

An aerial photograph of a vast, arid landscape. A winding river flows through the center of the frame, surrounded by dry, brownish terrain. In the background, a range of rugged, reddish-brown mountains stretches across the horizon under a clear sky. The foreground shows some sparse, dry vegetation and a few small structures or people near the riverbank.

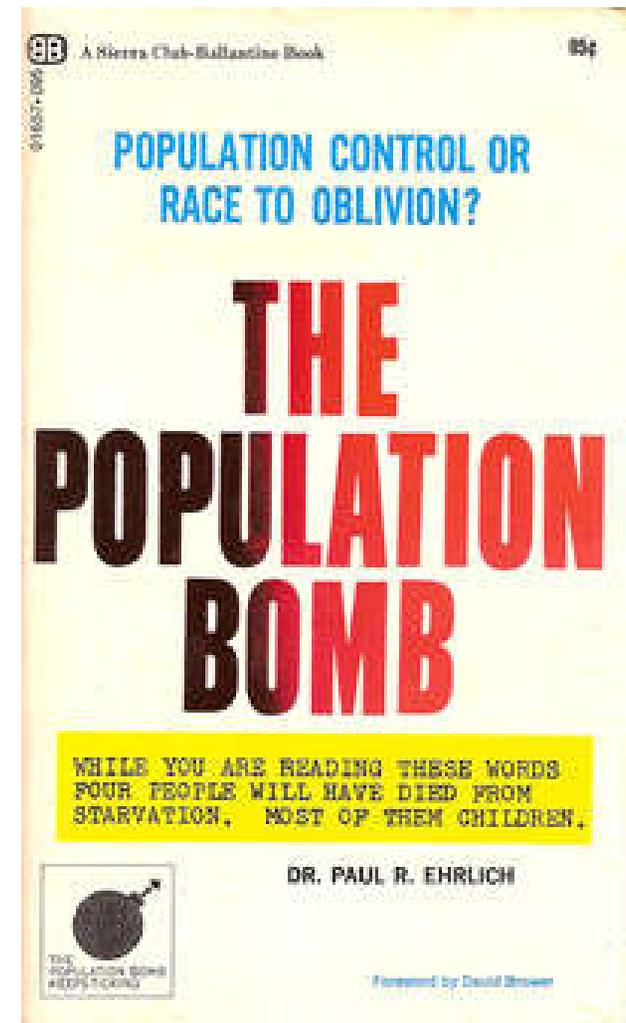
AAEC 4730:
THE WORLD FOOD
ECONOMY

Technology Part 2:
The Green Revolution

Ellen McCullough
emccullough@UGA.edu

The world in the 1950s

- Historically, slow growth in agriculture
 - New processes to manufacture inorganic fertilizer
 - Productivity gains in developed countries
- But these gains were not felt everywhere:
 - 1 Billion people hungry
 - 1/3 of the world's population
- *The Population Bomb*, published 1968



What Happened?

- A crisis declared:

The scale, severity and duration of the world food problems are so great that a massive, long-range innovative effort unprecedented in human history will be required to master it

- US Presidential Hunger Report, 1967

- An international effort mobilized, focused on technology:
 - Rockefeller and Ford Foundations
 - CGIAR System founded, now 16 centers
- Investments and technologies in Latin America and Asia:
 - Modern rice and wheat varieties (dwarf traits, responsive to inputs)
 - Expansion of irrigation
 - Use of fertilizer, pesticides, other modern inputs (subsidies)
 - Investments in roads and rural power
 - Policies to support farm credit, education and extension, better markets





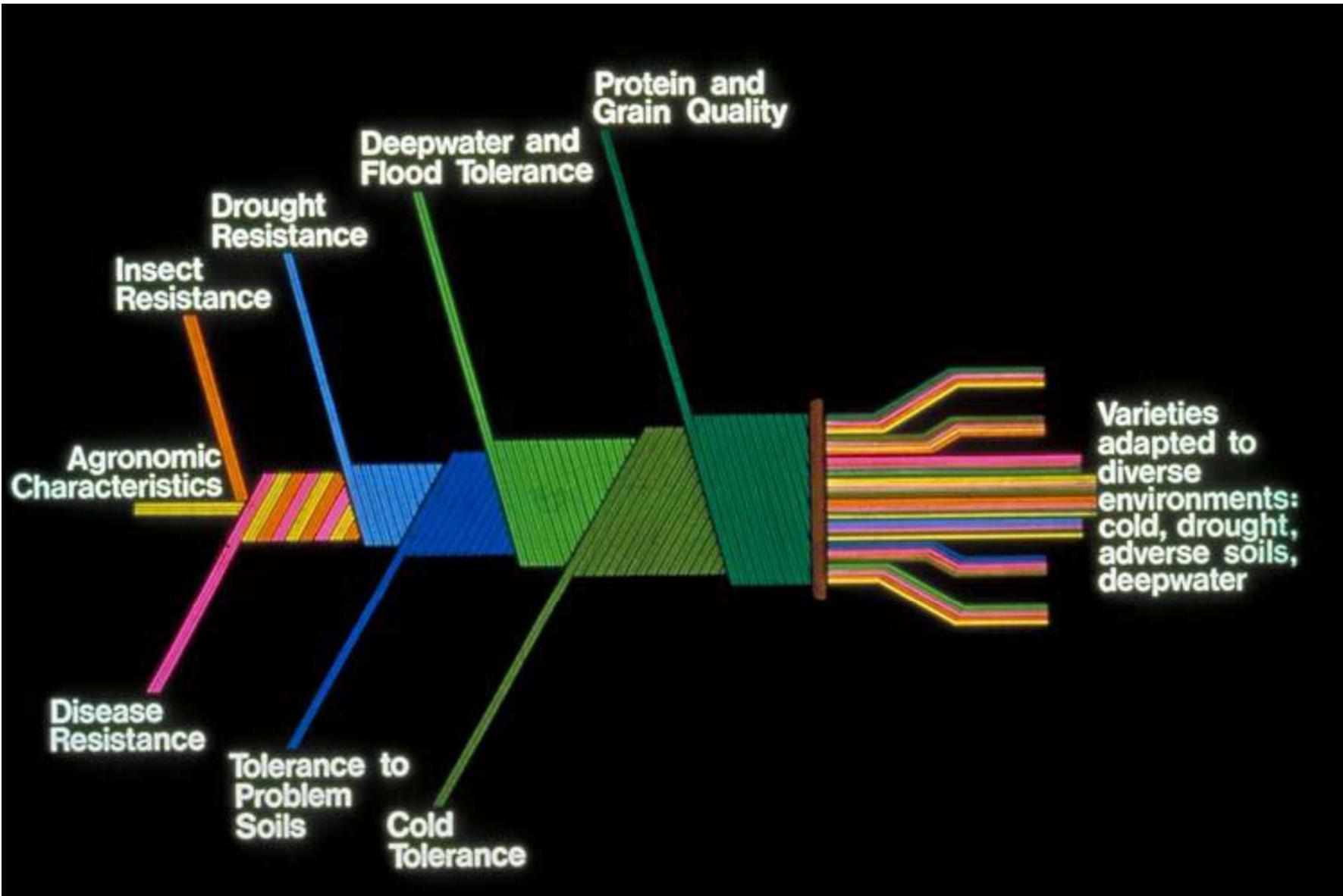
Traditional vs Modern (IR8) Rice Varieties



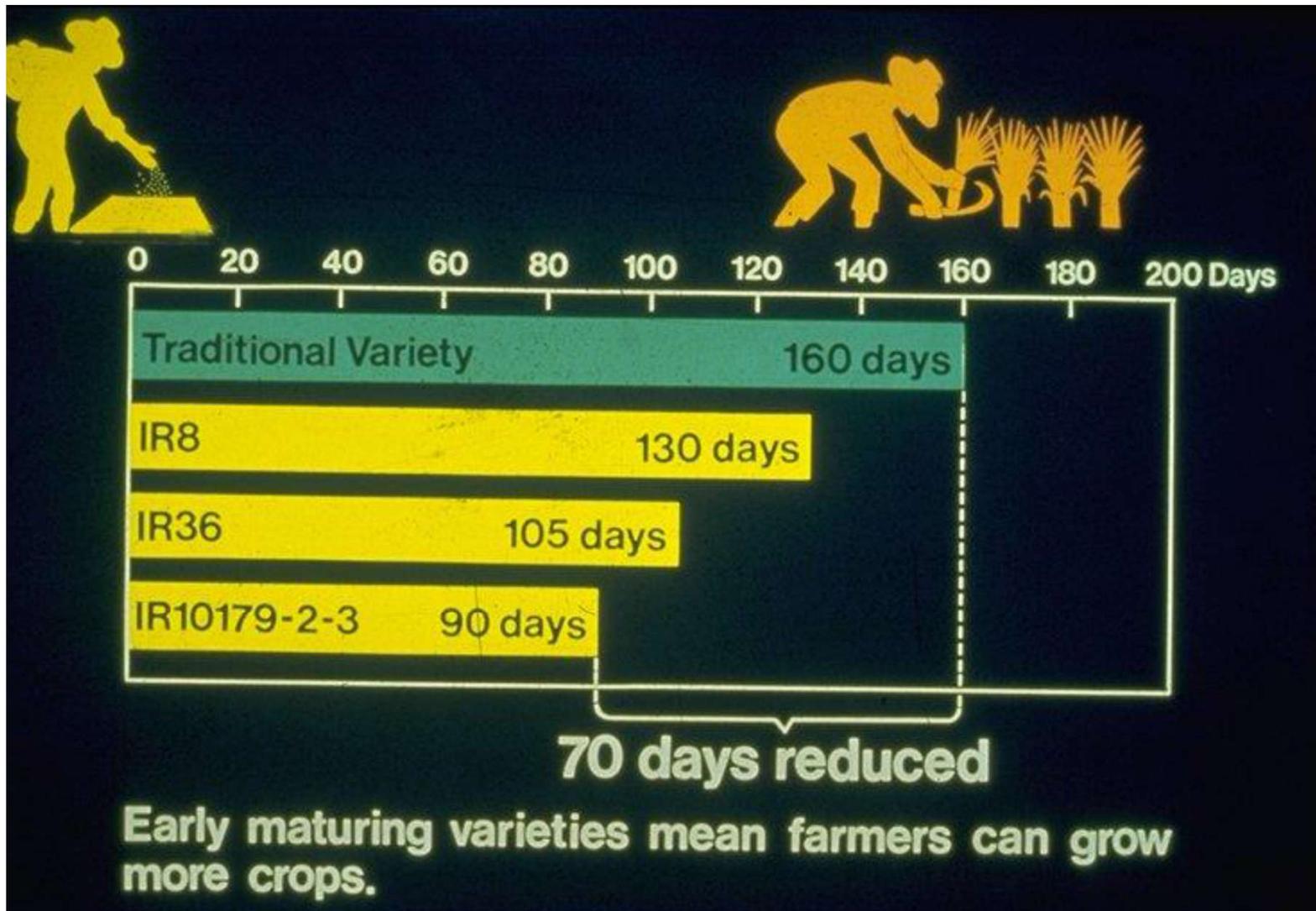
Tall conventional plant



**Improved high-yielding
plant**



Days to Maturity



The International Ag R&D System

Consultative Group for International Agricultural Research (CGIAR)



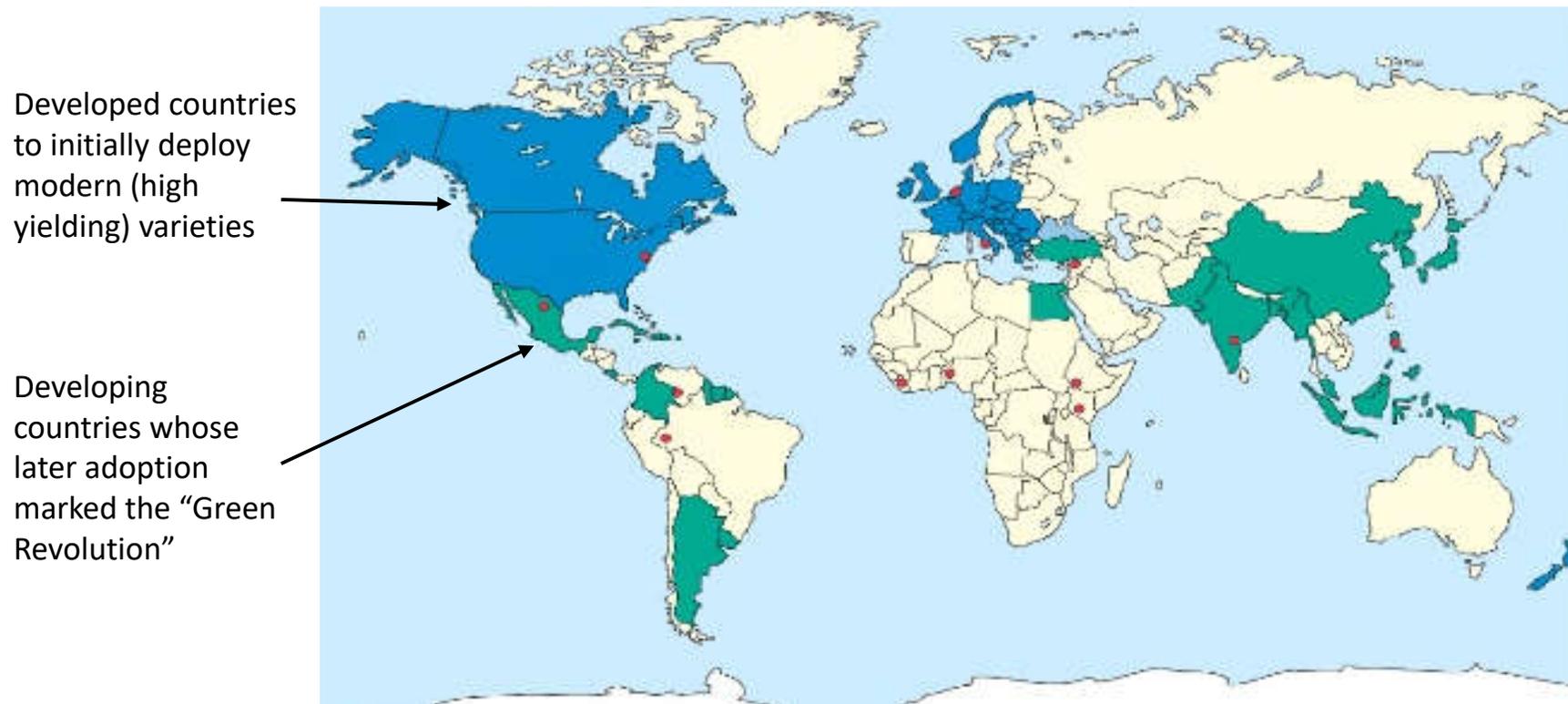
And national efforts!

Government expenditures on agriculture in Asia (\$USD, PPP, 1985)

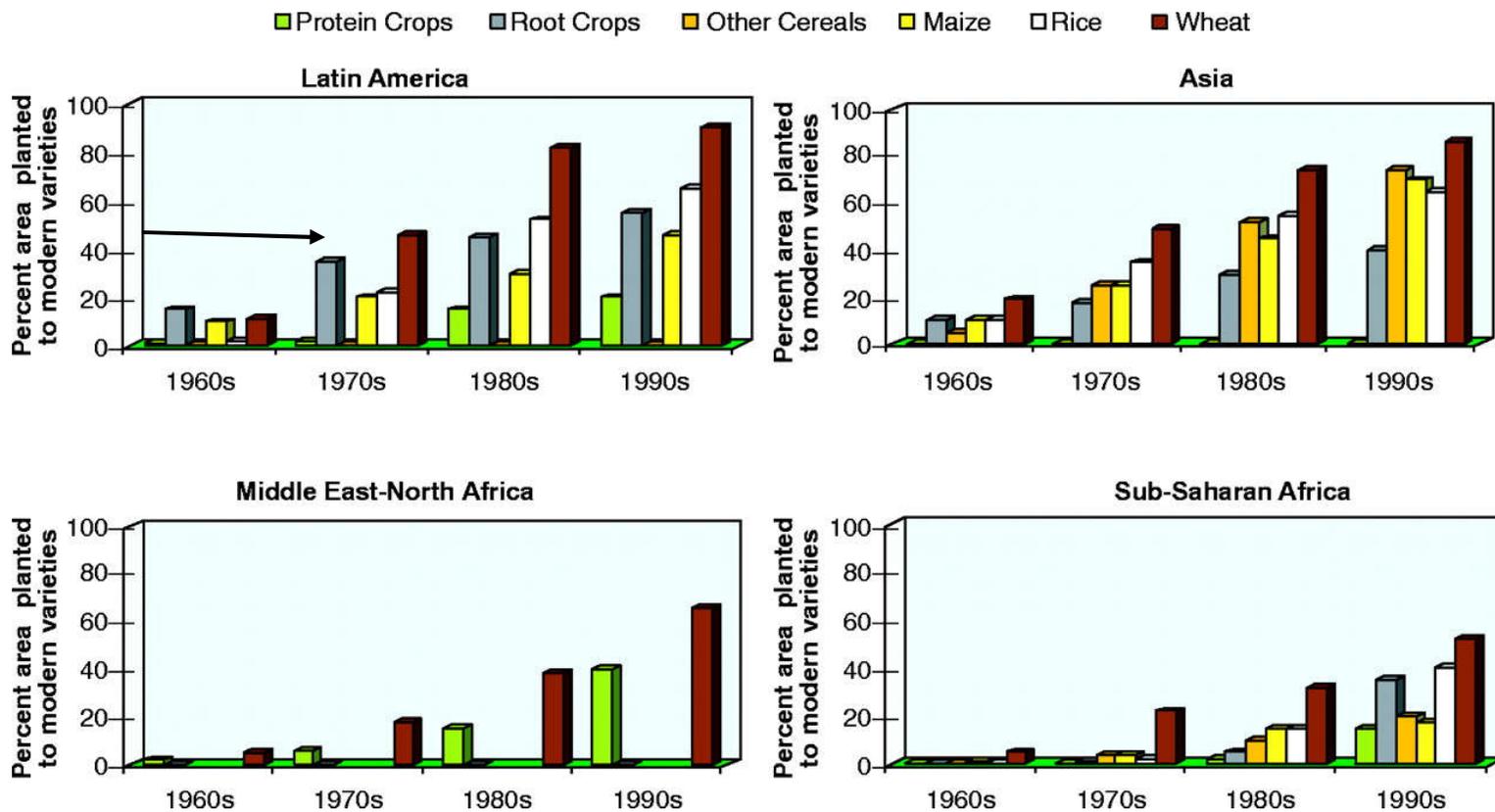
	1972	1975	1980	1985	1990	1972	1975	1980	1985	1990
	(million dollars)					(% total government expenditure)				
Bangladesh	2,358	528	1,187	1,749	1,269	23.2	11.0	12.3	15.7	5.4
China	11,595	17,843	24,542	21,113	28,229	8.5	12.1	12.4	8.3	8.9
India	15,491	13,680	22,877	30,549	39,109	22.1	9.7	14.6	12.6	11.5
Indonesia	1,436	3,020	5,026	4,351	6,157	7.6	9.8	9.6	6.8	7.6
Malaysia	348	458	1,264	1,581	1,830	4.0	4.2	7.2	7.9	5.7
Myanmar	272	219	655	874	296	12.5	13.3	23.6	24.5	9.3
Nepal	107	136	257	541	254	13.7	15.5	16.4	22.0	8.5
Pakistan	740	1,031	1,168	971	1,312	5.7	6.7	5.4	2.9	2.6
Philippines	416	1,145	729	604	1,409	4.5	9.0	5.3	5.7	6.0
South Korea	537	993	1,129	2,244	4,332	3.8	6.3	4.1	5.8	6.9
Sri Lanka	627	449	589	2,124	614	12.3	9.0	5.7	20.0	5.8
Thailand	902	767	1,850	3,181	3,190	7.8	5.9	8.1	11.7	10.4
Total	34,828	40,269	61,273	70,151	88,001	15.4	10.5	12.4	10.9	9.6

Source: Rosegrant and Hazell (2000)

Green Revolution Countries



Adoption of modern varieties by decade and region



Source: R. E. Evenson, and D. Gollin Science 2003;300:758-762

Impacts of the Green Revolution

- Growth of wheat and rice yields (output per acre)
- Expanded area planted to staple crops
- Doubling of cereal production (due to area expansion and yield growth)
- Not a one-time gain but a shift to a higher-growth trajectory

Consider this story - “doubling” of staple crop production...

What might this mean for a ...

1. Progressive farmer with good land
2. Landless rural laborer
3. Brick layer in a rural area
4. Urban slum dweller
5. Poor farmer with no access to credit
6. Goat farmer
7. Child to be born in 1976? 2006? 2026?

Impacts across farming environments

- Earliest impacts in irrigated areas and lowland rainfed areas w/ good water control
 - 40% yield gain of wheat w/ good water control, 10% dry areas
- Delayed release of Modern Varieties...
 - for crops that were needed in semi-arid and dry climates (sorghum, millet)
 - for tropical crops (e.g. cassava), where scientists needed to go beyond transferring technologies from rich to poor countries
- Lagging regions (Sub-Saharan Africa)
 - Limited national breeding efforts (initial attempts to short-cut w/ varieties from Latin America did not succeed)

A No-Green Revolution World

(estimated % changes)

	With no MVs in developing countries (NGR)
Crop yields	
Developed countries	2.4 to 4.8
Developing countries	-19.5 to -23.5
Cropped area	
Developed countries	2.8 to 4.9
Developing countries	2.8 to 4.9
Crop production	
Developed countries	4.4 to 6.9
Developing countries	-15.9 to -18.6
Crop prices, all countries	35 to 66
Increase in imports by developing countries	27 to 30
Percent of children malnourished, developing countries	6.1 to 7.9
Calorie consumption per capita, developing countries	-13.3 to -14.4

Social Impacts of Asian Green Revolution

- Food prices lower, rural incomes higher, employment growth
- Number of poor fell by 28% even while population grew by 60%
 - Mostly these were in rural areas with ag-based livelihoods
- Rural economic growth multipliers of 0.30-0.85
- 50% rate of return to public investments

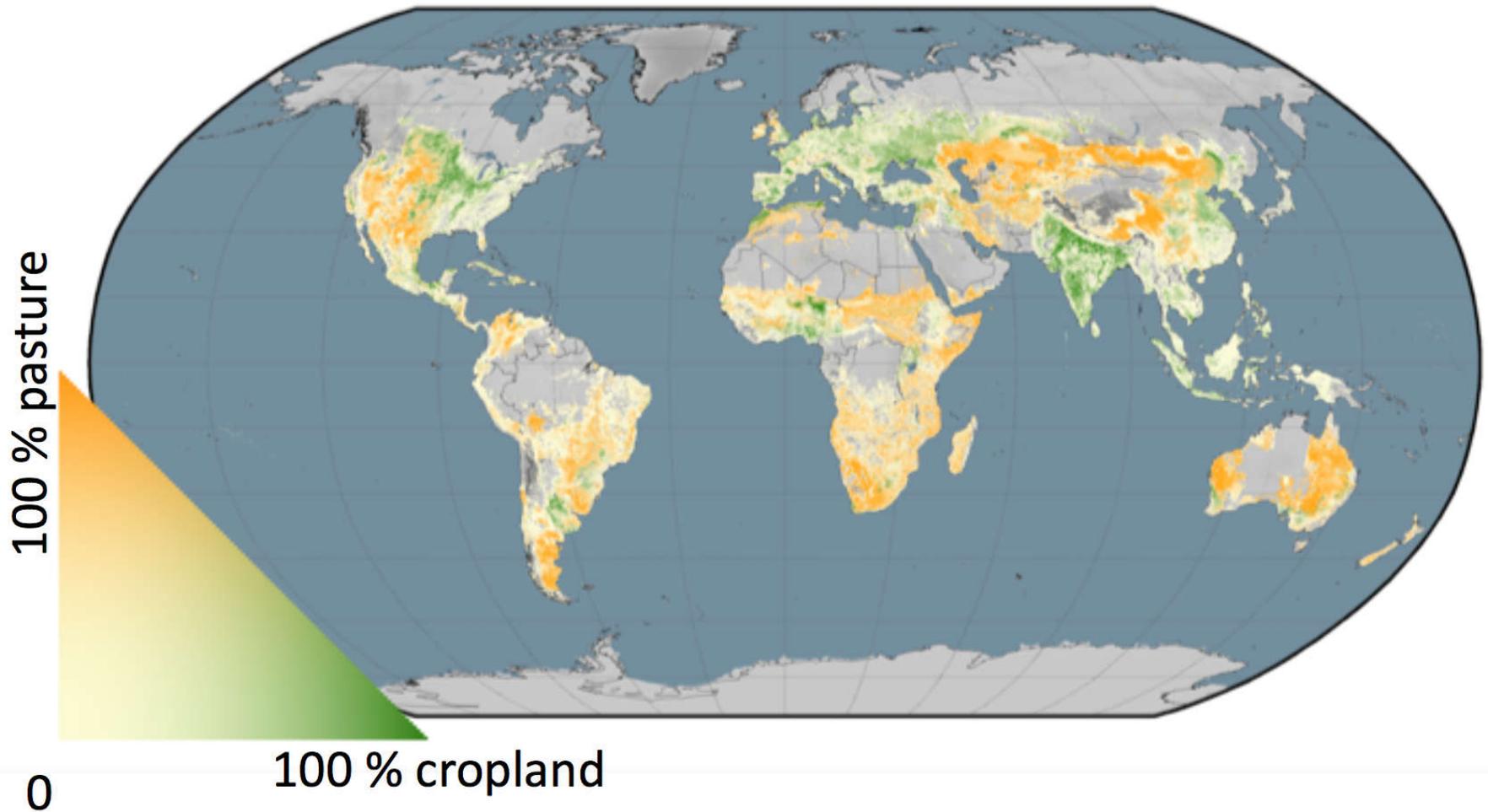
More Social Impacts of Asian Green Revolution

- Increased demand for unskilled agricultural wage labor
- More demand for non-agricultural labor
- Labor migration → wage equalization
- Women headed households benefitted less
- Initially higher production and price risk (because trade not open)
- Impacts on inequality? Unclear
- On Nutrition? Complicated

Environmental Impacts of Asian Green Revolution

- Prevented need to convert hundreds of thousands of hectares to agricultural land
- Yet... intensification is associated with:
 - Soil degradation
 - Chemical pollution
 - Aquifer depletion
 - Soil salinity





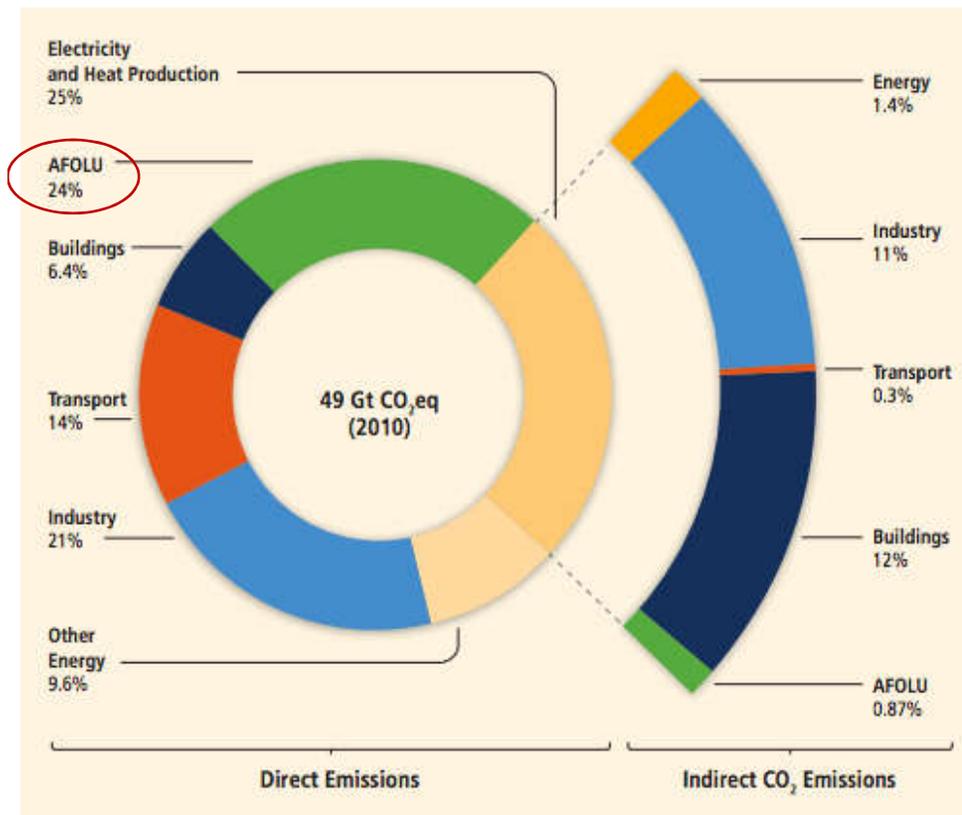
Cropland = 12%, pasture = 26% of ice-free earth



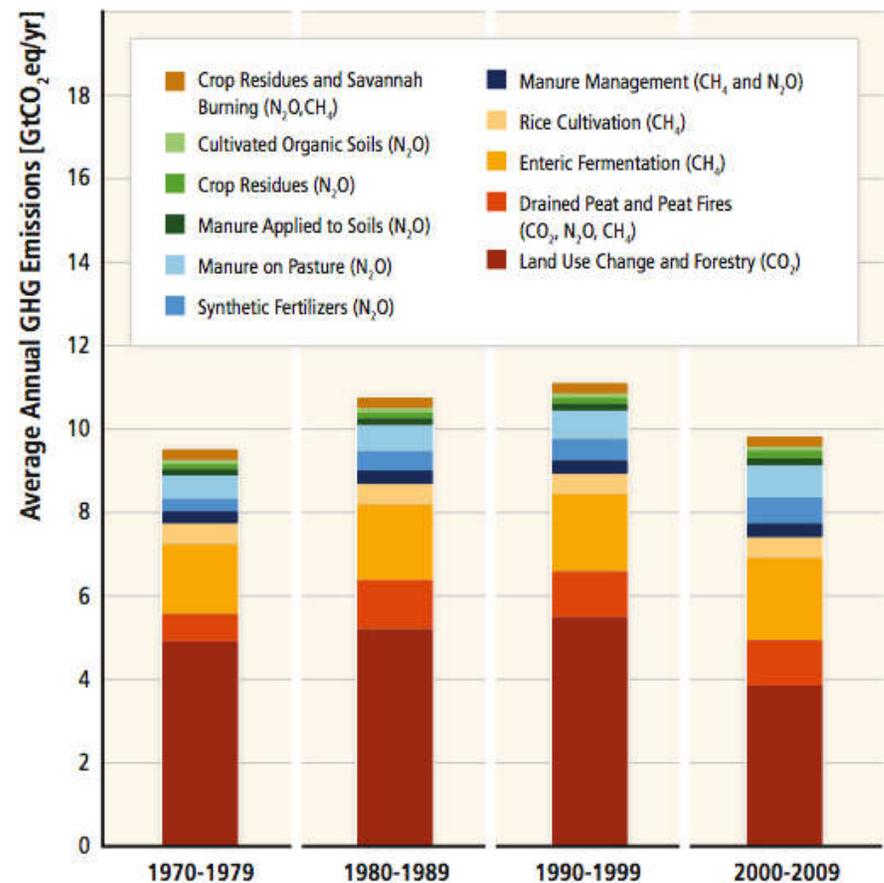
Priors: What percent of global greenhouse gas emissions come from the agricultural sector?

Agriculture = 20-25% of global GHG emissions

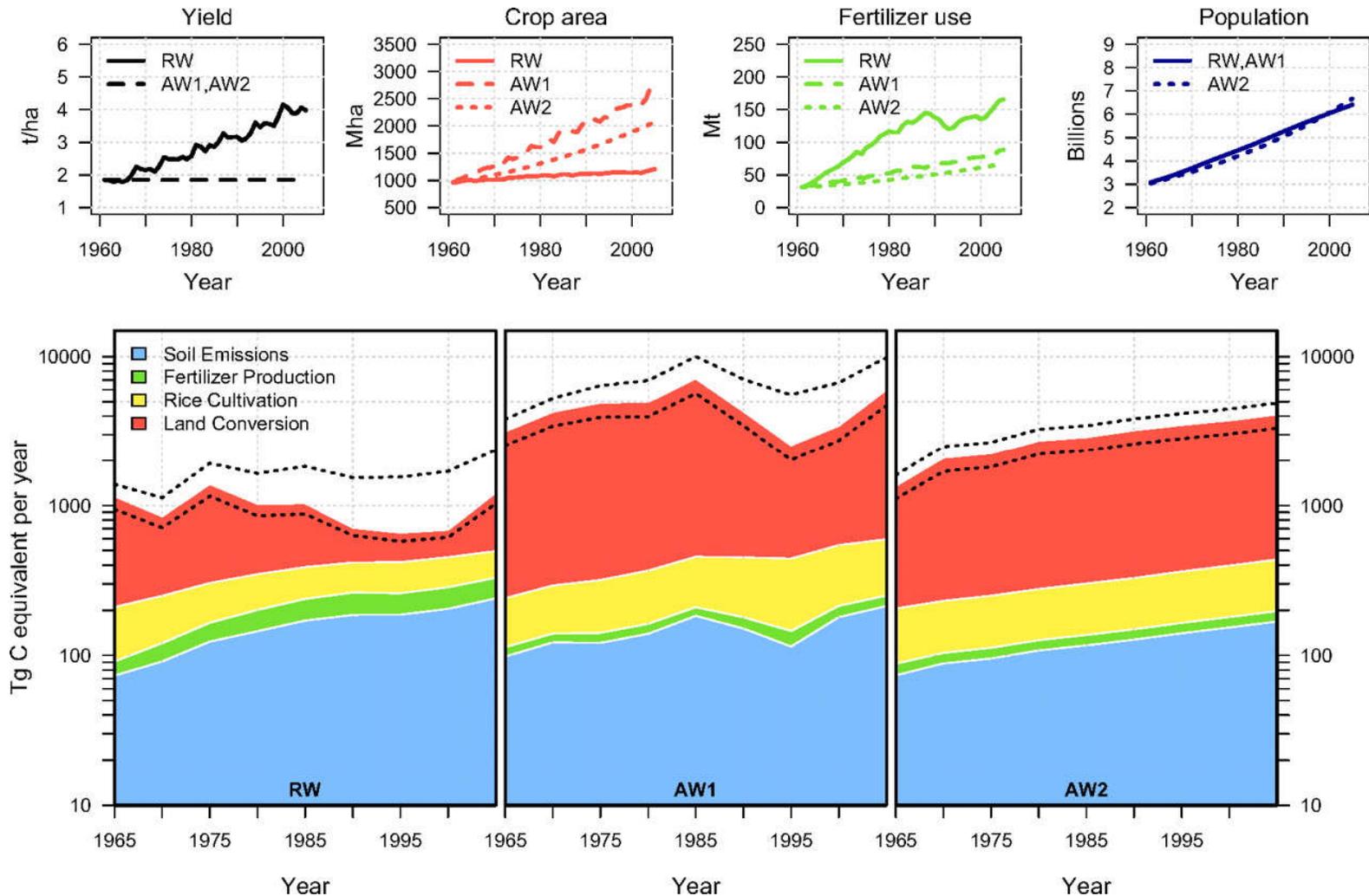
GHG emissions by sector



Ag + forestry emissions



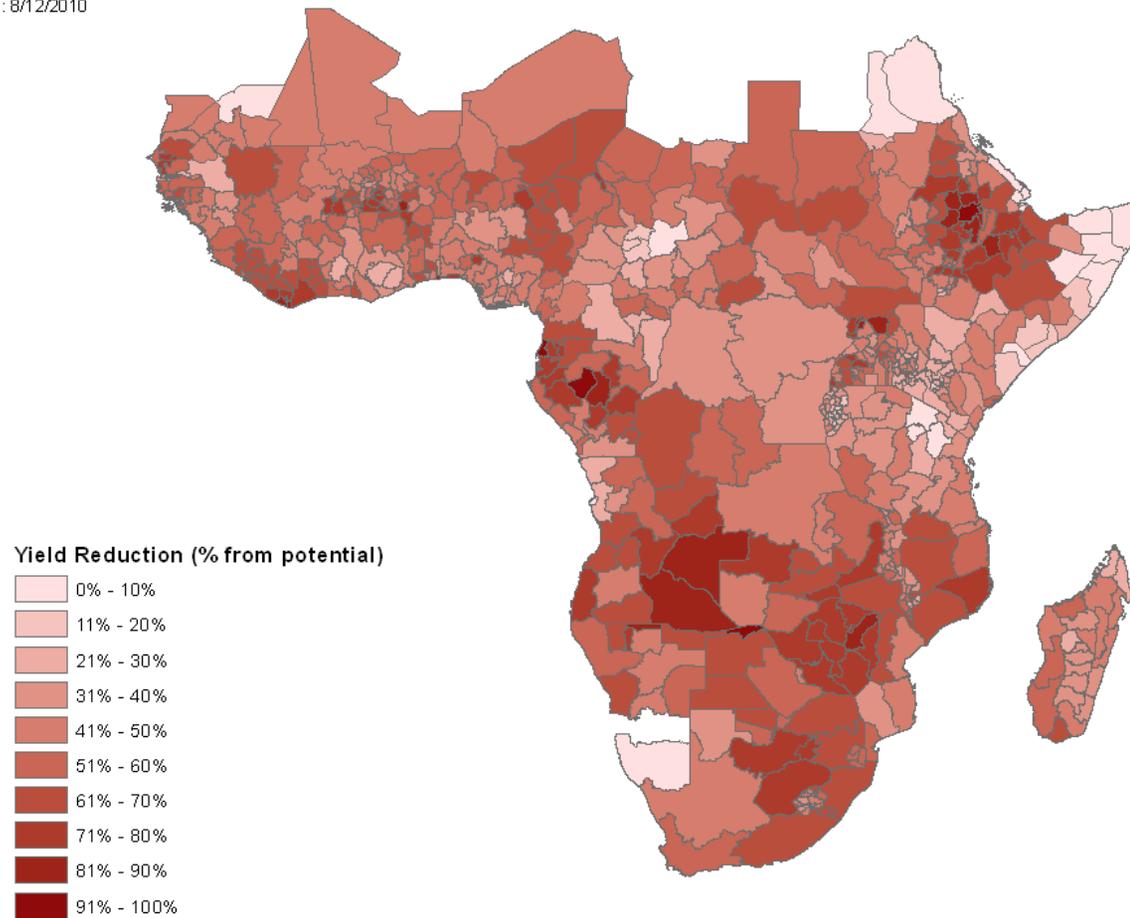
GHG Emissions without the Green Revolution



Source: Burney et al 2012

Room to improve yields (current Rainfed Maize Yield Gap Estimates)

Name: qnc_2010081115_hcadmin
Date: 8/12/2010



Simplr_QNC2 | Jawoo Koo (j.koo@cgiar.org)

Source: Koo, Harvest Choice

Green Revolution: Unfinished Business

Emphasis on:

- Africa
- Additional crops (e.g., Cassava)
- Genetic technologies
- Private Sector

Others calling for:

- Resources
- Ecosystem Services
- Local Adaptation
- Equitability

Alliance
for a **Green Revolution**
in **Africa**



Source: Conway

African GR Progress

AGRA is a farmer-centered, African-led, and partnerships-driven institution that is transforming Africa's smallholder farming from a solitary struggle to survive to businesses that thrive.

To increase incomes and improve food security for 30 million smallholder farm households in 11 African countries by 2021

ACHIEVEMENTS SINCE 2006

22.6 Million

Smallholder farmers reached



US\$ 554 million

Value of commodities sold through SMEs



US\$ 47 million

Private sector investments leveraged



700

PhDs and MScs scholarships



119

African seed companies established



44000

Agro-dealers supported



18

countries

AGRA's continental footprint



17500

Village Based Advisors mobilized and trained



7

countries

Supported to design and execute flagships and strategies



1628

Agri-SMEs supported



US\$ 553 million

In investments

African GR Progress

- Goal (2020 deadline)
 - double crop productivity and incomes for 30 million small-scale farming households
 - Halving food insecurity in 20 African countries
- Reality:
 - \$1 billion funding for AGRA, \$1 billion input subsidies per year funded by African governments
 - Slow productivity growth
 - Poverty and hunger have increased by 30% in AGRA's 13 priority countries

Why slow progress?

- The GR is a bad formula for Africa?
 - Successes in India were mostly from irrigation, rather than seeds and fertilizer.
 - Irrigation is harder to scale in Africa.
- Attempts to reach farmers in Africa haven't scaled
 - 2M farmers reached, 9M needed directly (21M total)
- Technologies haven't performed (output growth has come from area harvested not yields)
- Input-intensive approach is not appropriate. Agroecology approaches are better

Orphan Crops

Examples:

- Yams
- Finger Millet
- Pigeon Pea
- Staple Bananas and Plantains

Cassava



Millet



Tef



Sweet Potato

