Water Enough for the Food Supply? Outlining the Challenge

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Water Enough for the Food Supply?

- Long history of “Malthusian” predictions
  - Malthus (1798)
  - Paul Ehrlich: Population Bomb (1968)
  - Lester Brown: Who Will Feed China? (1995)
- Recently directed toward water required to grow food (Postel and UN-FAO)

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A First Look - To 2050

Component	Water Volume (Gm^3/yr)
present production	6800
eliminate current undernourishment	2200
food for additional population (8.9 billion)	3600
total	12600

Source: Rockström, J. 2003 Phil. Trans. Royal Soc. Lond. B 358:1997-2000

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Four Major Determinants

(a lumper's analysis)

- Population
- Diet
- Plant and animal water use
  - technological opportunities
- Equity

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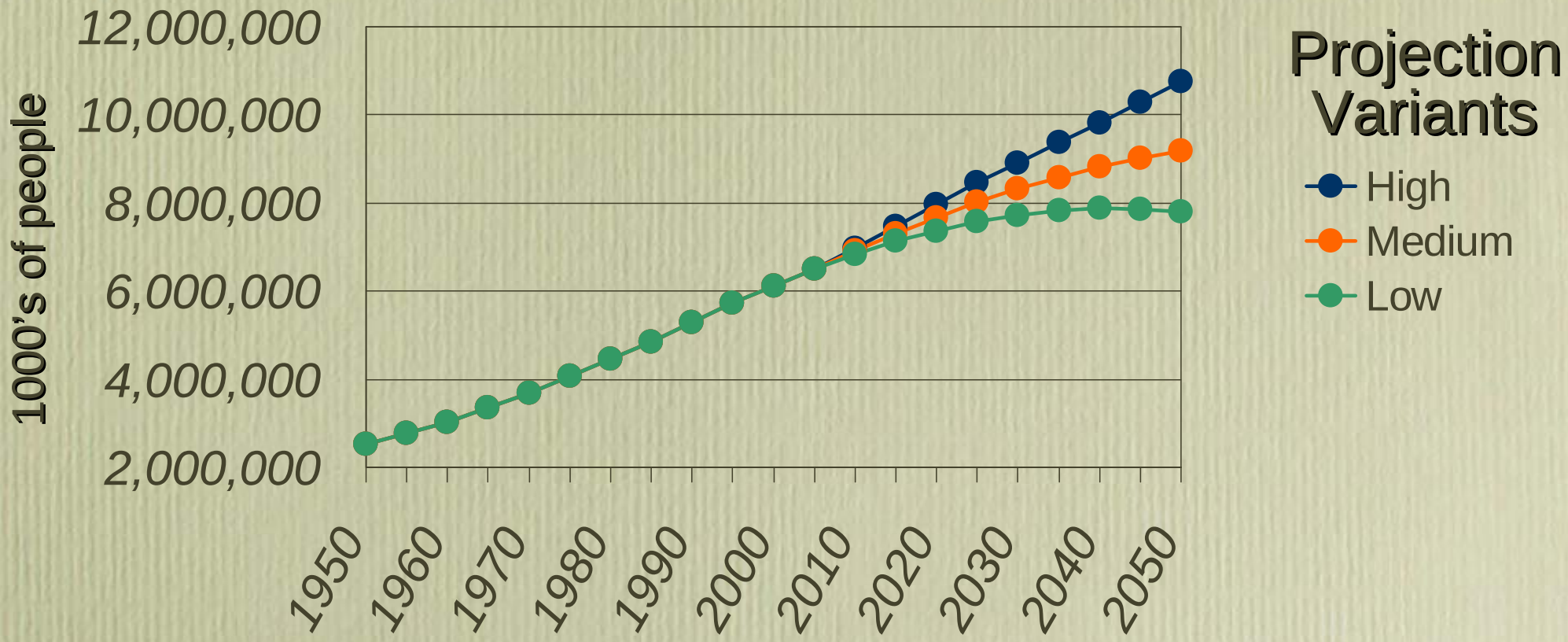
Population



Source: Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, World Population Prospects: The 2006 Revision and World Urbanization Prospects: The 2005 Revision, http://esa.un.org/unpp, Tuesday, August 28, 2007; 5:08:22 PM.

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Diet

Food has “embedded” or “virtual” water within:
that which it took to produce it

Product	VW (liter)
beer (250 ml)	75
milk (200 ml)	200
potato	25
hamburger	2400
cotton t-shirt	2000

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Dietary Choices…

- Can mean large difference in daily diet embedded water
  - vegan ~ 1 m^3; serious meat eater = 5
  - FAO target diet requires ~ 3.6 m^3 daily
  - proposed right to water = 50 L/day = 18 m^3 annual
- Meat consumption powerful factor
  - US meat consumption 120 kg/yr, 3x world
  - China meat consumption growing at 5%/yr

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Plant Water Use

- Fundamental requirements of plants for water, often expressed as plant mass gain per unit water: “water use efficiency”
- Function primarily of physiological pathway of specific plant (C3, C4) and climate (vapor pressure deficit)

Plant Water Use

- Water requirement mainly transpiration: water loss through stomata of plant leaves --
- Necessary cost of photosynthesis -- “inefficient”???
- Much more about this in Norman’s talk

Eye of Science

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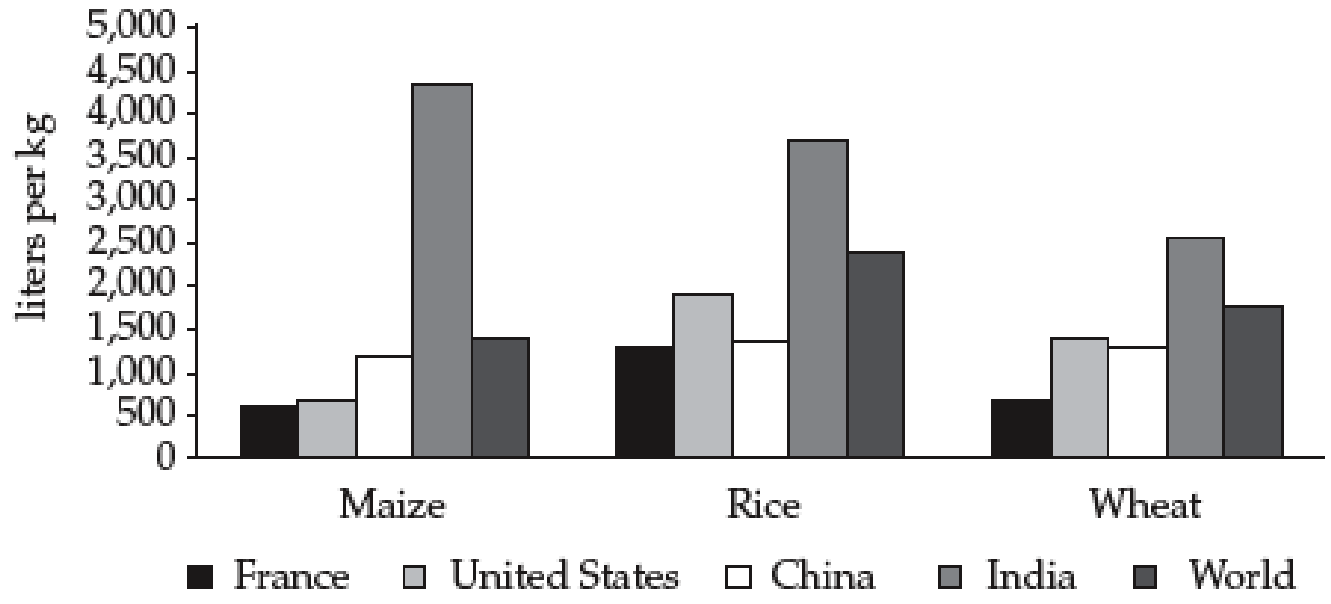
Location & Management

- Aridity and lower inputs raises virtual water in crops

Figure 5.3. The Amount of Water Used to Grow Food
(liters of water evapotranspirated per kg of food)



Source: Oyebankde 2004.

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Technology Impacts

- Genetic improvements?
- Improved rainfed productivity (green water)
- Irrigation expansion and improvement (blue water)
- Trade (virtual water)

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Rainfed Crop Production

- Green water agriculture arguably less environmental impact than blue water extraction
  - but productivity/land area often lower
- Hope for improvement lies in “evaporative shift”:
  - increased infiltration
  - more vegetative growth from fertility

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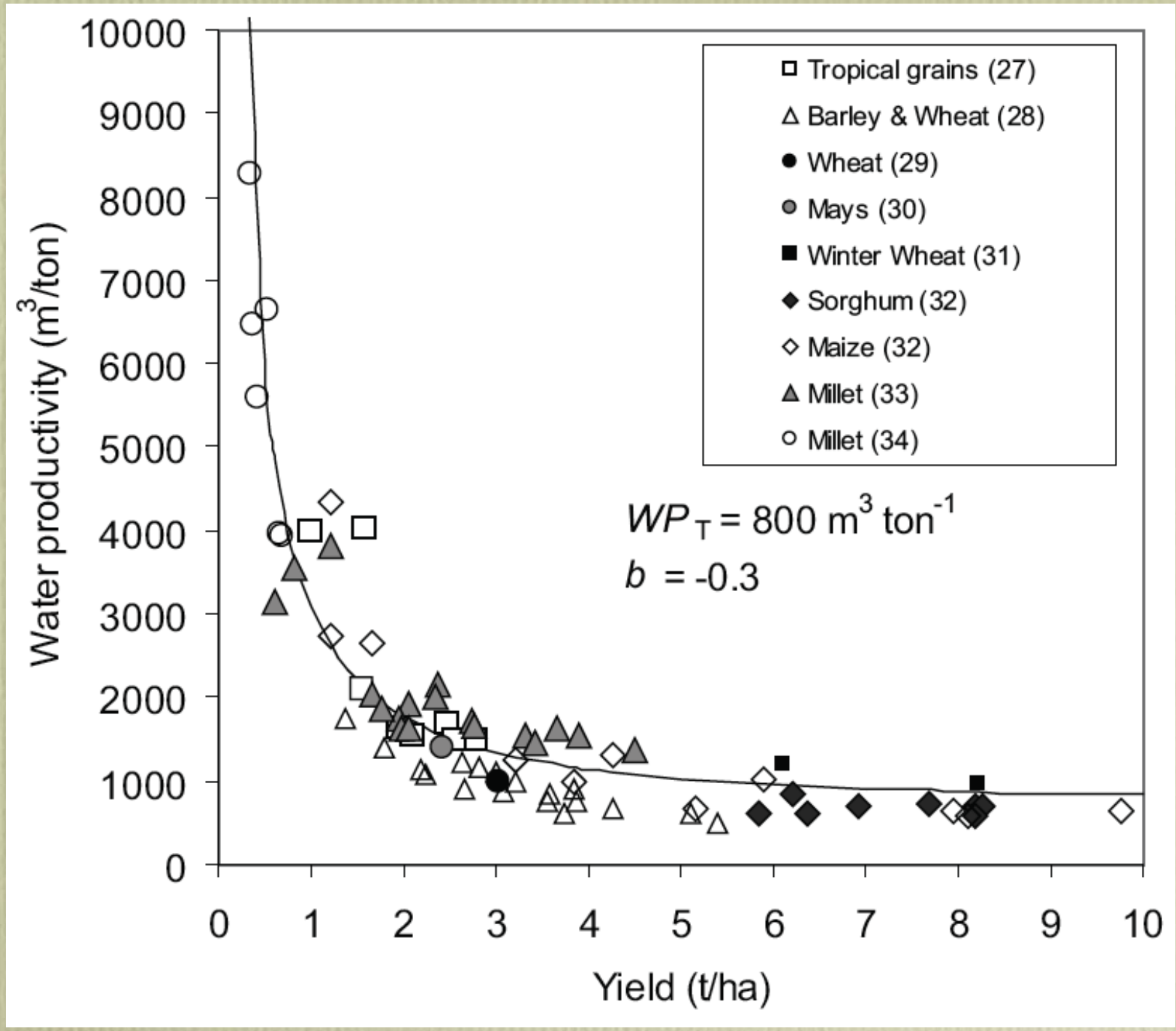

Source: Rockström, J. et al. 2007
PNAS 104:6253-6260

Rainfed Crop Production

- Soil fertility perhaps major avenue for improvement
  - Sanchez and others: “Soil Fertility Initiative”
  - Alliance for a Green Revolution in Africa

Irrigation

- of 6,800 Gm^3 of ag water, about 1,800 is “blue water” -- extracted from surface and ground water and used for irrigation
- makes agricultural irrigation largest water extraction worldwide
- 40% of food supply from 20% of crop land

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Irrigated Land per Capita

Source: Worldwatch Vital Signs 2002,
derived from FAOStat database

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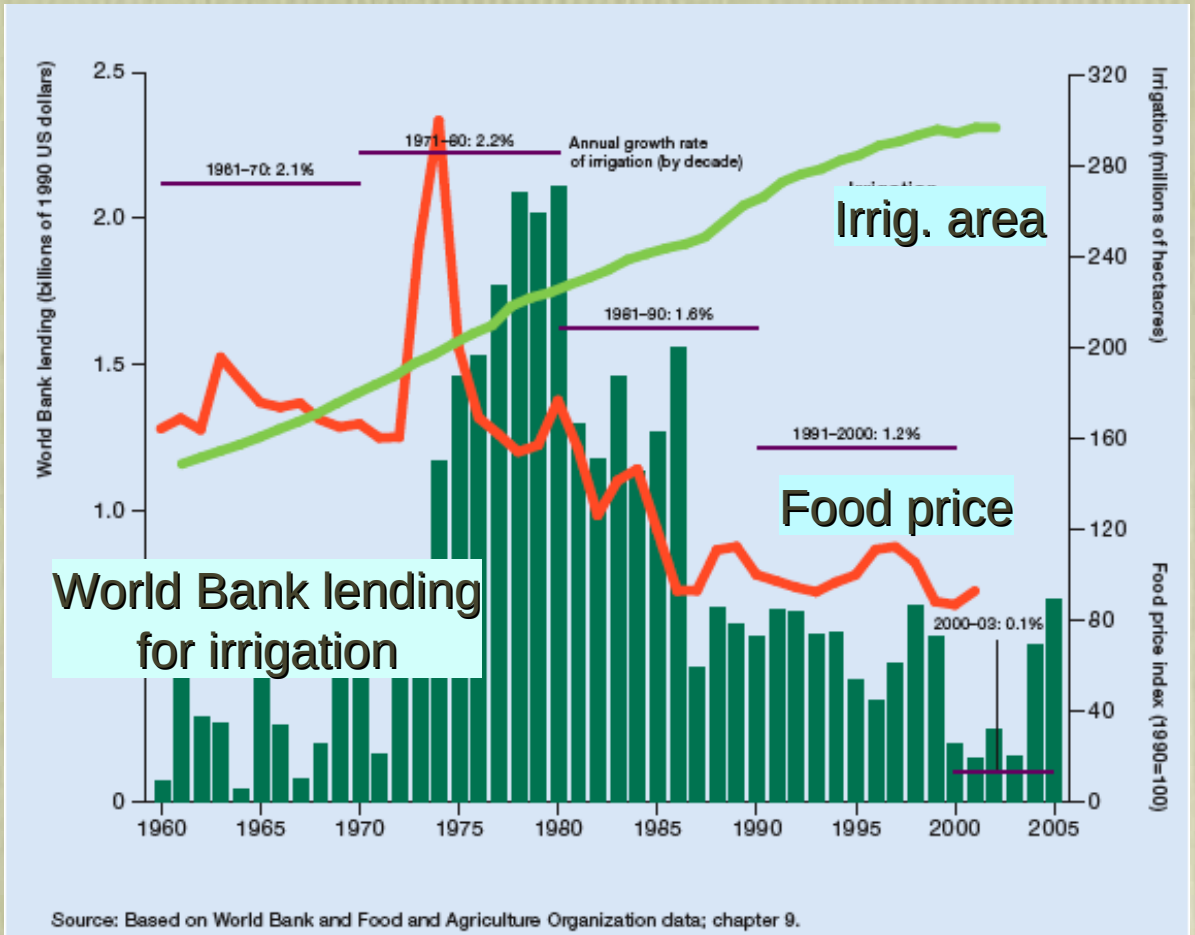
Declining Support for Irrigation Development



Source: Comprehensive Assessment of Water Management in Agriculture, 2007, from World Bank and FAO data

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Limits to Irrigation

- Development slowed after 1970s
- Best sites developed
- Appreciation of ecological and social costs
  - loss of terrestrial and aquatic habitat
  - displaced population & lost livelihoods
- Failure to deliver on promises

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Limits to Irrigation - 2

- Existing irrigated lands not fully productive
  - waterlogging
  - salinization
  - groundwater depletion
  - water reallocation to higher-value uses

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International Trade

- Trade of food products means transfer of virtual water
- Estimates range 700 to 1,000 Gm^3/yr (of 6,800)
- Biophysical & economic rationales
- Food security??

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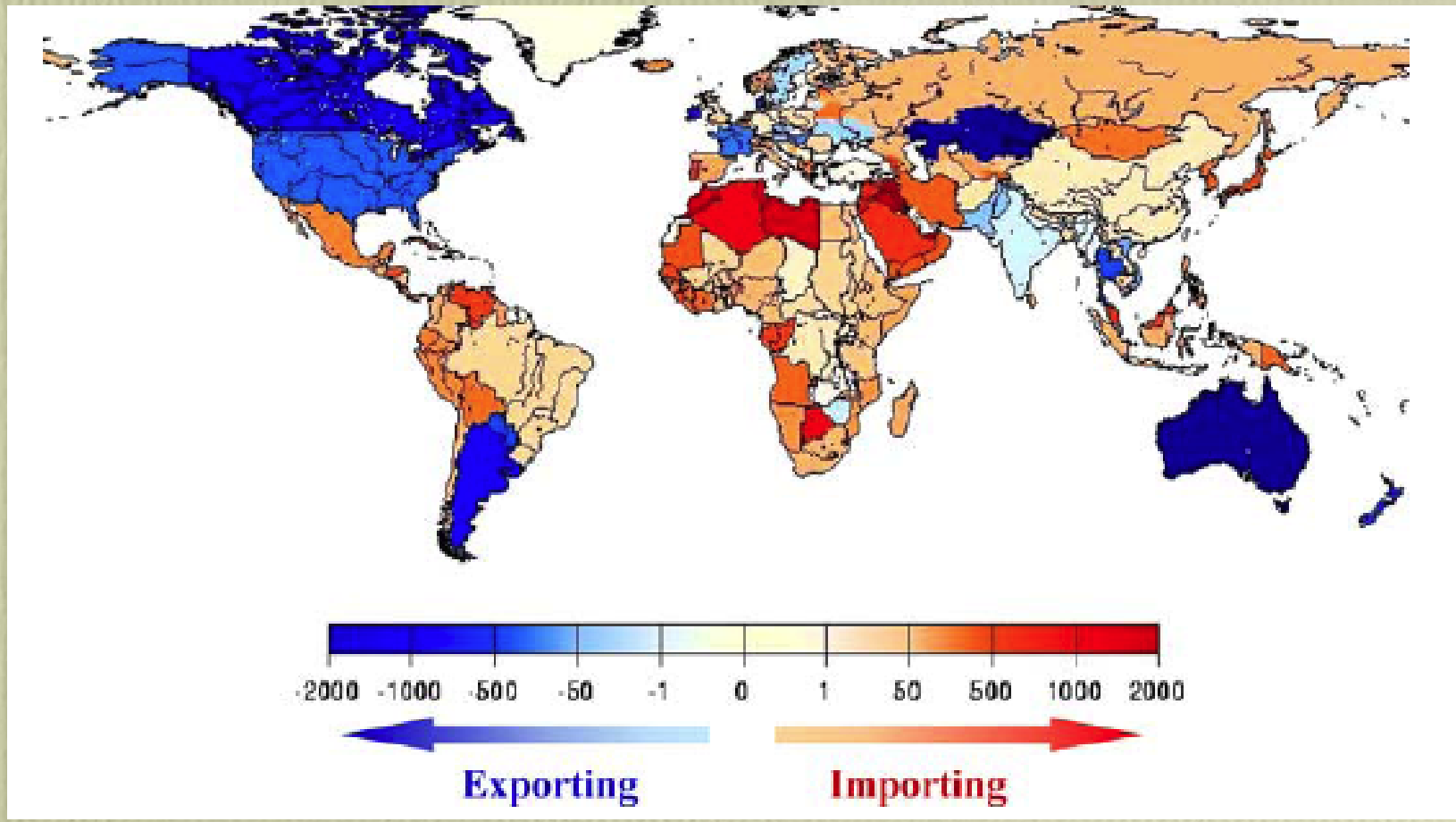
Virtual Water Trade



Annual trade in m^3/cap; Islam et al. 2007

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Equity

- Lumping: toward other humans & ecosystem
- Utilitarian and ethical arguments
- An emerging claim: in-stream flows, wetlands

Currently…

- 6,800 Gm^3/yr of water to create world food supply (atmosphere = 14,000 Gm^3)
- 5,000 is “green” water - rain infiltrated into soil - rain-fed agriculture
- 1,800 is “blue” water - extracted from ground and surface waters - irrigated agriculture

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...and by 2050, near doubling

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Future Some Mix Of...

- Rainfed area and yield
- Irrigated area and yield
- International trade
- Dietary and population moderation??
- Infinite possible combinations...

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Scenarios

- Scenarios fashionable technique for examining possible futures - Millennium Ecosystem Assessment
  - “Technogarden”...“Order from Strength”
- Not predictions, but credible futures, facilitating discussion of trade-offs
- Mountains of assumptions

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The Comprehensive Assessment Scenarios

- Rainfed
  - optimistic: 80% of yield gap, pessimistic: 20%
- Irrigated
  - expansion: 33% increase in area
  - productivity increase: 80% of yield gap
- International Trade
- Comprehensive Assessment (House Blend)

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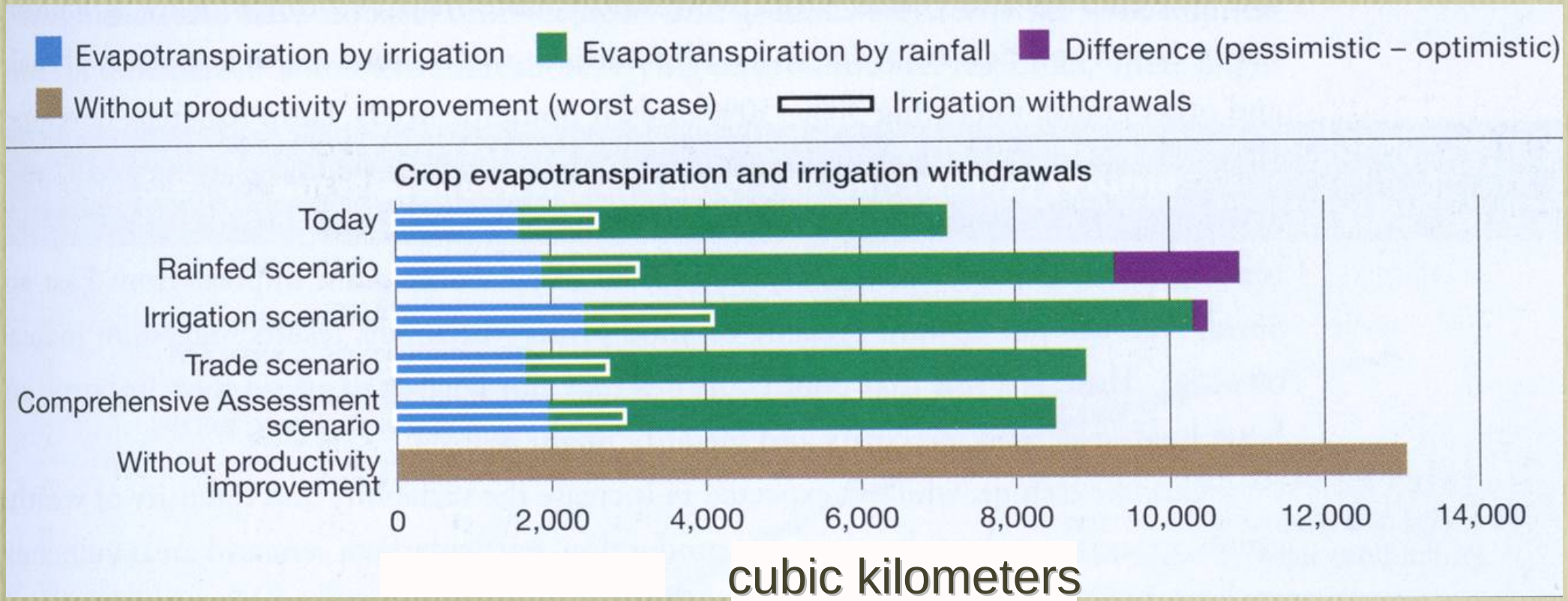
Scenario Water Outcomes



Source: Water for food, Water for life: A comprehensive assessment of water management in agriculture, p. 111 (2007)

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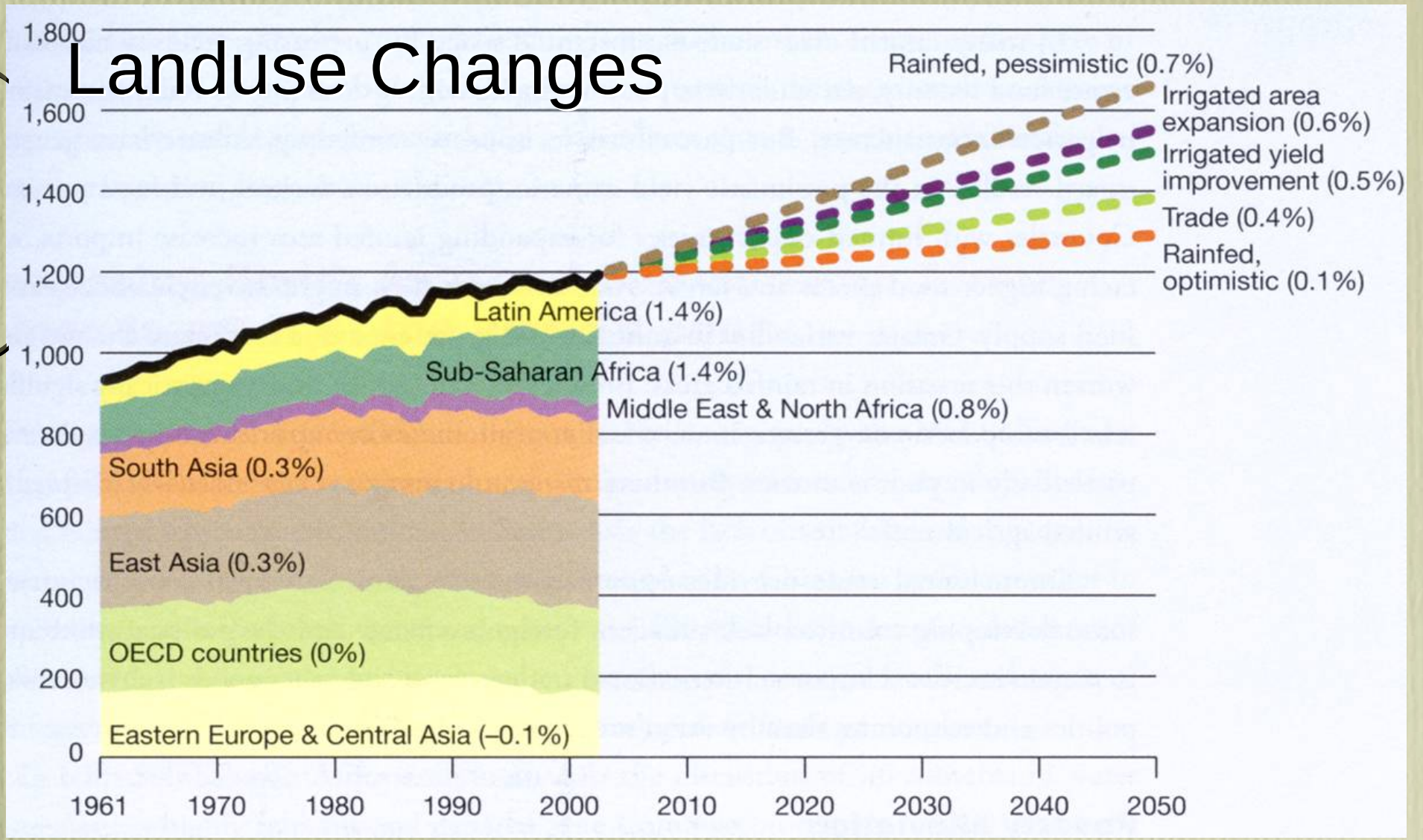
Landuse Changes



Source: Water for food, Water for life: A comprehensive assessment of water management in agriculture, p. 129 (2007)

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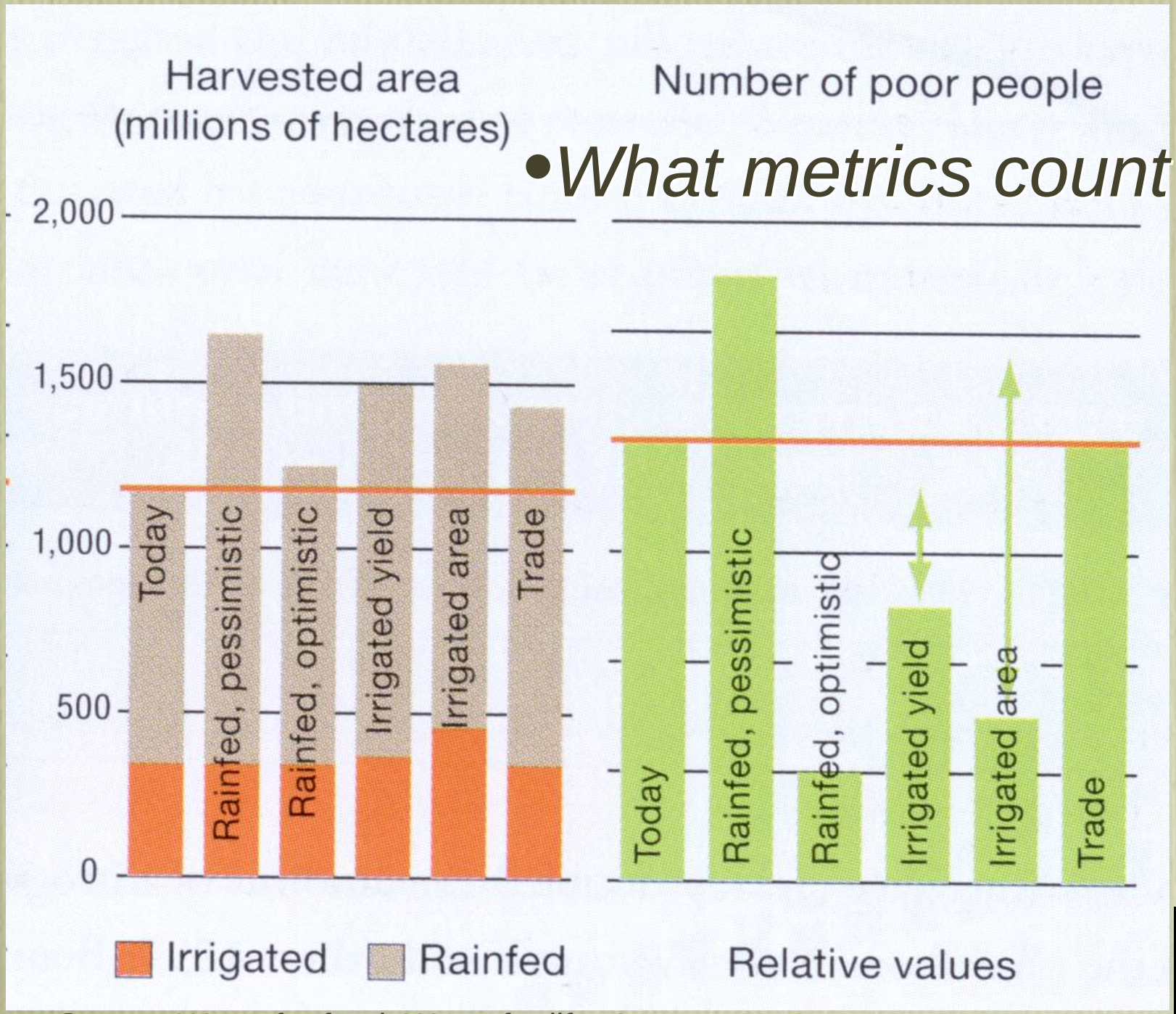

- *What metrics count for you??*

Source: Water for food, Water for life: A comprehensive assessment of water management in agriculture, p. 127 (2007)

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Summary

- Projecting to 2050, water requirements for global food supply could be nearly double current flow
- The Comprehensive Assessment of Water Management in Agriculture investigated *scenarios* that combined possible mitigation tools
  - rainfed area and yield
  - irrigation area and yield
  - international trade

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Summary (cont.)

- Does seem possible to feed humanity in 2050
- Best case: 30% increase in ET, green water, 6% increase in land use
  - optimistic increases in rainfed yield
- BUT: adequate regard to climate change, impacts of bioenergy, unwarranted optimism about human behavior??
- Few places sitting as pretty as we are :)

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