development Bank.

Projected Population Growth

Region	2011	2050	Change	Percent
World	6,987	9,587	+2,600	+ 38
High Income	1,242	1,333	+ 91	+ 7
Low Income	5,745	8,254	+2,509	+ 44
East & S.E. Asia	2,183	2,308	+ 125	+ 6
South Central Asia	1,795	2,574	+ 779	+ 43
Sub-Saharan Africa	883	2,069	+1,186	+134
Lat. America/Carib	596	746	+ 150	+ 25
N. Africa & W. Asia	451	725	+ 274	+ 61

Source: Population Reference Bureau. 2011 World Population Data Sheet.

10 Largest Countries (millions)

2011		2050	
1. China	1,346	1. India	1,692
2. India	1,241	2. China	1,313
3. United States	312	3. Nigeria	433
4. Indonesia	238	4. United States	423
5. Brazil	197	5. Pakistan	314
6. Pakistan	177	6. Indonesia	309
7. Nigeria	162	7. Bangladesh	226
8. Bangladesh	151	8. Brazil	223
9. Russia	143	9. Ethiopia	174
10. Japan	128	10. Philippines	150

Source: Population Reference Bureau. 2011 World Population Data Sheet.

Dynamics of Food Demand Growth

- With $2.00 per day per capita income most people have sufficient purchasing power to escape hunger, but not to be able to consume a nutritionally balanced diet.
- As their incomes rise from about $2 to $10 per day, people eat more meat, dairy products, fruits, vegetables & edible oils, causing rapid growth in raw ag commodity demand.
- After about $10 per day, people buy more processing, services, packaging, variety, and luxury forms, but not more raw ag commodities.

- *Poverty statistics (World Bank) as of 2005, before commodity price explosion.

Huge Growth in Food Consumption Expected from Economic Growth

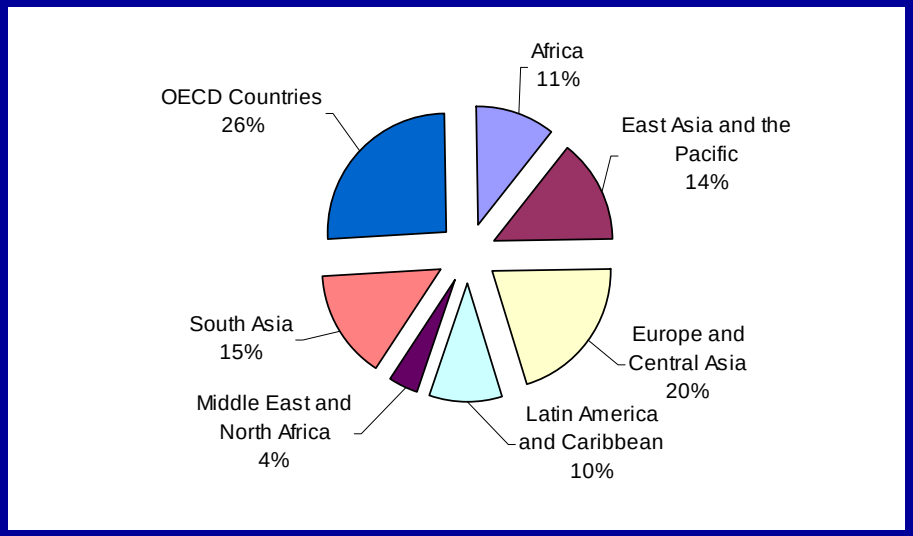
Country	Population	%<$1.25/day	%<$2/day
China	1,326	15.9	36.3
India	1,140	41.6	75.6
Indonesia	228	21.4	53.8
Brazil	192	7.8	18.3
Pakistan	166	22.6	60.3
Bangladesh	160	49.6	81.3
Nigeria	151	64.4	83.9
Philippines	90	22.6	45.0

Source: World Bank. World Development Indicators 2008. Population in millions.

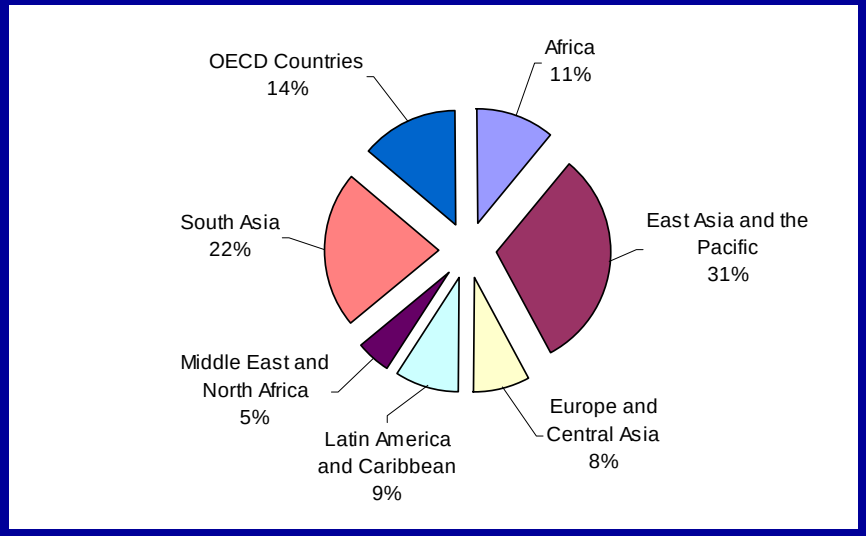
Projected World Food Demand

- World food demand could double by 2050
  - 50% increase from world population growth – from 6 to 9 billion -- all in developing countries
  - 50% increase from broad-based economic growth in low income countries
- The World Bank has estimated the number of people in developing countries in households with incomes >$16,000/year will rise from 352 million in 2000 to 2.1 billion by 2030.
- How many presently low income consumers escape from poverty is the *most important* uncertainty re future global demand for food.
- Any policy that accelerates broad-based economic growth in low income countries will expand demand for ag products.

Larger Fraction of Ag Production to Move Through Trade



Distribution of Arable Land



Distribution of World Population

- With population growth, urbanization and broad-based economic development, many low-income countries' food consumption will outstrip their production capacity, and they will become larger net importers.

Growing Demands on Forests, Too

- The same forces of population and income growth that increase demand for food also increase demand for things made out of wood, e.g. paper, furniture, building materials; poles.
- In rich countries, growing demand for environmental amenities and preservation of (especially old-growth) forested areas.
- At the same time biofuels production is claiming more and more land.

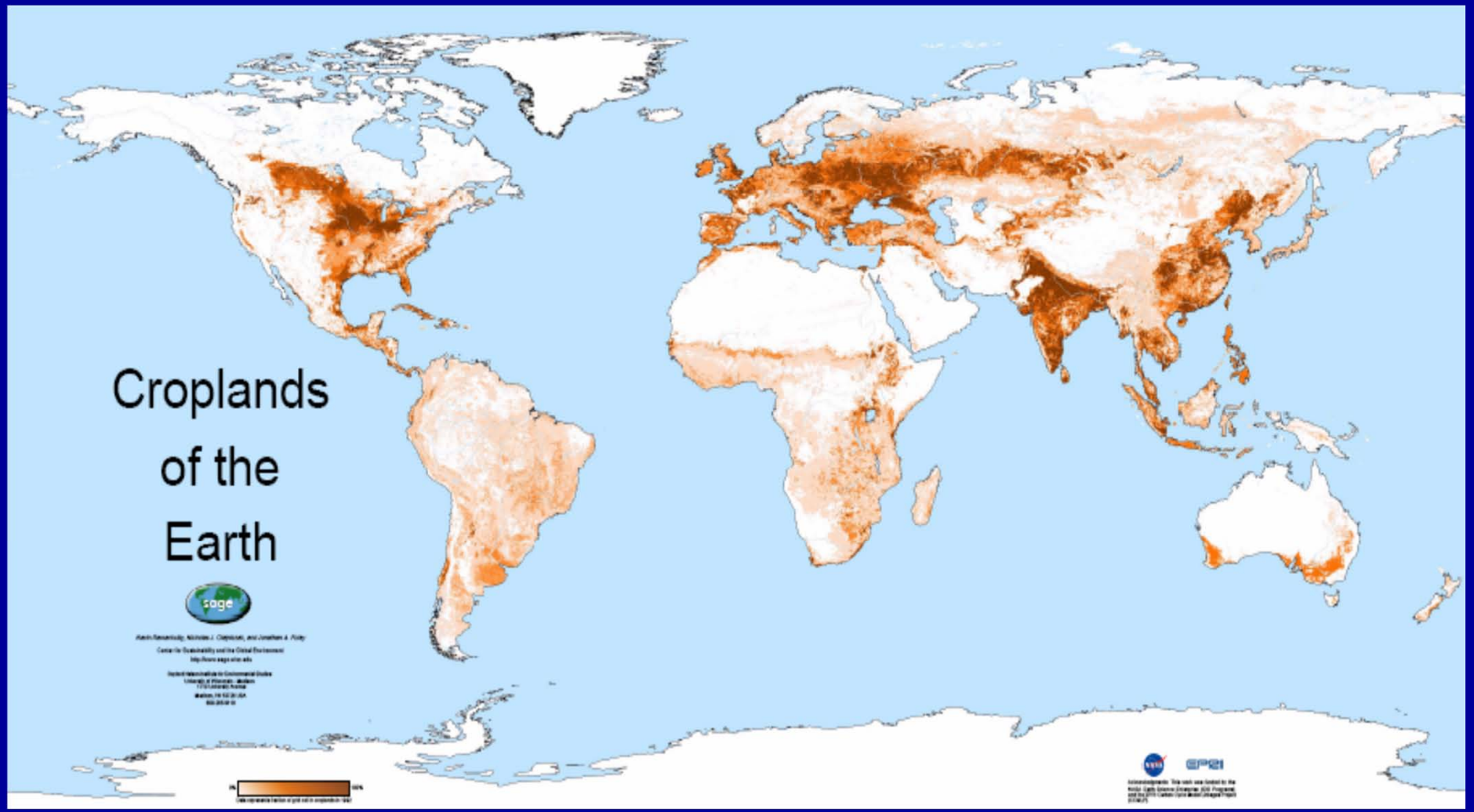
The Land Constraint

- There is at most 12% more arable land available worldwide that isn't presently forested or subject to erosion or desertification, and…
- Loss and degradation of many soils continues:
  - Urbanization & infrastructure construction
  - Nutrient mining
  - Erosion
  - Desertification
  - Natural reserves
  - Reforestation

The Land Constraint (cont'd.)

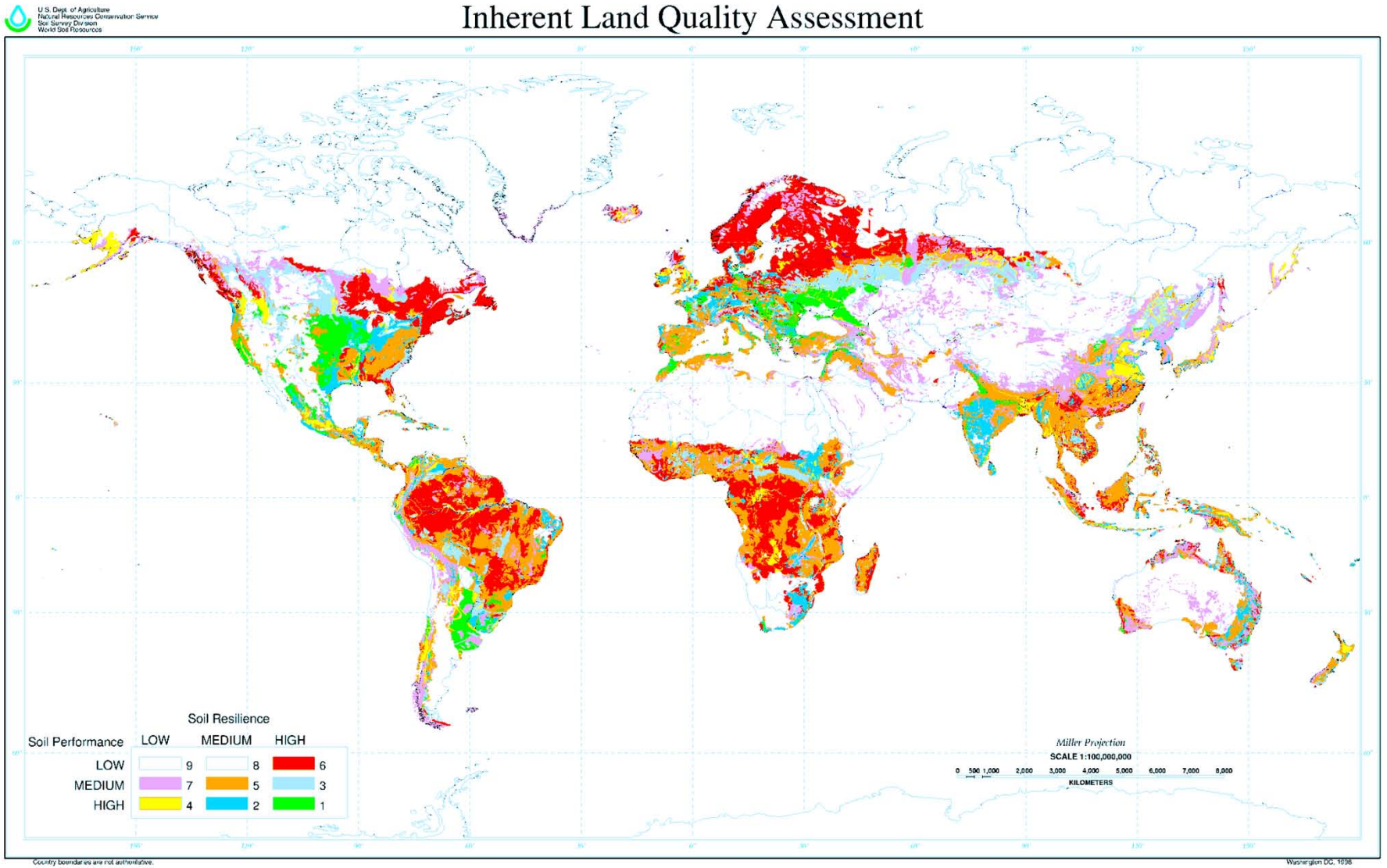
- The area of land in farm production could be doubled…
  - But only by massive destruction of forests and loss of wildlife habitat, biodiversity and carbon sequestration capacity
- The only environmentally sustainable alternative is to double productivity on the fertile, non-erodible soils already in crop production.
- Most available cropland is in remote areas of South America and Sub-Saharan Africa where infrastructure is minimal and soils are inferior in quality to many already in production.

Croplands of the Earth



Interpretation: The darker the shading, the larger the percent of the land under that pixel that is in crop production.
Source: Center for Sustainability and the Global Environment (SAGE), University of Wisconsin.

Inherent Land Quality



Climate Constraints

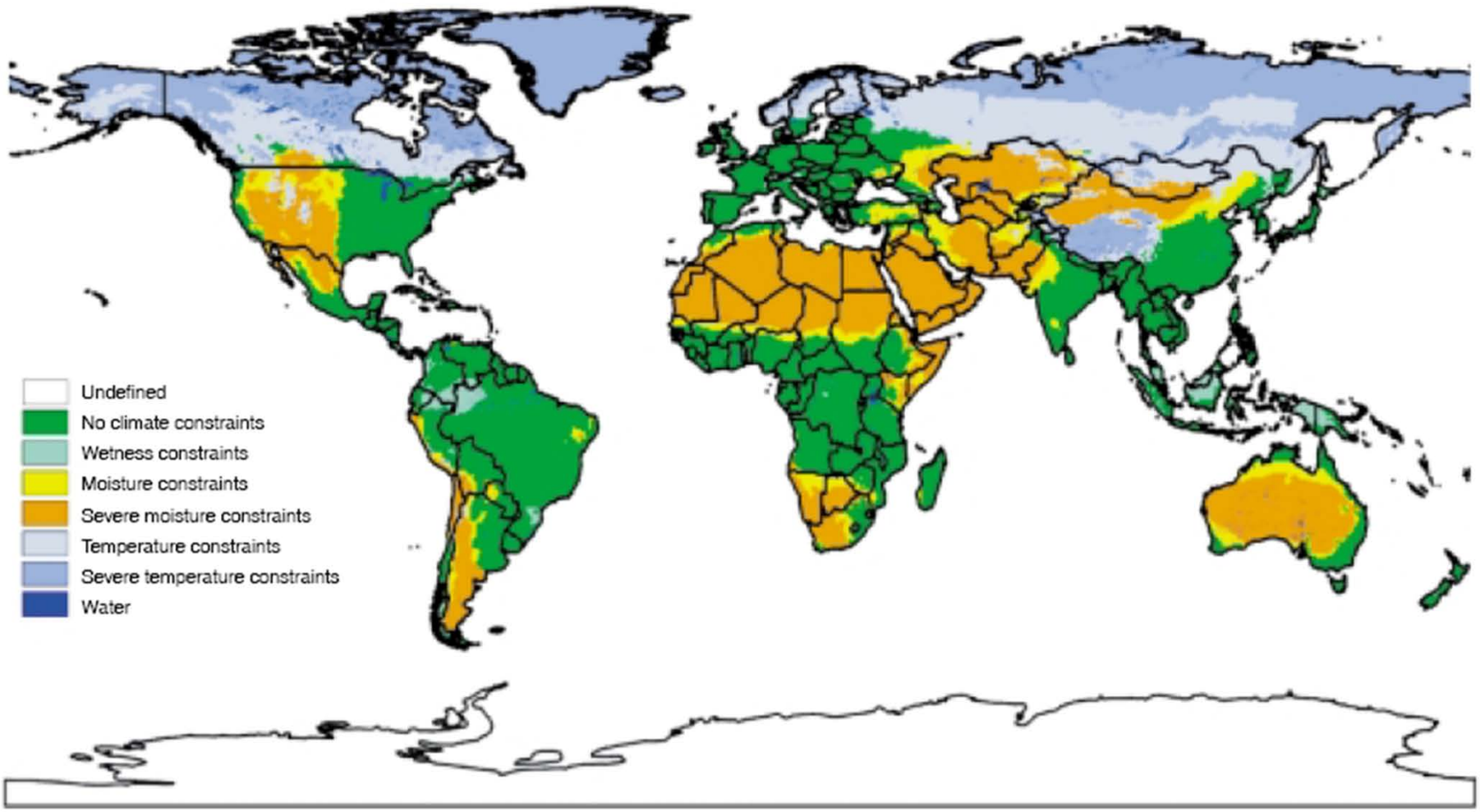


Plate E. Climate constraints.

Source: International Institute for Applied Systems Analysis


Fraction of grid cell
0 - 0.1
0.1 - 0.2
0.2 - 0.3
0.3 - 0.4
0.4 - 0.5
0.5 - 0.6
0.6 - 0.7
0.7 - 0.8
0.8 - 0.9
0.9 - 1
Grazing Lands of the World

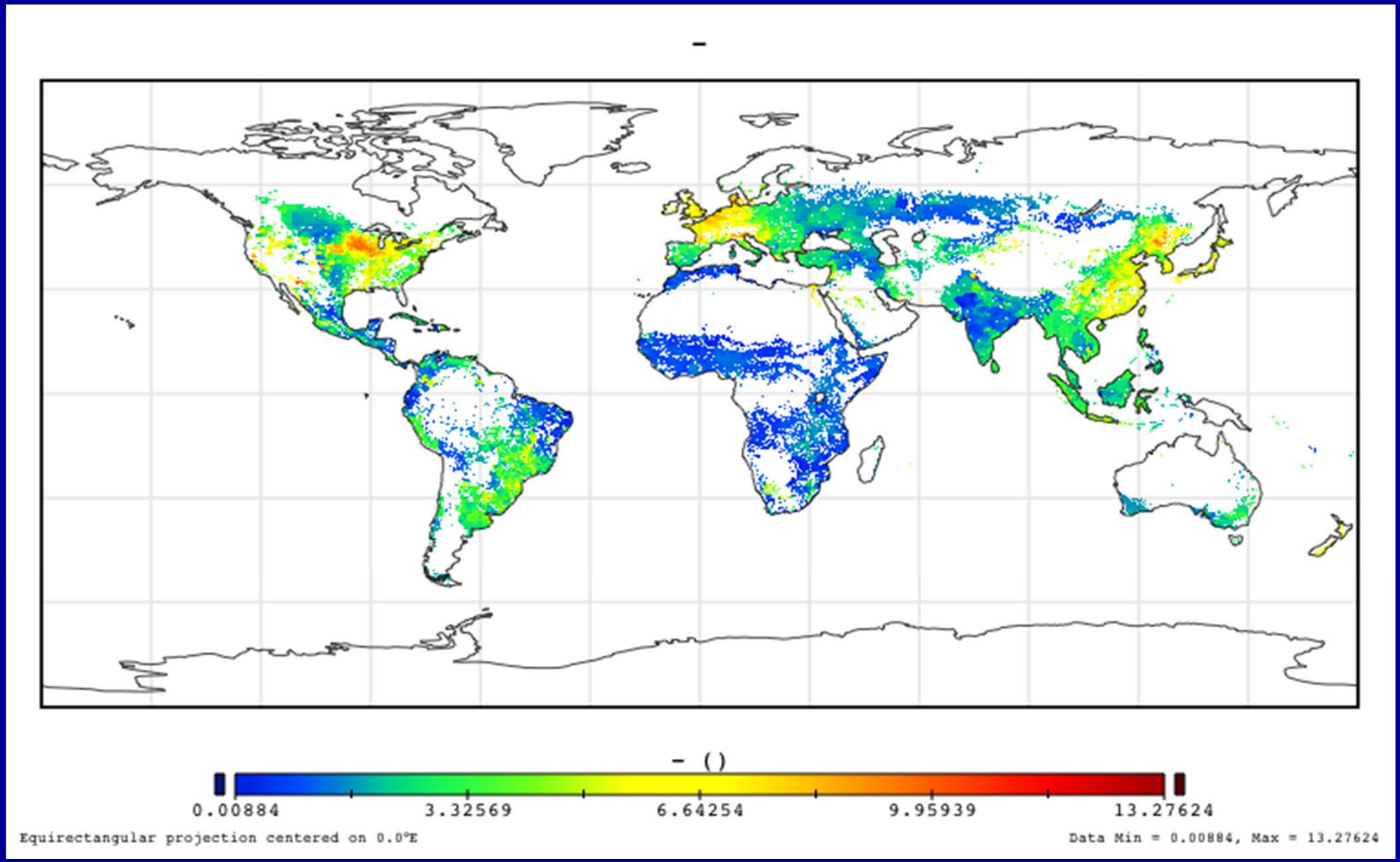
Water A Growing Constraint

- Farmers use 70% of the fresh water used in the world.
- With rapid urbanization, cities are likely to outbid agriculture for available water.
- The world's farmers need to double food production using less water than today. Biofuels will add further to this challenge.
- Water is priced at zero to most farmers, signaling that it is much more abundant than in reality and providing no incentive to use it efficiently or adopt already existing water-saving technology.

Need to Double Food System Productivity

- Make presently unusable soils productive
- Increase genetic potential (of individual crops and/or farming system) (ditto for farm animals)
- Achieve as much of that potential as possible by:
  - Improving nutrition of that crop
  - Increasing water availability and control
  - Reducing competition from weeds for water, nutrients and sunlight
  - Reducing losses from disease and insects
- Reduce post-harvest losses

Grain Yields Around the World

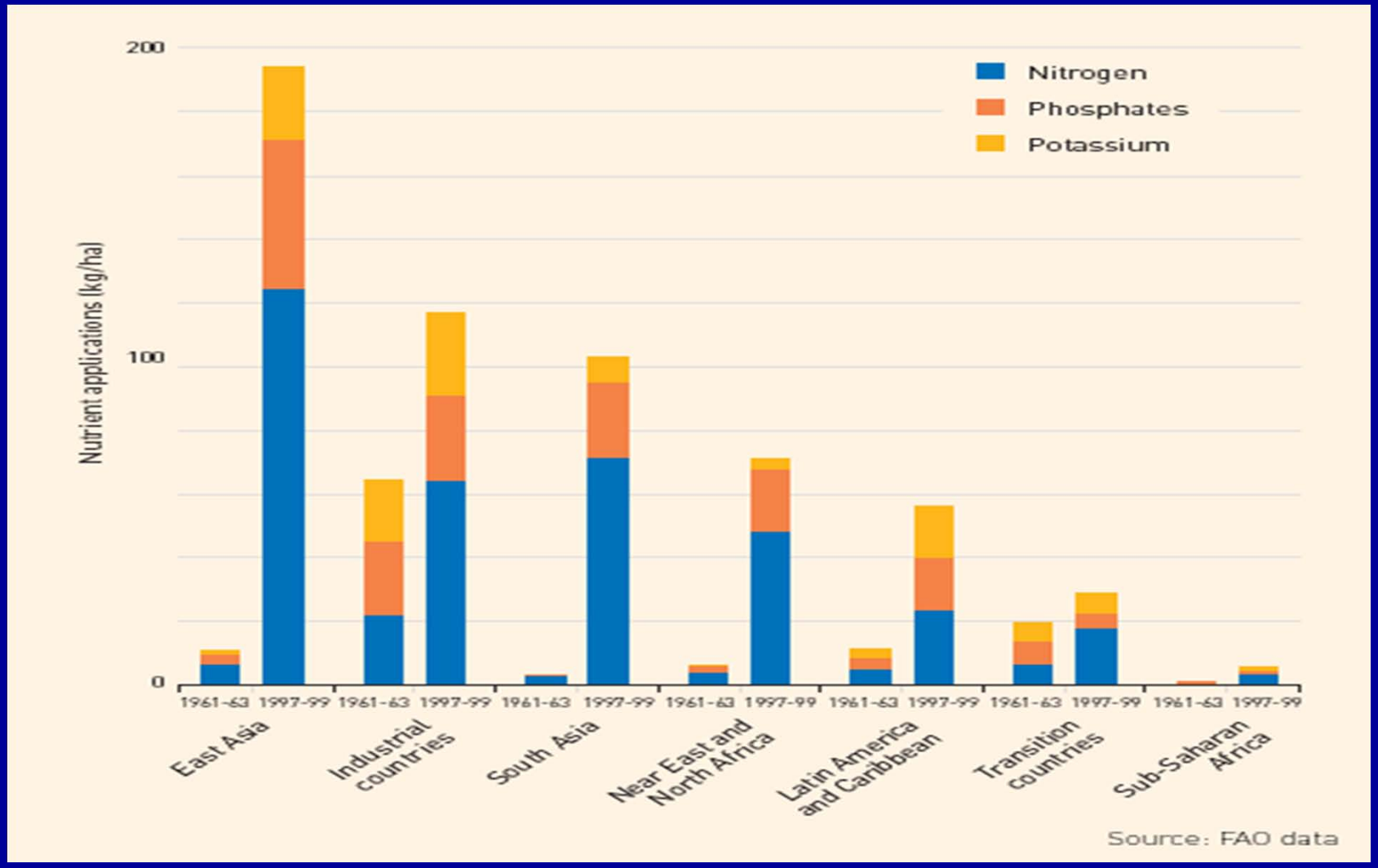


Interpretation: Grain yields (in metric tons per hectare) rise from lowest (dark blue) to highest (dark red)
Source: Center for Sustainability and the Global Environment (SAGE), University of Wisconsin.

Sources of Observed Differences in Crop Yields in Different Locations

- Genetic potential embodied in the seeds of the crop being grown.
- Climatic conditions (level and variation in temperature and precipitation)
- Quality of soil (fertility, water holding capacity; resilience)
- Supplementation of soil fertility and precipitation with fertilizer and irrigation.
- Losses of yield potential from disease and insect infestations and competition from weeds.

Fertilizer Use



More Sources of Observed Differences in Grain Yield in Different Locations

- Existence of markets to supply farmers inputs that embody improved technologies (and available credit) and buy their outputs
  - Requires a business friendly investment climate
- Remunerative input and output prices
  - Reflect public policy and state of transport and communications infrastructure.
- Knowledge and skill of farmers.

Agriculturally Important Effects of Climate Change

- Warming greater over land than over water and greatest at higher latitudes.
- Increases spatial distribution of precipitation*
  - Largest reduction in subtropics (especially on their poleward edges)
  - Largest increases in higher latitudes
  - Increase under monsoons
- Increased frequency of extreme events, such as droughts and flooding.

*But what matters to agriculture is soil moisture when growing plants need it. This is determined by precipitation net of evaporation. Evaporation occurs faster at higher temperatures. Moreover, different soils have different water retention capacity.

Agriculturally Important Effects of Climate Change

- More carbon dioxide enhances plant growth
- Higher temperature extends growing season in high latitudes, but likely detrimental in low latitudes
- Available water (increase demand for irrigation?)
- Increased risk from greater climatic variability and more frequent extreme events
- Proliferation of pests and diseases further north
- Sea-level rise causes loss of cropland
- Loss of soil fertility and increased erosion

Adaptations Will be Required Due to Global Warming

- Need adaptive plant (and animal) breeding , just as has been done successfully to relax physical constraints in given regions for more than a century, e.g. introduce more drought or heat tolerance.
- Change the mix of what crops are produced in a given geographic location
- Rely more on international trade.

Agricultural Research Potential

- Most productivity enhancement potential of Green Revolution technologies already exploited.
- But biotechnology opens new frontiers:
  - Improve nutritional content of grains, etc.
  - Increase tolerance to drought, wetness, temperature, salt, aluminum toxicity, …. (to increase yields and/or planted area under adverse or variable conditions)
  - Internalize resistance to diseases; viruses
  - Reduce pesticide use, esp. insecticides
  - Herbicide-resistant varieties
  - Slow down product deterioration

Public vs. Private Biotech Research

- Private sector role in biological ag research only took off after late 1970s when U.S. Congress & European parliaments cut appropriations and encouraged private sector to take on this role
- As tools of biotechnology were being developed, governments were reducing investments in ag research – both at home and in their foreign aid
- There is nothing inherent in biotechnology that says it must be done by private sector.
- A key question is how much will the public sector invest in adaptive ag research in the future, especially in developing countries.

World Agriculture in Disarray*

- Most high income countries have subsidized their agriculture, distorting relative returns to various outputs and inducing larger total investment in agriculture relative to other sectors.
- Many low-income countries' food policies have turned the terms of trade against agriculture to keep urban food prices low, reducing the incentive to invest; agriculture underperforms relative to its potential.
- Protectionist import policies and export subsidies have further distorted what is produced where.

*Title of a famous book by D. Gale Johnson

OECD Producer Support Estimates

(Percent of Gross Receipts)

Country	1986-88	2004-06
Switzerland	77	66
Japan	64	55
European Union	41	34
Canada	36	22
United States	22	14
Mexico	28	14
Australia	8	5
New Zealand	10	1
OECD average	38	29

Source: OECD Agriculture Directorate

Single Commodity Transfers in OECD Countries, % of Gross Receipts

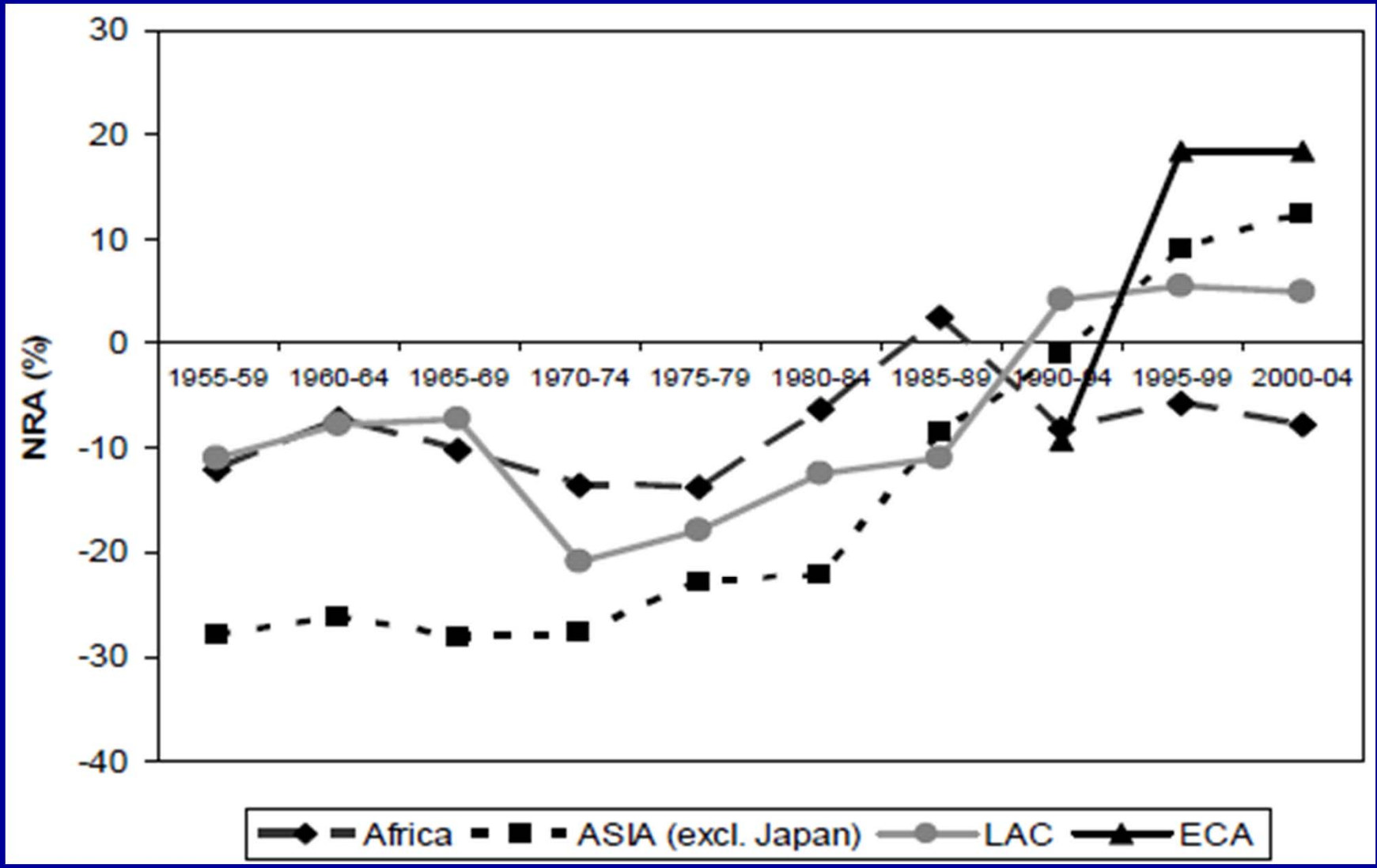
Commodity	1986-88	2004-06
Rice	75	65
Sugar	62	44
Milk	56	25
Beef	27	19
Pork	12	18
Corn	12	3
Wheat	32	4
Soybeans	1	2
Overall	35	21

Source: OECD Agriculture Directorate

Developing Countries' Policies Have Impeded Their Ag Development

- Corruption and/or macroeconomic instability
- Lack of definition or enforcement of property rights and contract sanctity
- Underinvestment in public goods, such as rural infrastructure, education and R&D.
- Cheap food policies to keep urban consumers quiescent – often reinforced by food aid or subsidized exports from OECD
- Lack of technology adapted to local agro-ecological conditions (soils, climate; slope)

Anti-Agricultural Bias Dropping in Developing Countries -- Except in Africa



Agriculture Has Been Off the Global Development Agenda

- Low world commodity prices in 1980s, in part due to OECD ag production & export subsidies, incl. easy access to food aid.
- Crowded out by hot new donor issues, e.g. environment and HIV/AIDS.
- Lack of political clout of rural relative to urban areas in low income countries
- Ag development projects seen as riskier
- Transnational NGO activism against modern agriculture

Decline in ODA Investments in Agriculture Development

- Between 1980 to 2005, foreign aid to LDCs for ag development dropped from $8 billion to $3.4 bill./yr (from 17 to 3% of the whole)
- In the 1980s, 25% of US foreign aid went to agriculture; dropped to 6% by 1990 and 1% last year.
- Share of World Bank lending going to agriculture fell from 30% in 1978 to 16% in 1988 to 8% in 2006.

Long-Run Prospects

- Since Malthus, prophets of doom have argued population growth will increase food demand faster than agricultural production can grow.
- Public and private sector investments in agricultural research have increased productivity faster than demand growth, with resulting 150-year downward trend in real price of grains.
- Need big increase in world food production by 2050 using less water and little more land than today and also produce biofuels feedstocks.
- Future world market price trends will depend on whether ag research increases land and water productivity faster than world demand grows.

Growing Agricultural Trade

- The world's arable land is not distributed around in the world in the same proportions as is population. (No way for Asia or North Africa & Middle East to be self-sufficient.)
- Agriculture in most LDCs underperforming relative to its potential, but disincentives declining.
- With population growth & broad-based economic development in LDCs, growth in their food demand will outstrip production potential & more of world ag production will move through trade.
- Greater trading opportunities for LDCs would accelerate their economic growth and accelerate growth in their food consumption and imports.
- Need a successful WTO Doha Round.

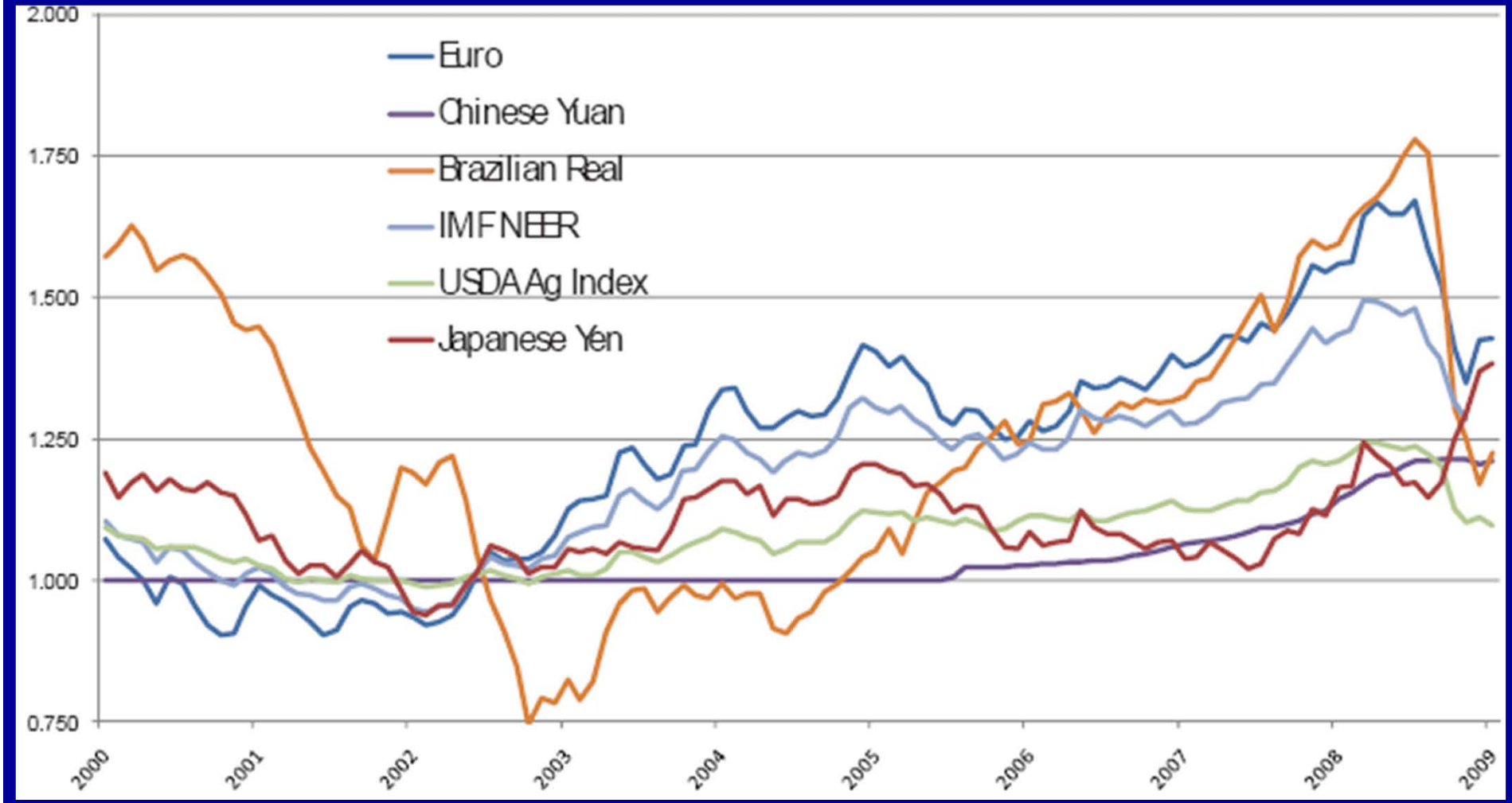
Historic Confluence of Agricultural Policy Decisions?

- 2012 Farm Bill
- EU deciding post-2013 CAP
- Rethinking in Canada; Japan?
- Is agriculture back on the global development agenda?
- WTO Doha Round negotiations, which will set the future rules for agricultural trade, will not finish before 2012 or 2013.

Similar Themes Across OECD

- Ag policy decisions will be made under tight government budget constraint following bailout from financial crisis of 2008.
- Volatility of agricultural commodity prices and in turn farm revenue.
- Should there be limits on payments to large farmers?
- Concerns of urban consumers are encroaching on ag policy decisions.

Whither Exchange Rates?



Source: IMF. International Financial Statistics .(normalized so 2002=1.000).