Environment, Disasters and Climate Change: Thinking Water System-wide and Globally

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Presented at Teaching Water: Global Perspectives on a Resource in Crisis
Harvard University
8 August 2013

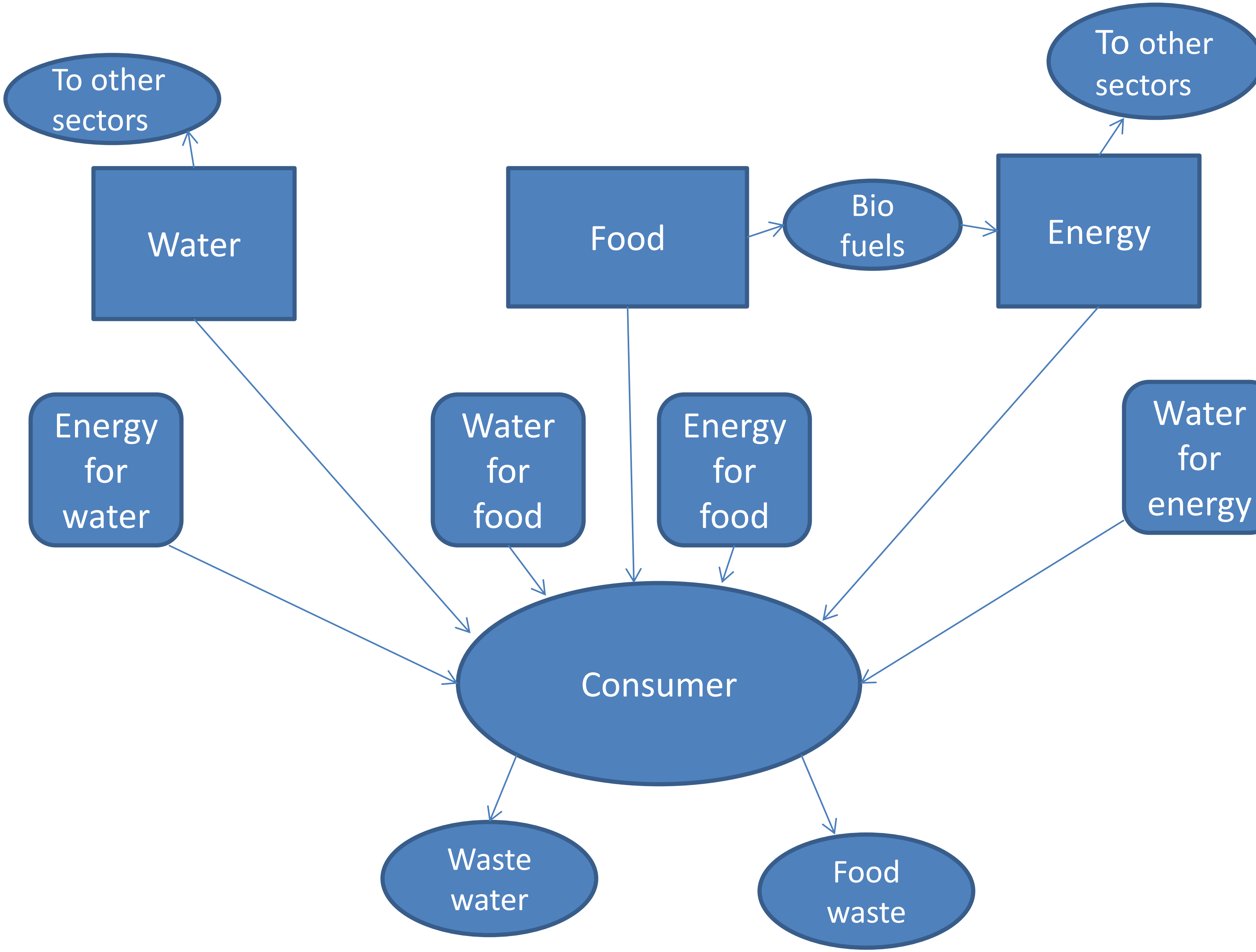
Global Trends 2030: Alternative Worlds

US National Intelligence Council, 2012

GLOBAL TRENDS 2030: AN OVERVIEW	
MEGATRENDS	
Individual Empowerment	Individual empowerment will accelerate owing to poverty reduction, growth of the global middle class, greater educational attainment, widespread use of new communications and manufacturing technologies, and health-care advances.
Diffusion of Power	There will not be any hegemonic power. Power will shift to networks and coalitions in a multipolar world.
Demographic Patterns	The demographic arc of instability will narrow. Economic growth might decline in "aging" countries. Sixty percent of the world's population will live in urbanized areas; migration will increase.
Food, Water, Energy Nexus	Demand for these resources will grow substantially owing to an increase in the global population. Tackling problems pertaining to one commodity will be linked to supply and demand for the others.

Interactions-The Nexus

- Food
  - Population increases demand for water, ag. chemicals and energy for food production, and urbanization has an amplifying effect on demand
  - Improved diets demand considerably more water, ag. chemicals, and energy inputs
  - Production and use of ag. chemicals increases energy demand and GHG emissions
  - Transportation, refrigeration, storage , and processing of food requires large incremental amounts of energy
- Water
  - Substantially more water needed to meet food and fiber demands
  - Water development and management needs more energy and capital
- Energy
  - More energy for pumping, refrigeration, and processing food
  - More water for energy production via thermal and hydro projects, and for preparation of fuels via mining and combustion.



Schematic for Food, Water, Energy Nexus in overall context

Dimensions of the Food Crisis

The History

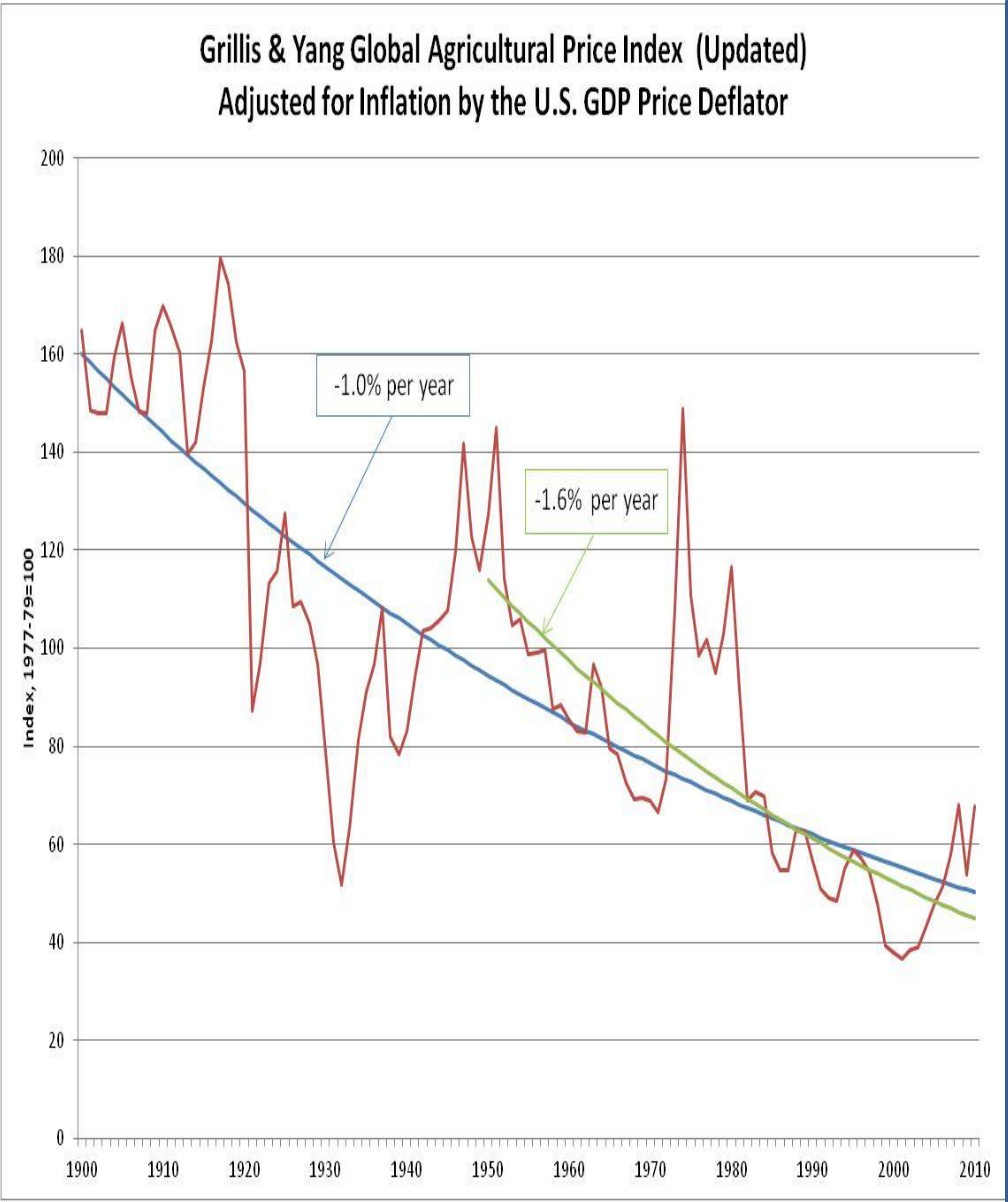
Current Situation

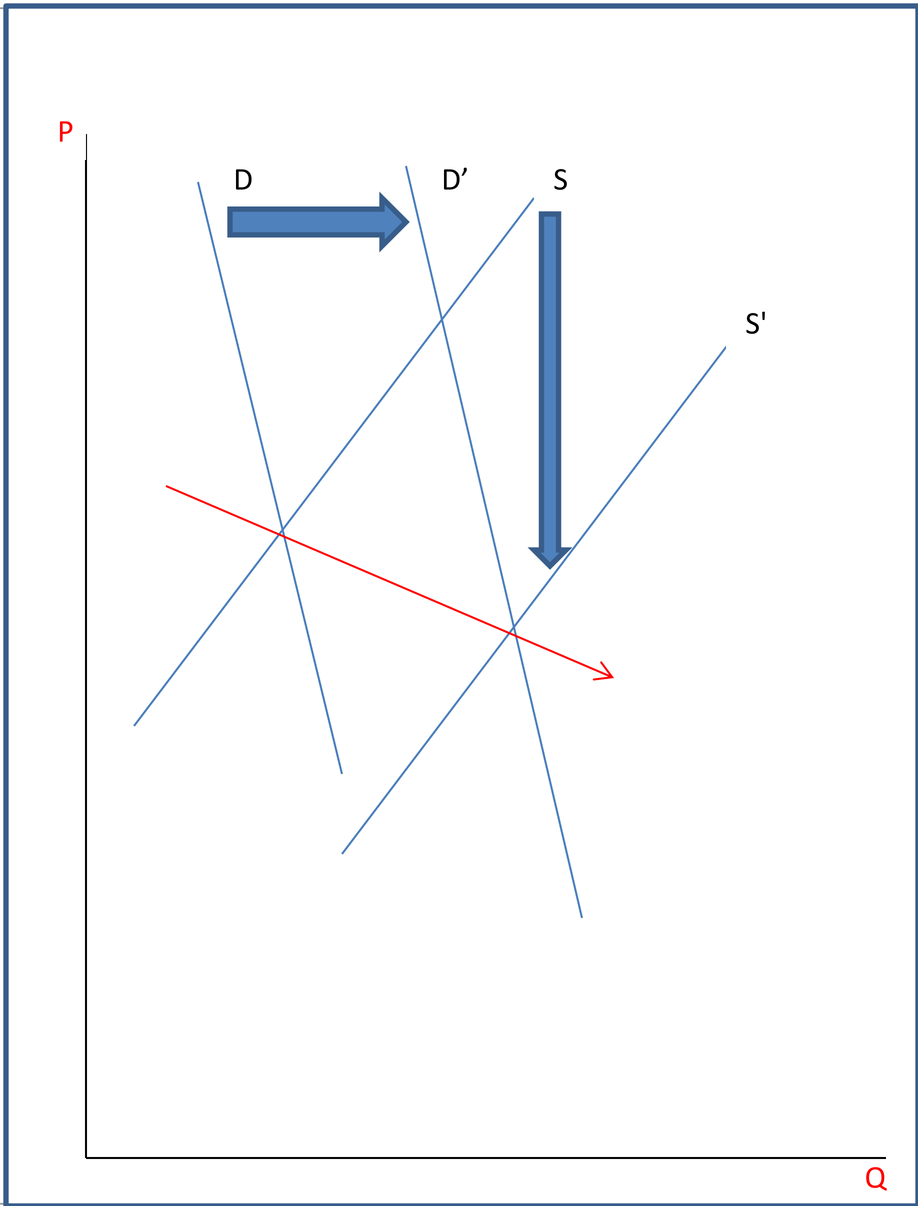
The Future

One Billion Hungry (Conway, 2012)

- Three Challenges
  - The probability of repeated food price spikes and a continued upward trend in food prices
  - Persistence of a billion or more people suffering from chronic hunger
  - How to feed the growing population in the face of a wide range of adverse factors including climate change
- Fundamental drivers
  - Increasing demand for food; population increases, rising per capita incomes, competing demands for biofuel crops
  - Deficiencies in supply; rising input prices, land and water scarcity and deterioration, slowing productivity gains, and climate change

The 20th Century decline in food prices

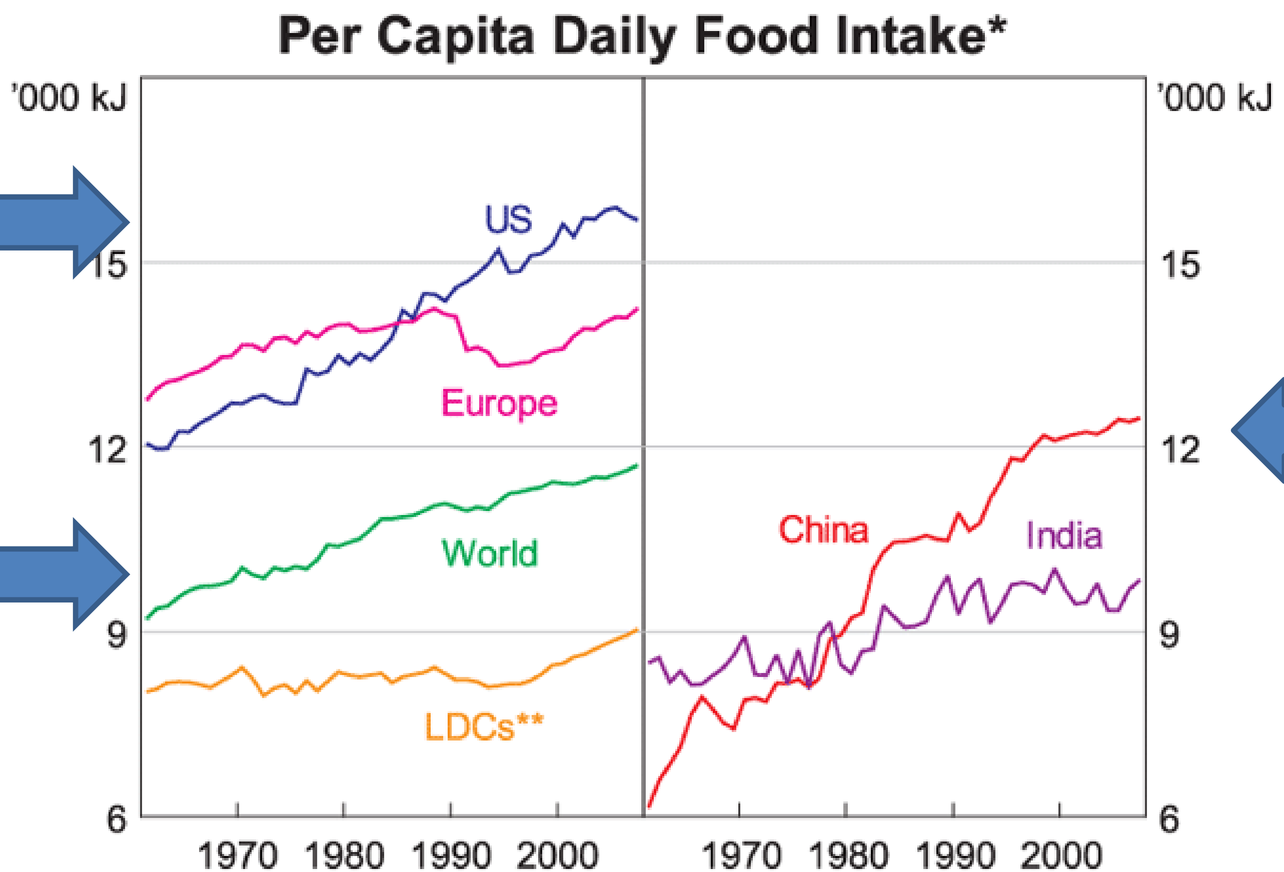




Obesity increase explained in one slide:

Aprox
3900 kcal

Aprox
2300 kcal



2900 kcal

* These data represent each region's total caloric value of food supplied to retail firms and households divided by its population

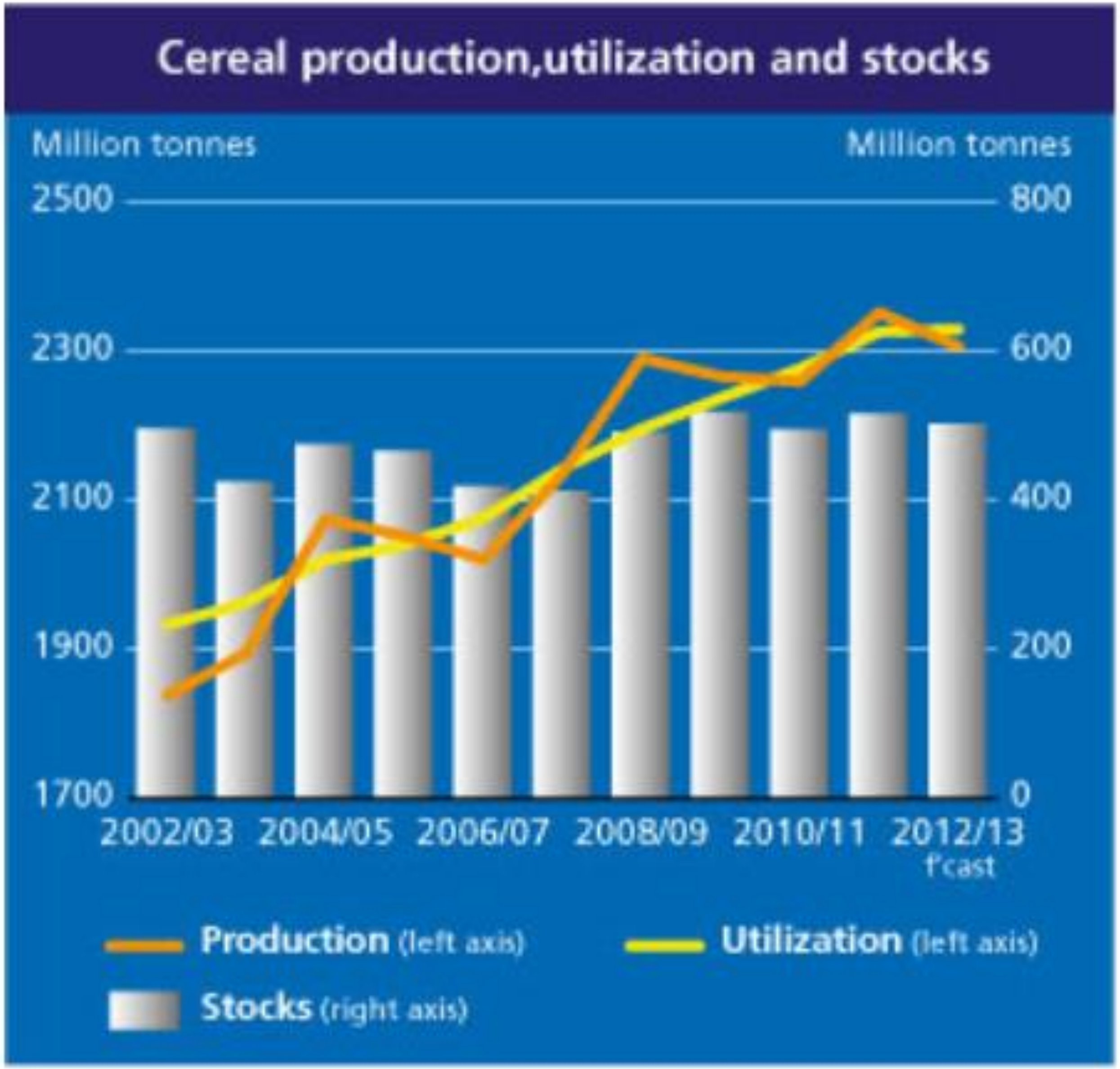
** The world's 49 least developed countries

Source: FAO

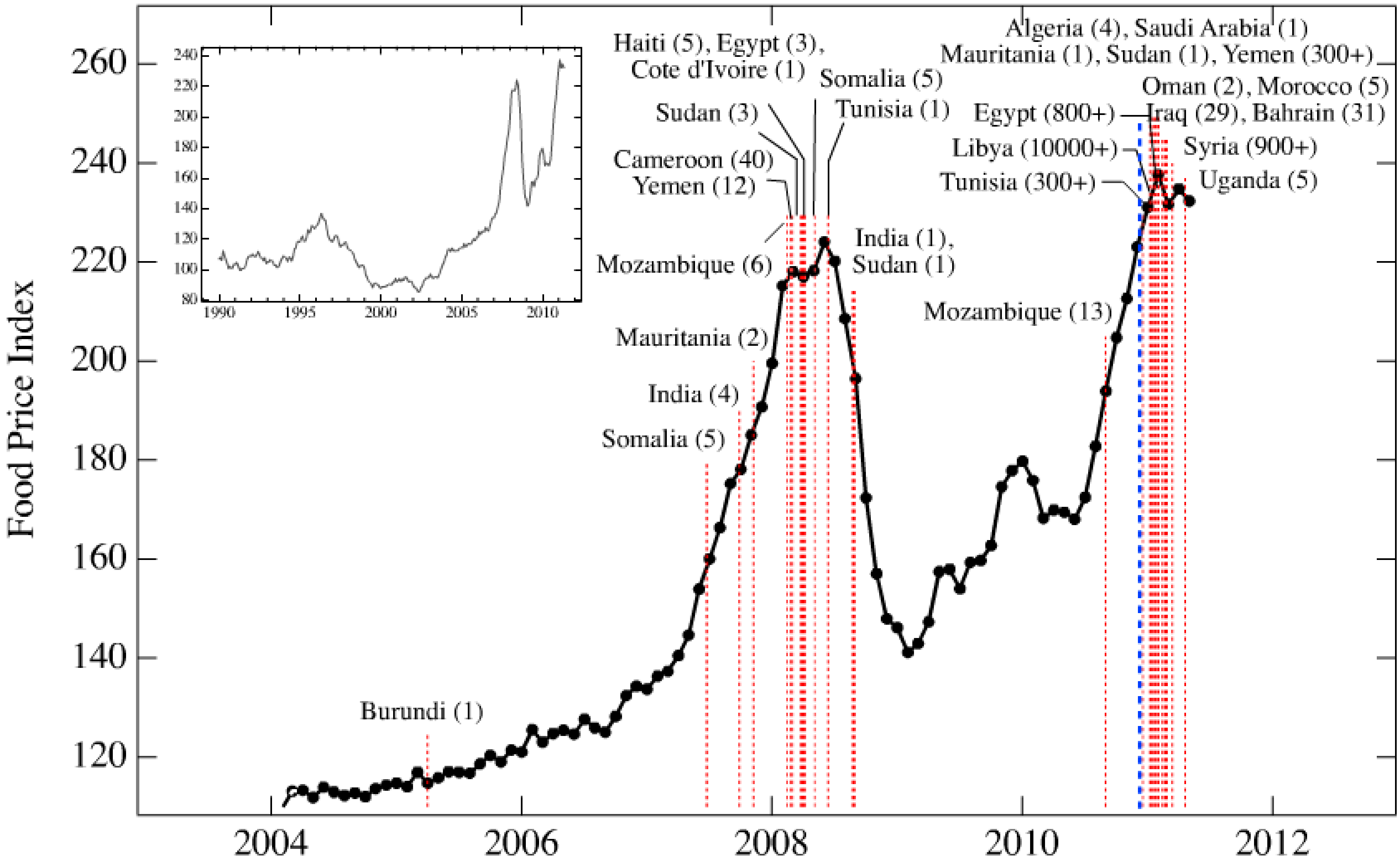
1 kJ equivalent to 0.239 kcal

FAO Cereal Supply and Demand Brief

(Release date 07/03/2013)



Social Unrest and Food Prices



Marco Lagi, Yavni Bar-Yam, Karla Z. Bertrand and Yaneer Bar-Yam, “The Food Crises: A quantitative model of food prices including speculators and ethanol conversion,” New England Complex Systems Institute, Cambridge, September 21, 2011. Numbers in parentheses are estimated death toll.

Post Harvest Losses in the Food Chain

The New York Times June 8, 2012

Manpreet Romana for The New York Times

Sacks of rice stored in the open in Ranwan, India, have rotted and suffered other damage.

Close Window

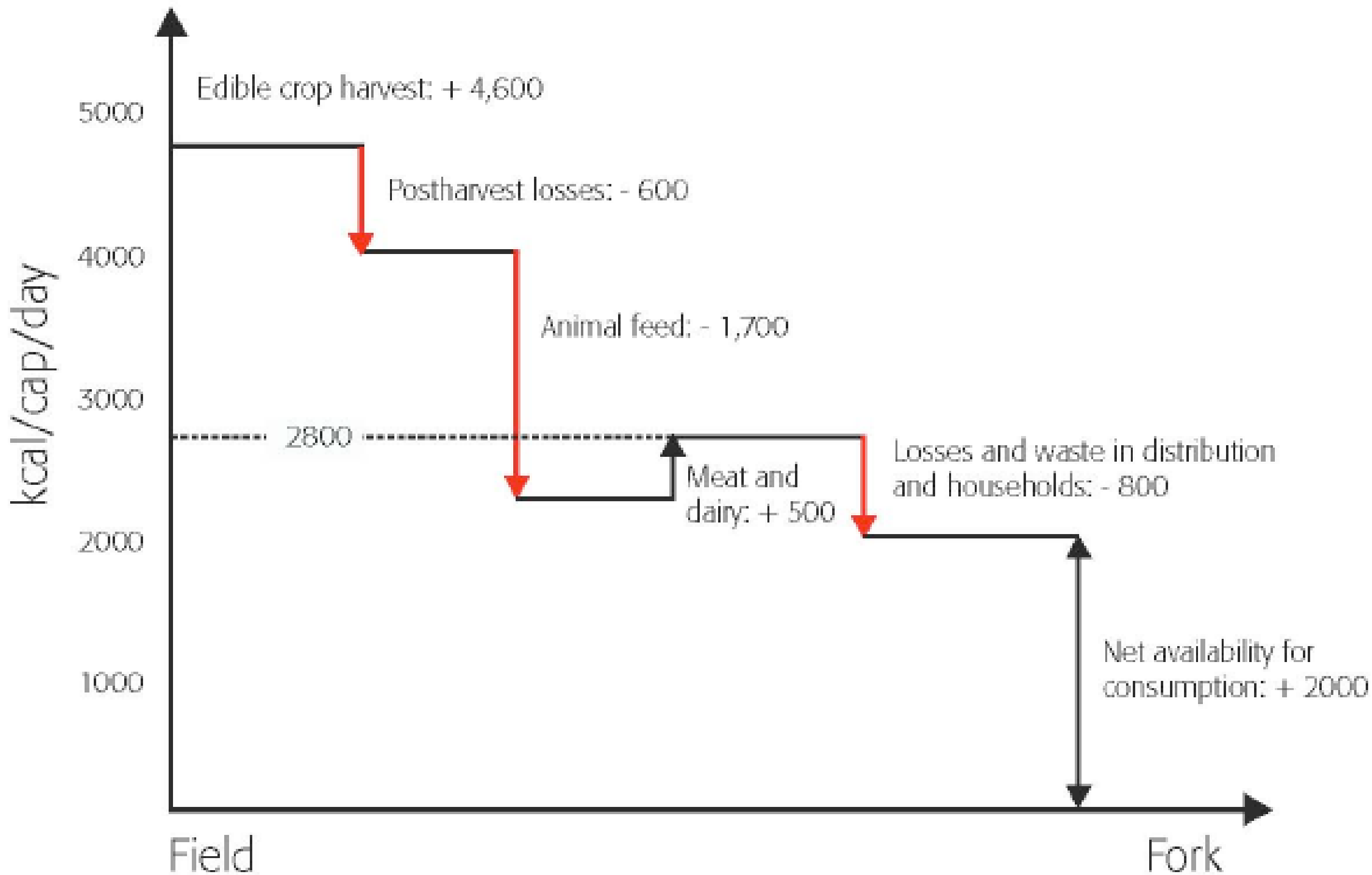


Figure 5

From field to fork: estimation of food losses, conversion and wastage in the world food chain.

Source: Lundqvist et al. (2008) from Smil (2000)

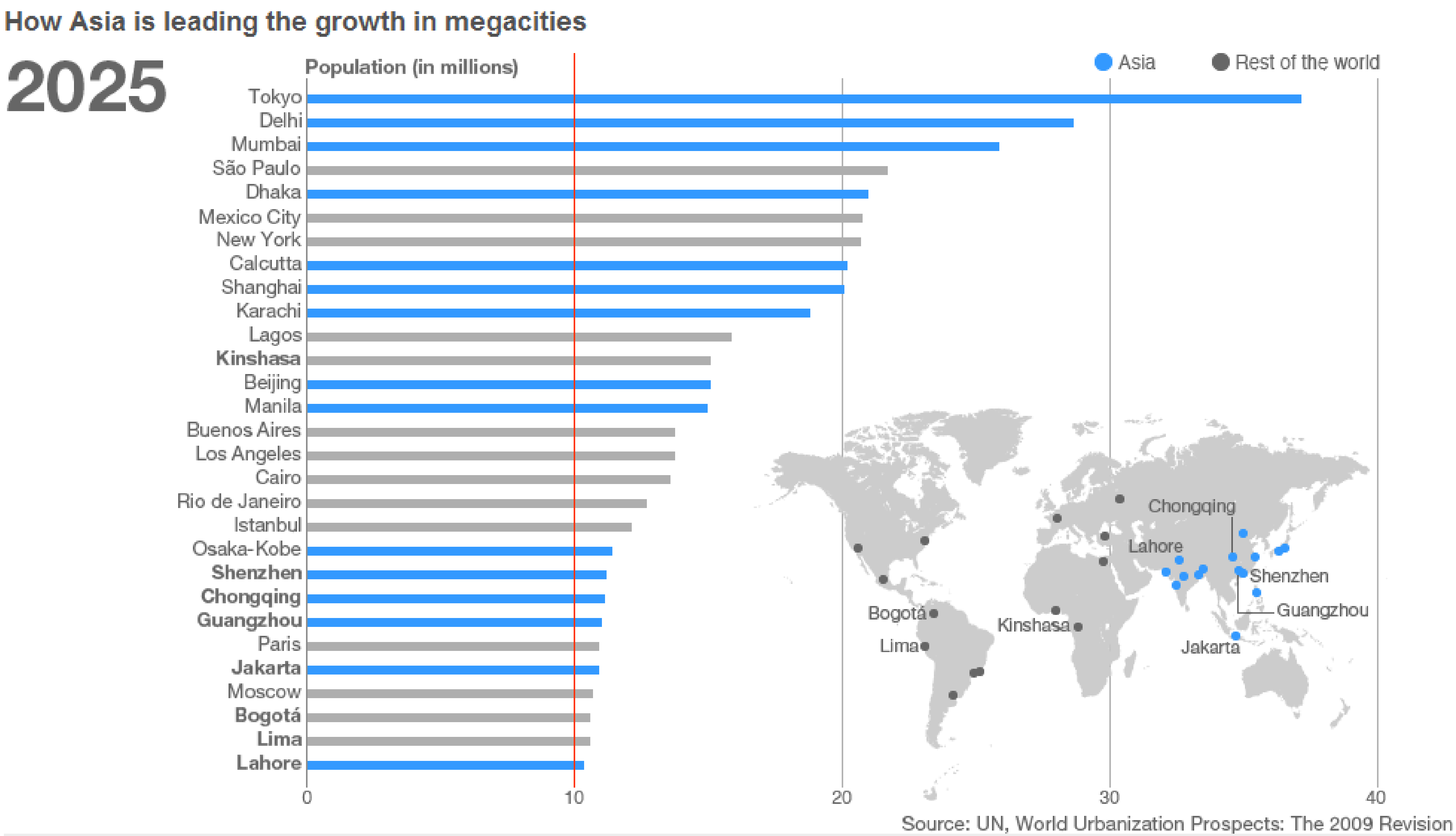
Guyomard et al., p. 8, 2011

FIVE GLOBAL TRANSITIONS

- "**Urban** Population Transition" large and rapidly growing urban populations and large malnourished rural populations
- "**Nutrition** Transition" rapid shifts in demand for food types and quantities consumed
- "**Agricultural** Transition" shortage of agricultural land and low productivity of agriculture, huge losses in the food chain from farm to consumer leading to industrial scale agricultural systems
- "**Energy** Transition" shifting away from fossil fuels towards renewable energy sources
- "**Climate** Transition" large uncertainty in food and water supplies introduced by changing climate, and leading to insecurity of supply and volatility in food prices and impacts on hydro energy

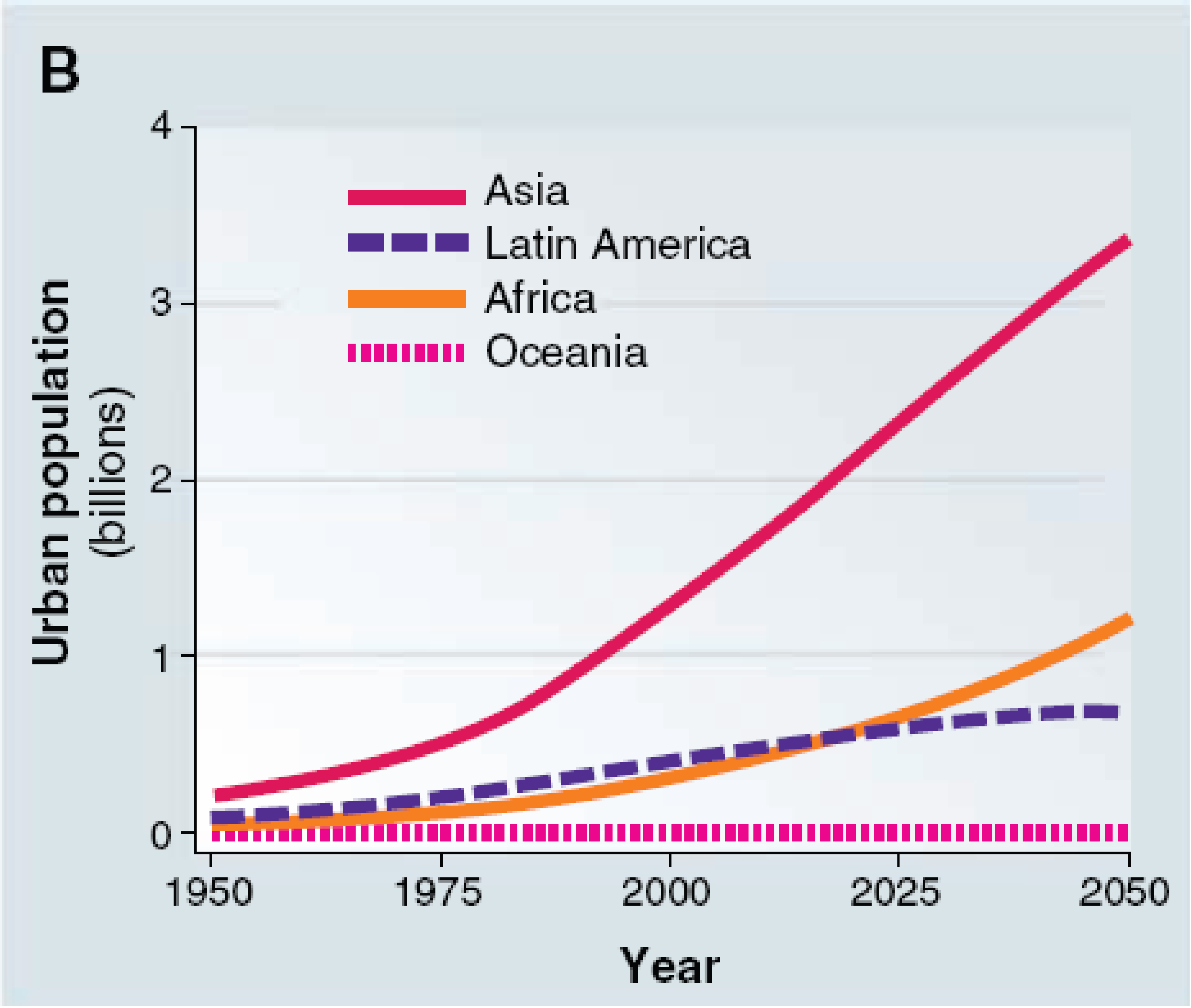
Urban Transition

Water, Food, and Energy in Megacities



By 2025, Chongqing, Guangzhou and Shenzhen, will take the number of megacities in China to five. In India, Mumbai is predicted to become the third most populous city in the world with 25.8 million inhabitants. The nine biggest cities are likely to have populations of over 20 million people

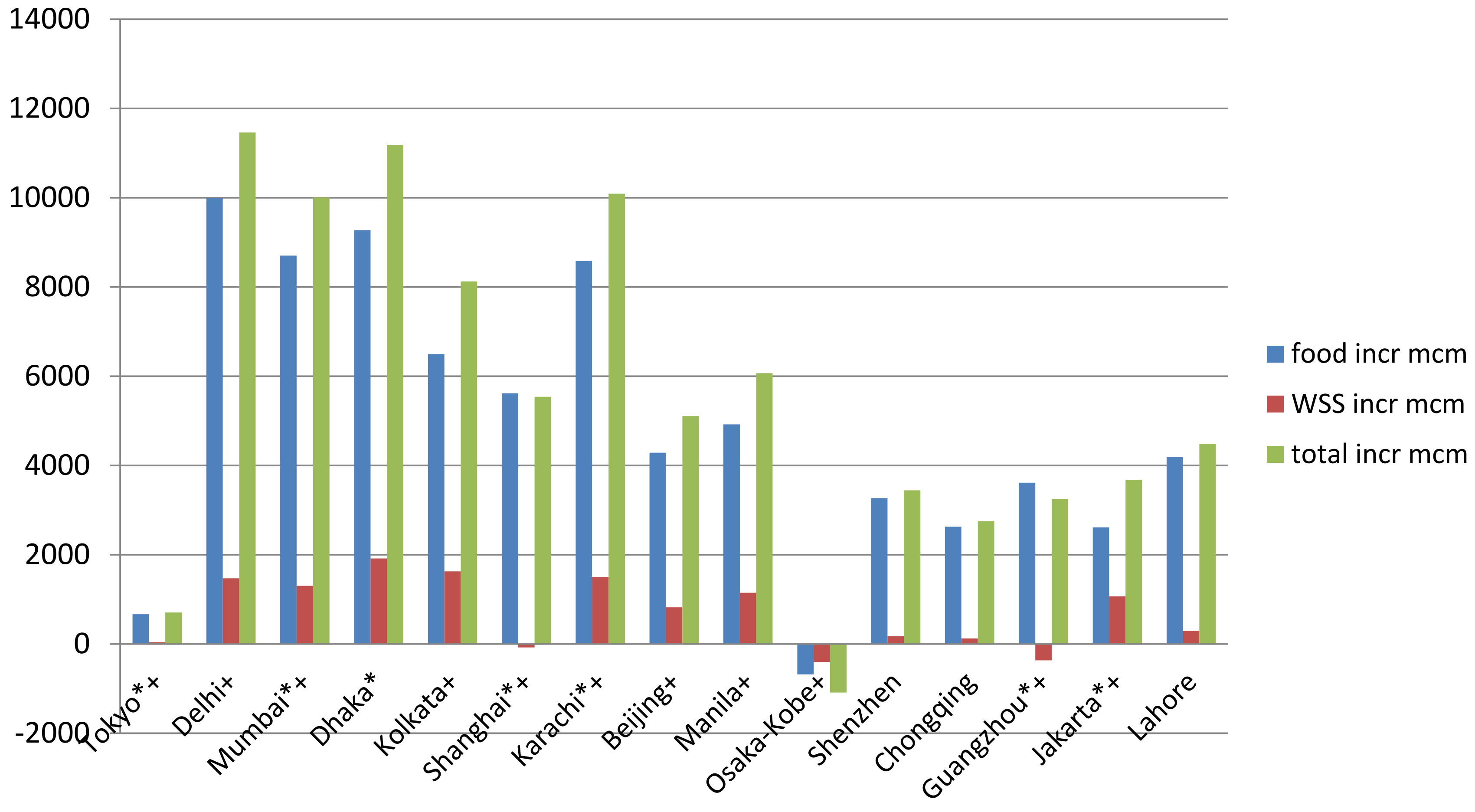
URBAN DEMOGRAPHIC TRANSITION



DOI: 10.1126/science.1153012 The Urban Transformation of the Developing World, *Science* ***319, 761 (2008);*** Mark R. Montgomery, *et al.*

AS ASIA URBANIZES

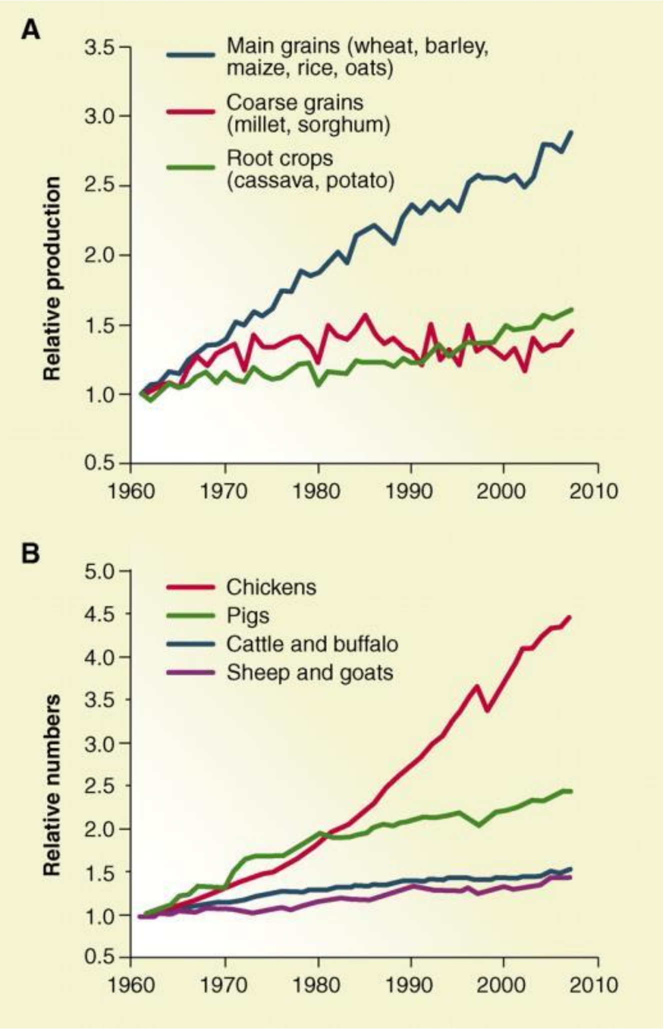
- The total demands placed upon the water, food, and energy resources will be very substantially increased
- Land use changes lead to reduction of high quality farmland and a consequent impact on food production
- Urbanization also increases water and food based energy uses
- Of these energy requirements water demands are likely to be the most stressed
- Hence, a focus improving water use efficiency is warranted
- It should be stressed that these effects are on the total resource base not just limited to cities



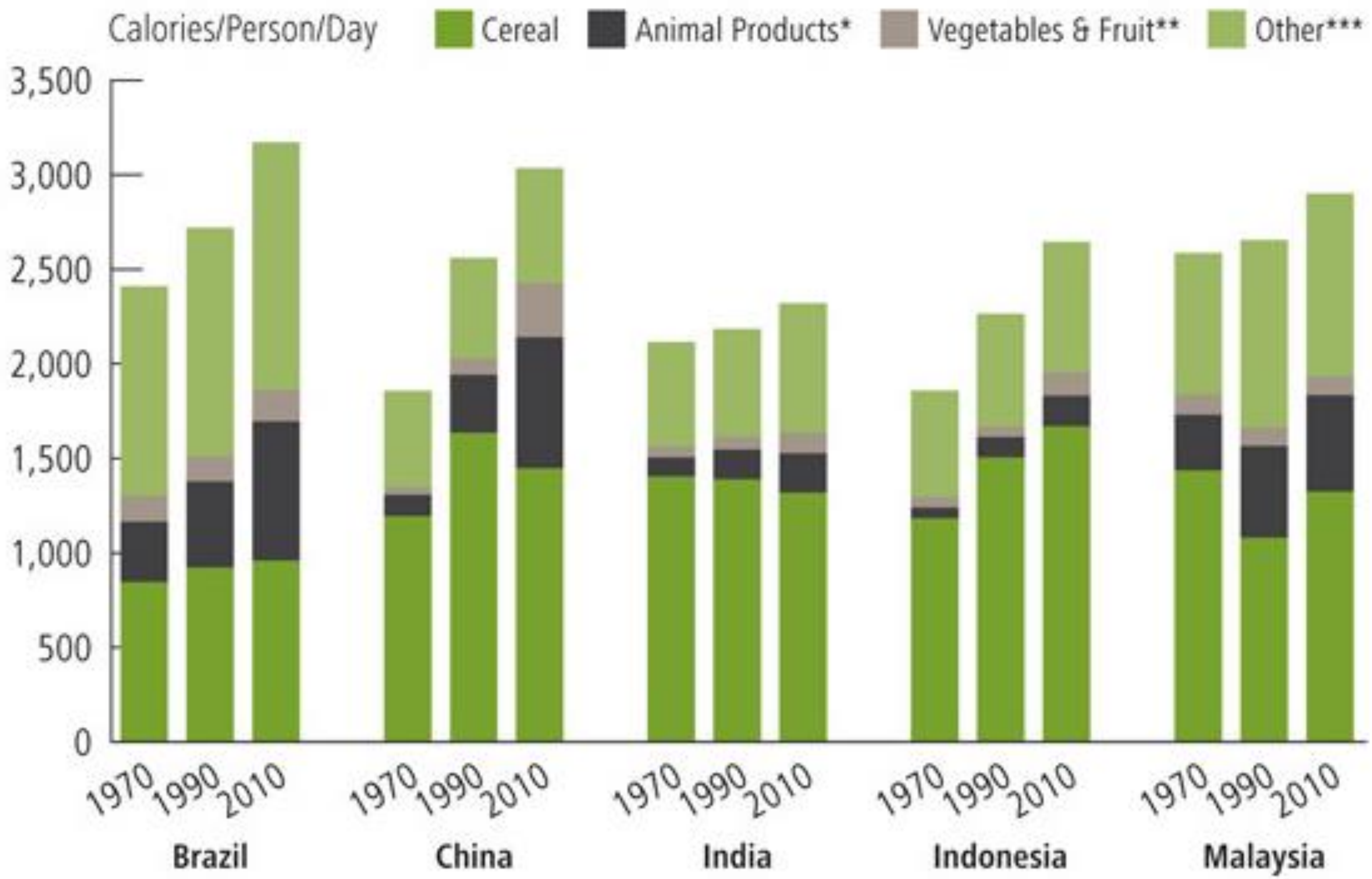
Asian megacities: Incremental water needed for food and energy 2010-2025. (Rogers, 2012)

NutritionTransition

Fig. 1 Changes in the relative global production of crops and animals since 1961 (when relative production scaled to 1 in 1961).



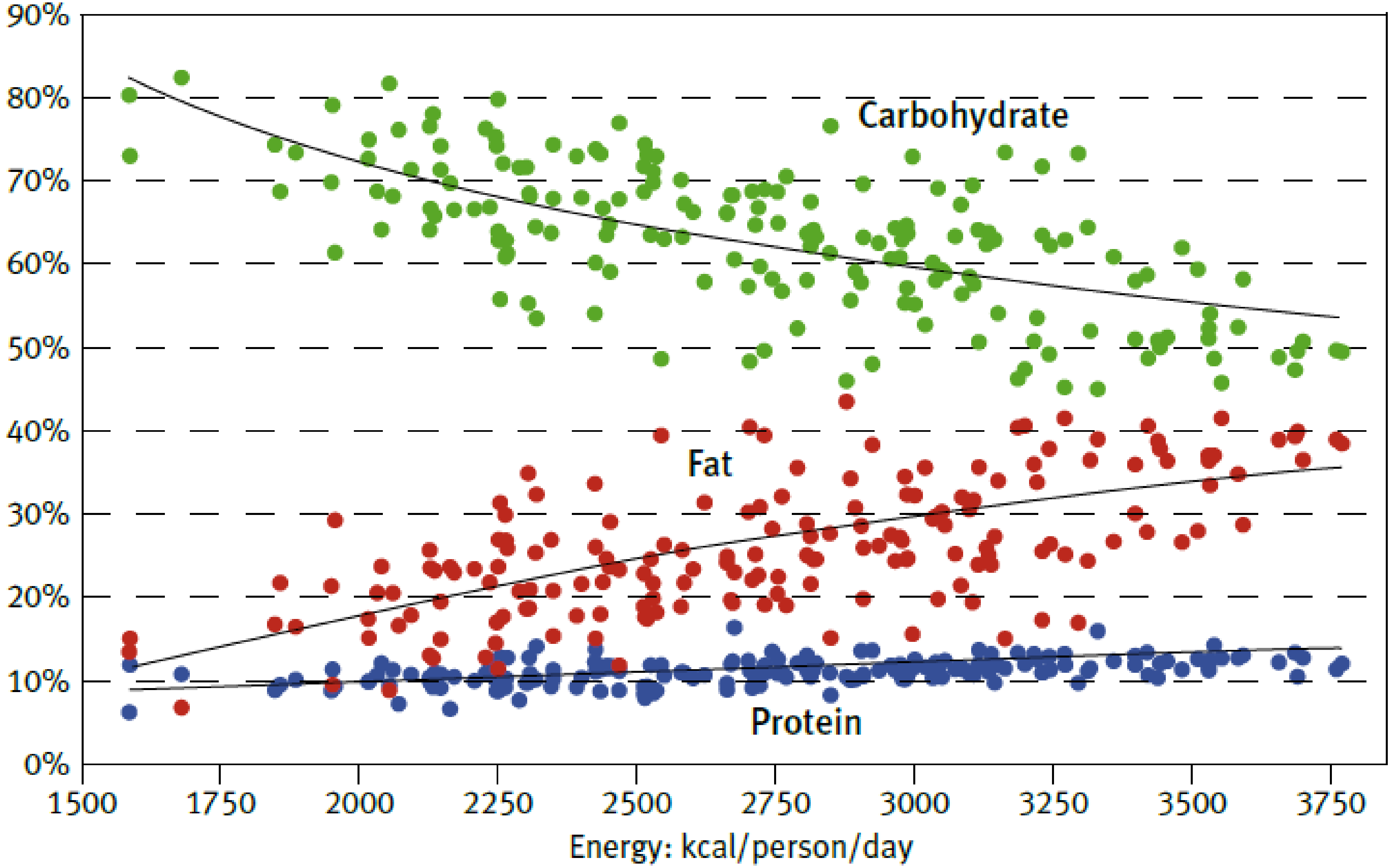
H C J Godfray et al. Science 2010;327:812-818



Daily Caloric Intake per Capita

* Includes meat, eggs, fish and animal fats
** Includes vegetable oils
*** Includes starches, sugar, pulses, beverages
Source: FAO

NUTRITION TRANSITION

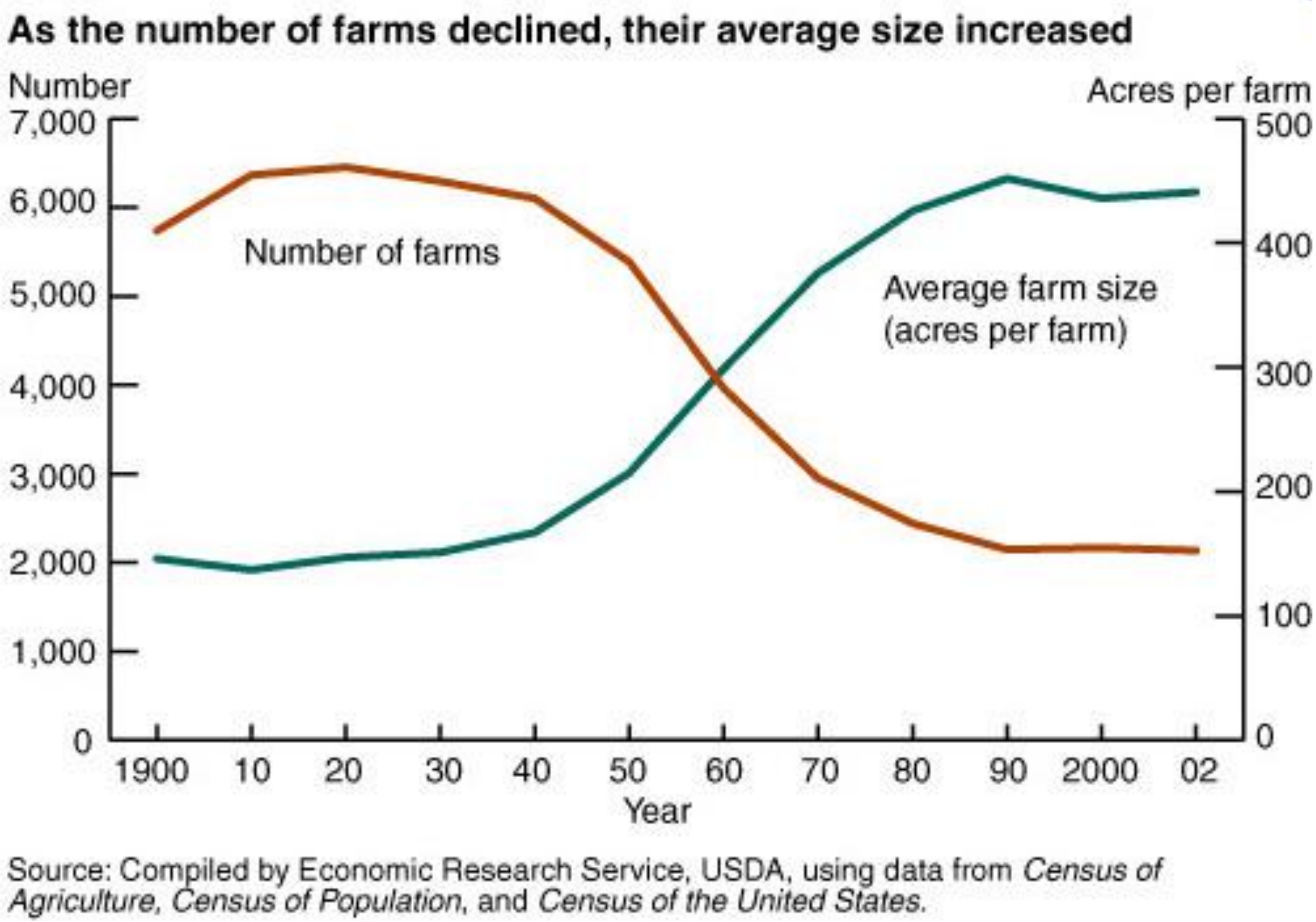


Substitution of fats for carbohydrates as consumption of kcals as wealth increases

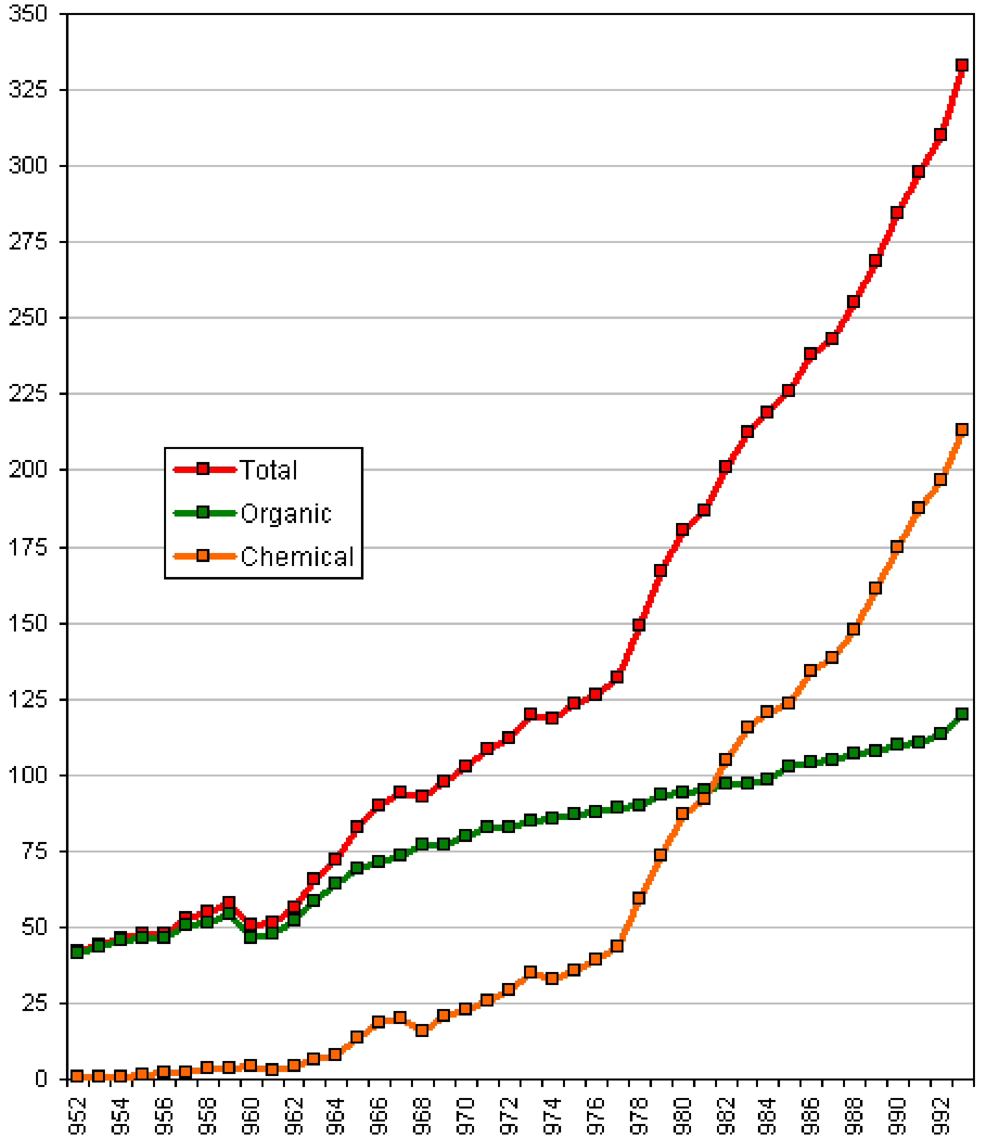
Sus Ag and Climate, p. 9

Agricultural Transition

AGRICULTURAL TRANSITION

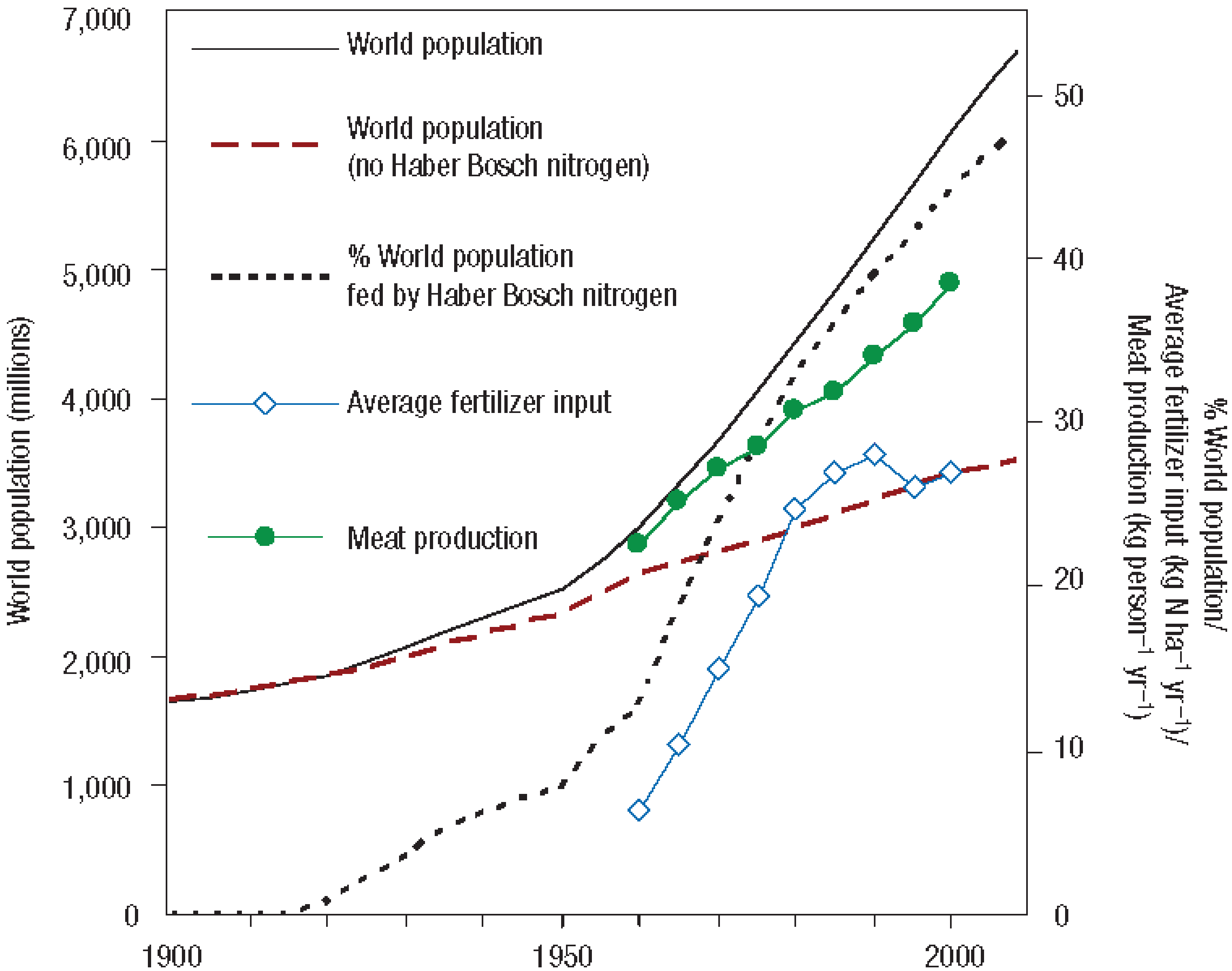


Fertiliser usage 1952-1993



http://www.paulchefurka.ca

GLOBAL USE of SYNTHETIC FERTILIZER



Source. iTulip

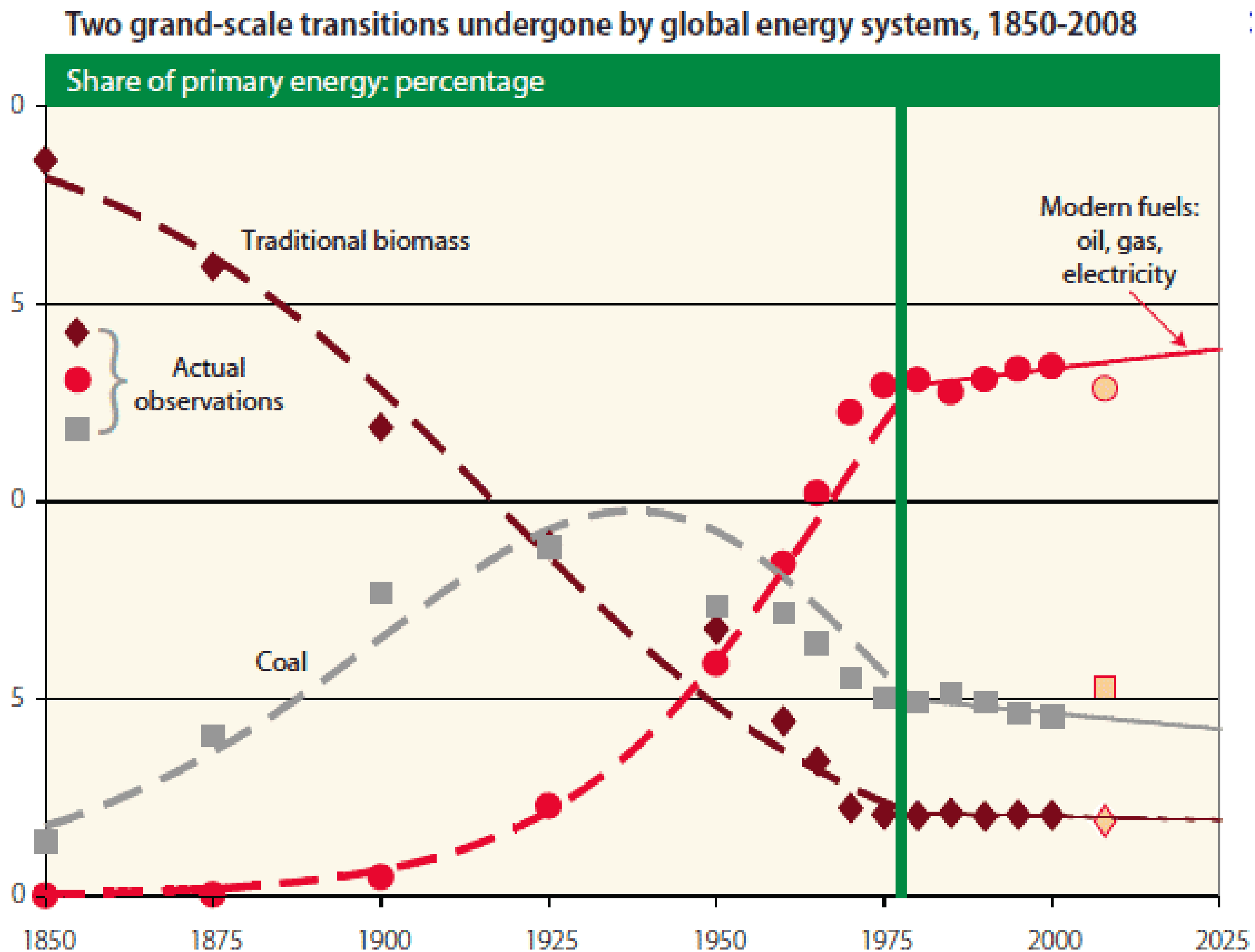
Irrigated Hectares of Top Irrigated Countries

Country	Irrigated Hectares (in millions)
India	62
China	60
United States	25
Pakistan	19
Iran	9
Indonesia	7
Thailand	6
Mexico	6
Turkey	5
Bangladesh	5

Source: ICID 2010

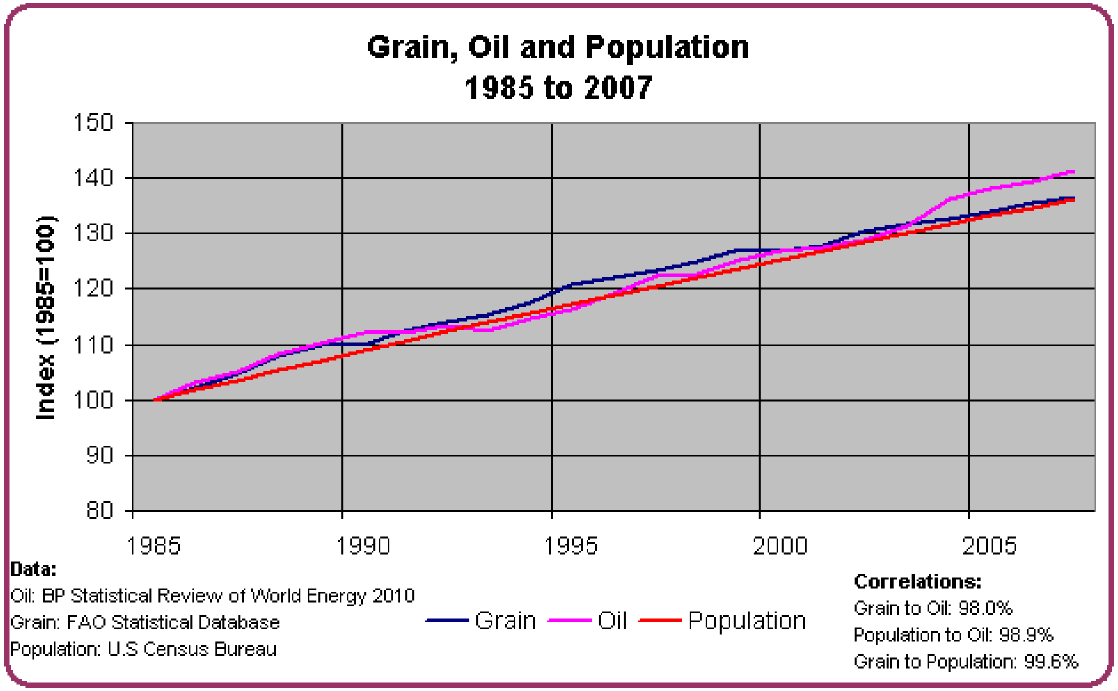
Energy Transition

ENERGY TRANSITION



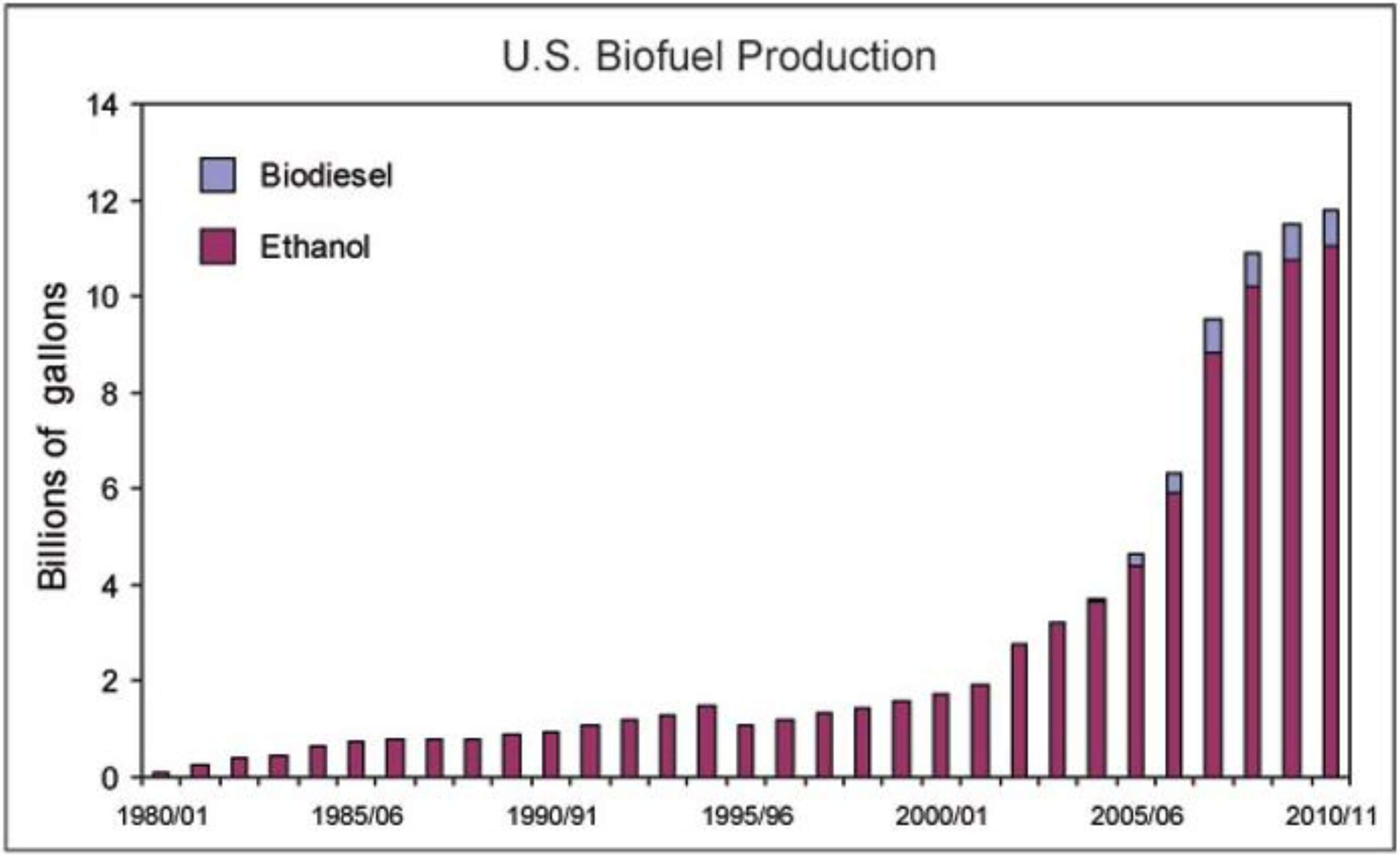
energy_transitions.gif
gees.cat
579 × 428 - Fuente: British Petroleum (2010); Grübler (2008); y International

www.eoearth.org/article/**Energy_transitions** . A Grubler



http://www.paulchefurka.ca

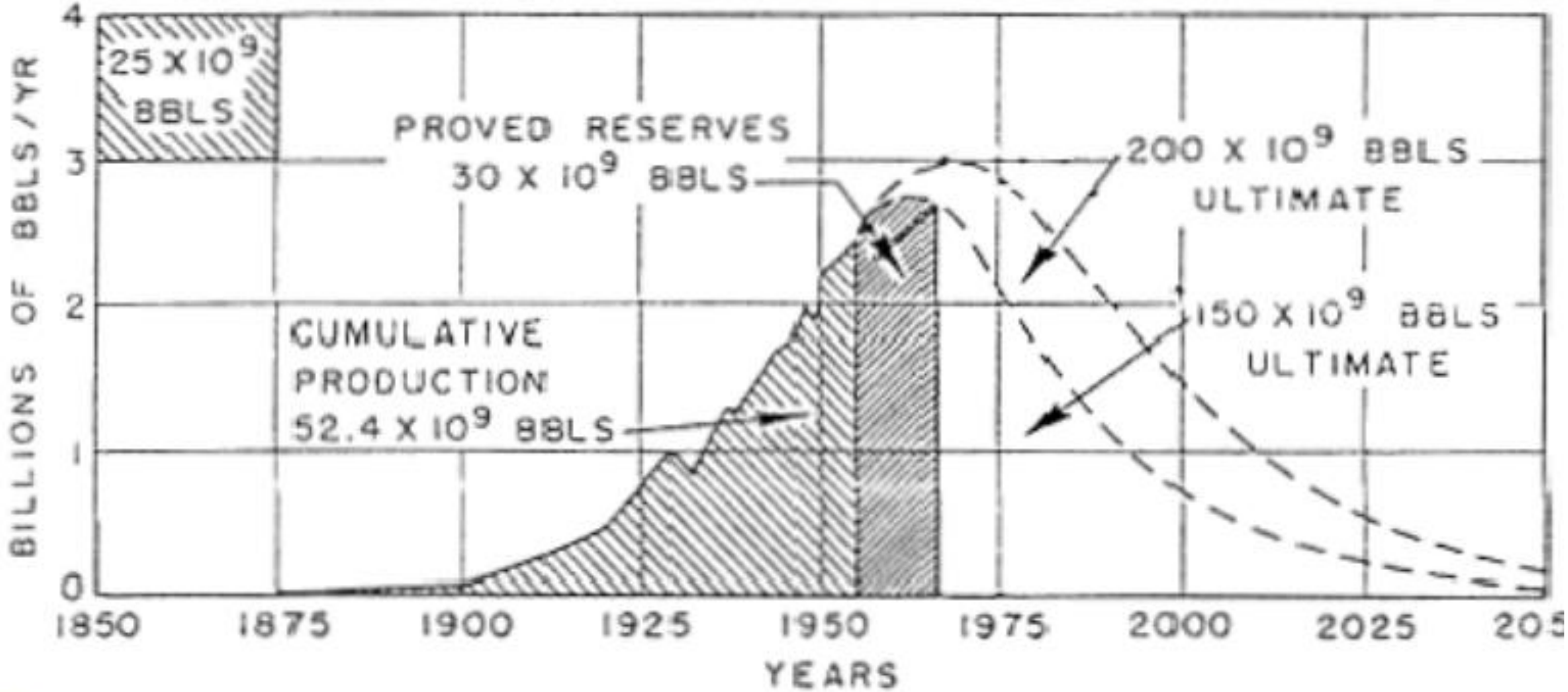
23% of all fossil fuels used globally go to the production of FOOD.



Source. Southwest Climate Change Network, U. Arizona.

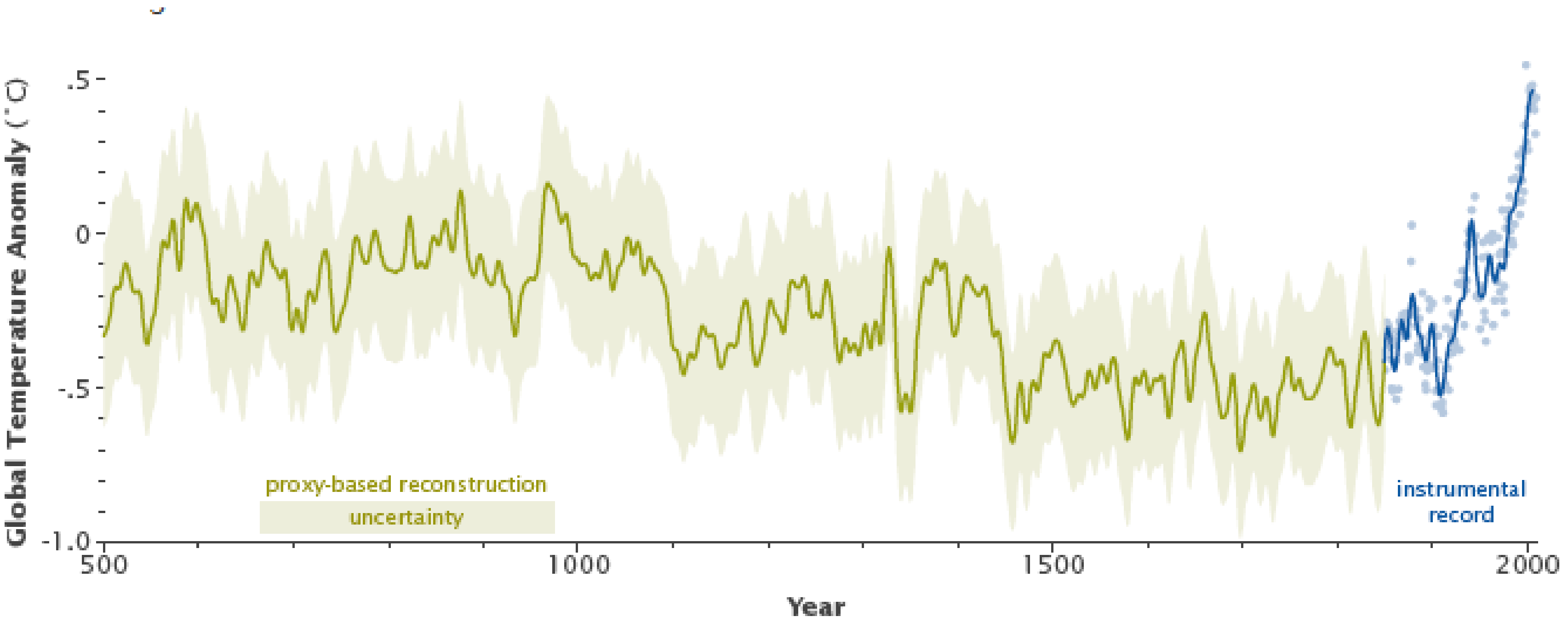
Peak "EVERYTHING"

USA Peak-Oil -- The famous King Hubert curve



Climate Transition

CLIMATE TRANSITION



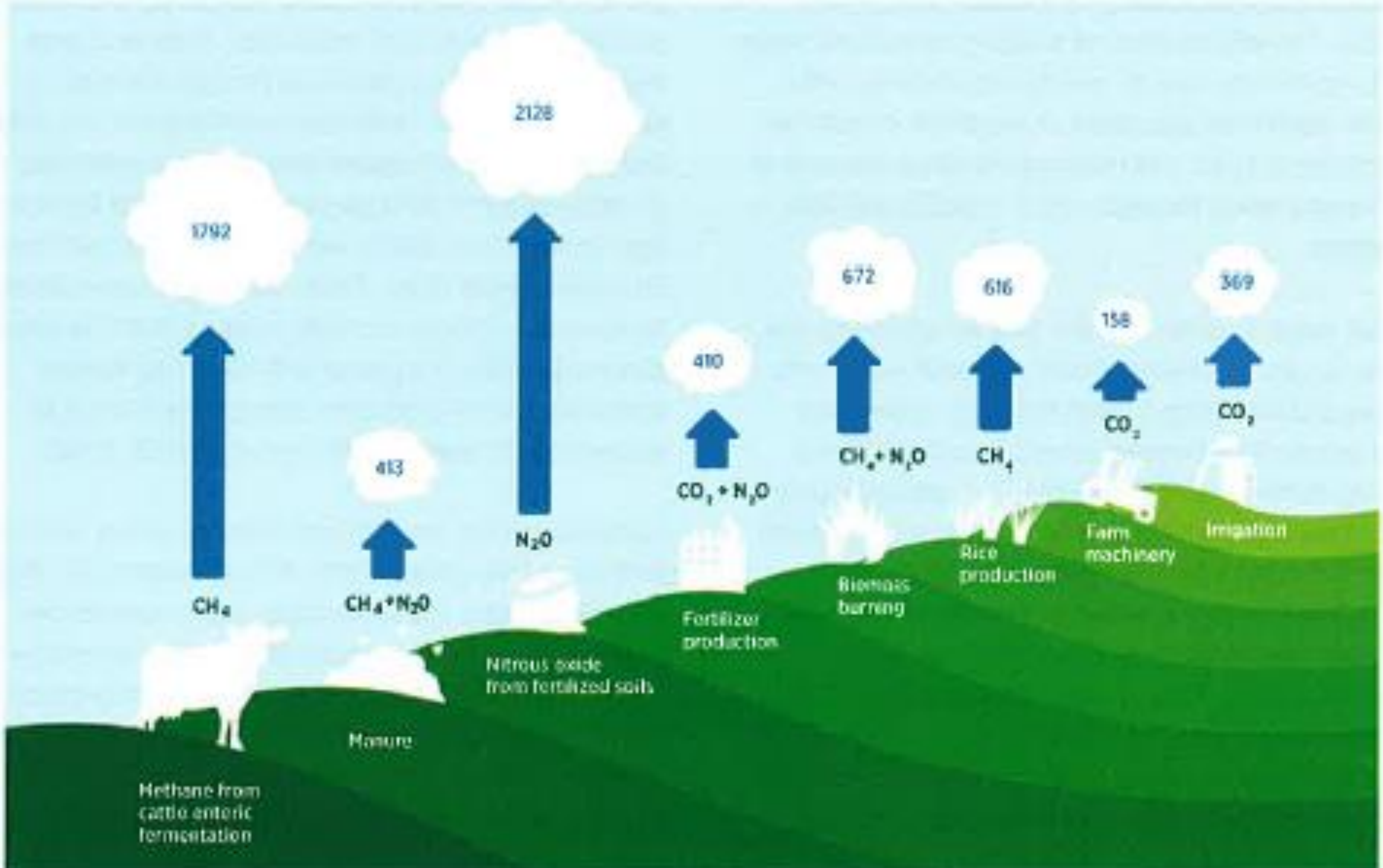
Temperature anomalies for past 1500 years

NASA Earth Observatory, adapted from [Mann et al., 2008.]

Another anomaly is the reduction in the rate of warming from 0.17C per decade from 1970 -1998 to 0.04C per decade from 1998-2012

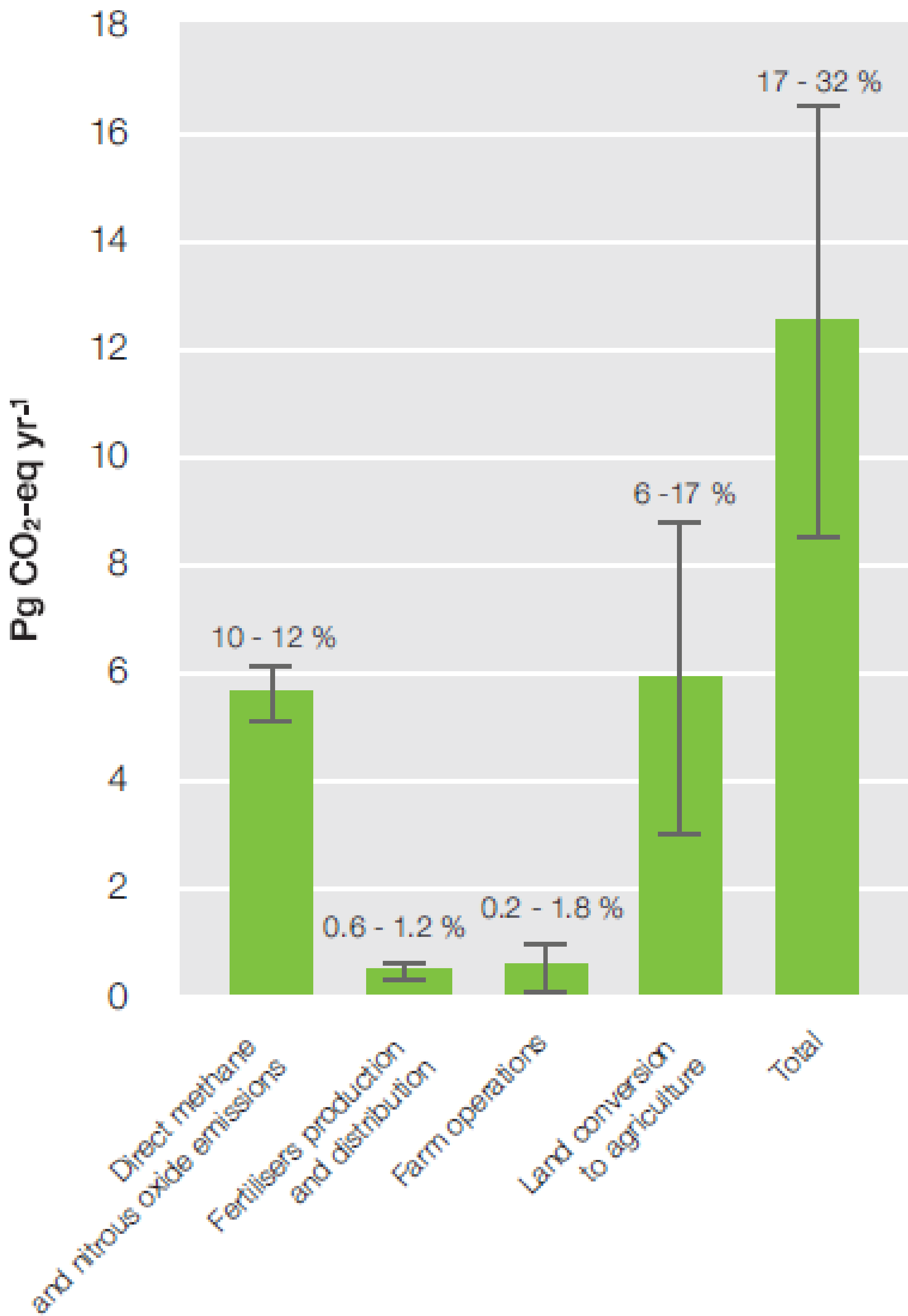
FIGURE 18.5

Sources of agricultural greenhouse gases excluding land use change



Source: Bellarby et al. (2008 fig. 2, p. 7).

MT of CO2 equivalents



Agriculture and Climate Feedbacks

Conventionally we note that climate affects food production, but less well understood is agriculture's impact on climate

Global Contribution of Agriculture to Greenhouse Gas Emissions
Bellarby, et al, 2008

ENOUGH DISMAL THINKING

Securing Future Global Water Demands

Facts are Facts, but Perception is Reality!

Originally attributed to the Director the EU's Environmental Directorate DG 12

STATEMENT OF DR. ROGER PIELKE, JR.
to the COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS
of the UNITED STATES SENATE
HEARING on CLIMATE CHANGE: IT'S HAPPENING NOW
18 July 2013

Basic review of the US data over IPCC's recent climate timescales (30-50 years)

Humans influence the climate system in profound ways, including through the emission of carbon dioxide via the combustion of fossil fuels. (Some Caveats)

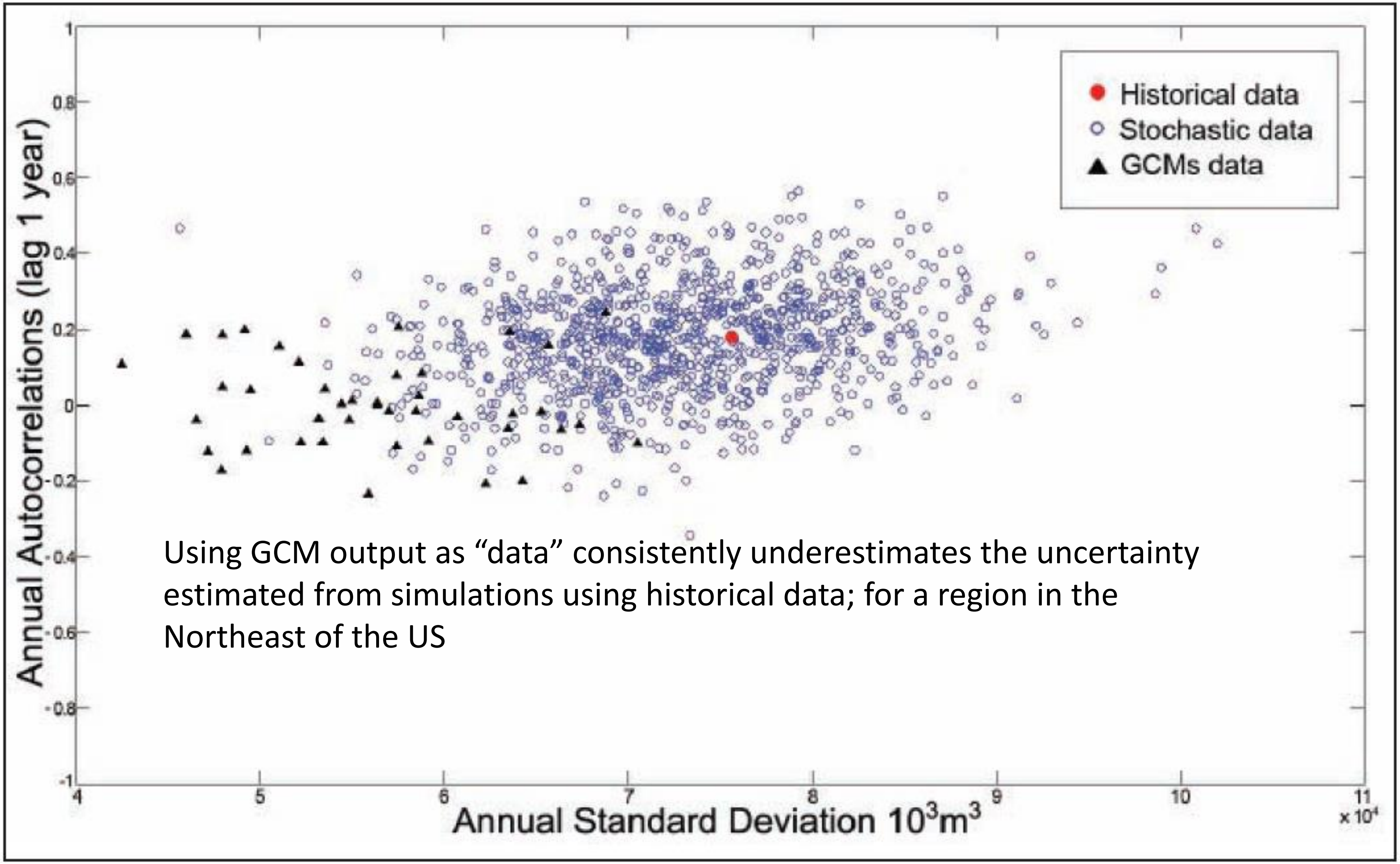
- Researchers have detected and (in some cases) attributed a human influence in other measures of climate extremes beyond those discussed in this testimony, including surface temperatures and precipitation.
- The inability to detect and attribute changes in hurricanes, floods, tornadoes and drought does not mean that human-caused climate change is not real or of concern.
- It does mean however that some activists, politicians, journalists, corporate and government agency representatives and even scientists who should know better have made claims that are unsupportable based on evidence and research.
- Such false claims could undermine the credibility of arguments for action on climate change, and to the extent that such false claims confuse those who make decisions related to extreme events, they could lead to poor decision making.
- A considerable body of research projects that various extremes may become more frequent and/or intense in the future as a direct consequence of the human emission of carbon dioxide.
- Our research, and that of others, suggests that assuming that these projections are accurate, **it will be many decades, perhaps longer, before the signal of human-caused climate change can be detected in the statistics of hurricanes** (and to the extent that statistical properties are similar, in floods, tornadoes, drought).

Current “Stylized Perceptions” are the Opposite of the “Facts” marshaled by Pielke.

It is misleading, and just plain incorrect, to claim that disasters associated with hurricanes, tornadoes, floods or droughts have increased on climate timescales either in the United States or globally. It is further incorrect to associate the increasing costs of disasters with the emission of greenhouse gases.

- Globally, weather-related losses ($) have not increased since 1990 as a proportion of GDP (they have actually decreased by about 25%) and insured catastrophe losses have not increased as a proportion of GDP since 1960.
- Hurricanes have not increased in the US in frequency, intensity or normalized damage since at least 1900. The same holds for tropical cyclones globally since at least 1970 (when data allows for a global perspective).
- Floods have not increased in the US in frequency or intensity since at least 1950. Flood losses as a percentage of US GDP have dropped by about 75% since 1940.
- Tornadoes have not increased in frequency, intensity or normalized damage since 1950, and there is some evidence to suggest that they have actually declined.
- Drought has “for the most part, become shorter, less frequent, and cover a smaller portion of the U. S. over the last century.” Globally, “there has been little change in drought over the past 60 years.”
- The absolute costs of disasters will increase significantly in coming years due to greater wealth and populations in locations exposed to extremes. Consequent, disasters will continue to be an important focus of policy, irrespective of the exact future course of climate change.

Comparing historical data with “modeled future data” from GCM Models

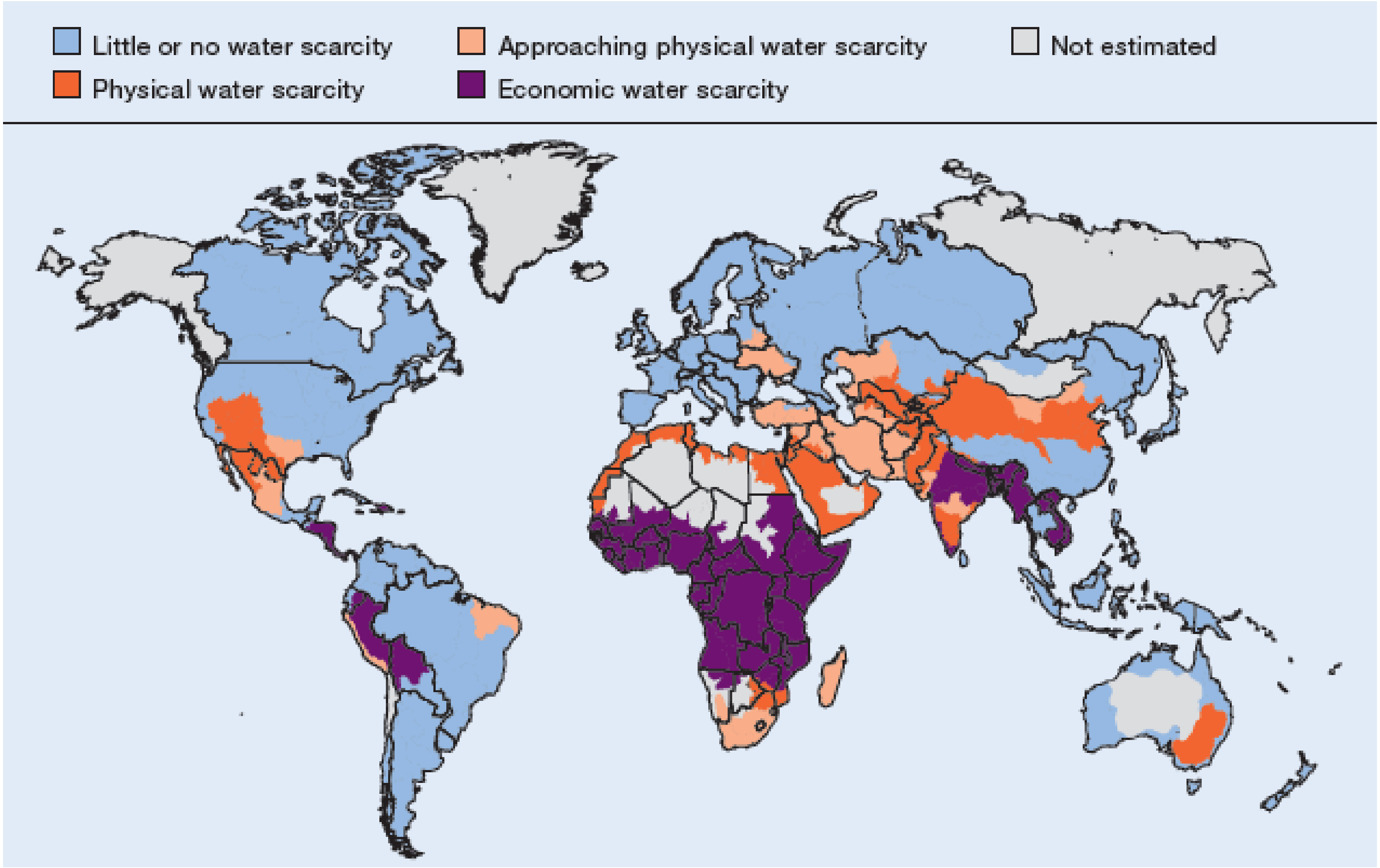


Using GCM output as “data” consistently underestimates the uncertainty estimated from simulations using historical data; for a region in the Northeast of the US

Four types of “water scarcity”: Difference between having the resource and being able to use it

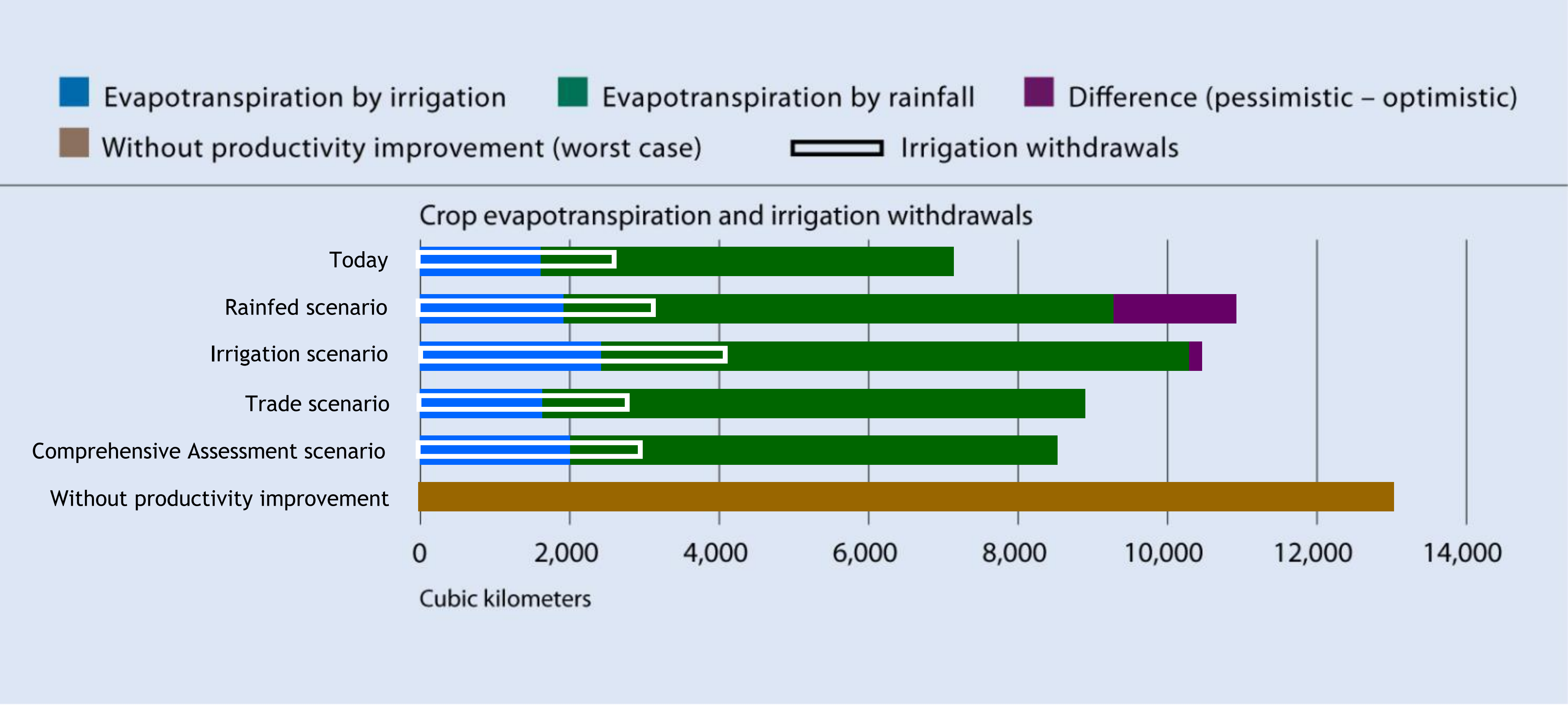
1. Little or no scarcity (less than 25% of blue water used)
2. Approaching physical scarcity
3. Physical scarcity (more than 75% of blue water used)
4. Economic scarcity (less than 25% withdrawn)

The Present Physical and Economic Scarcity



CA, p.11

Scenarios to 2050

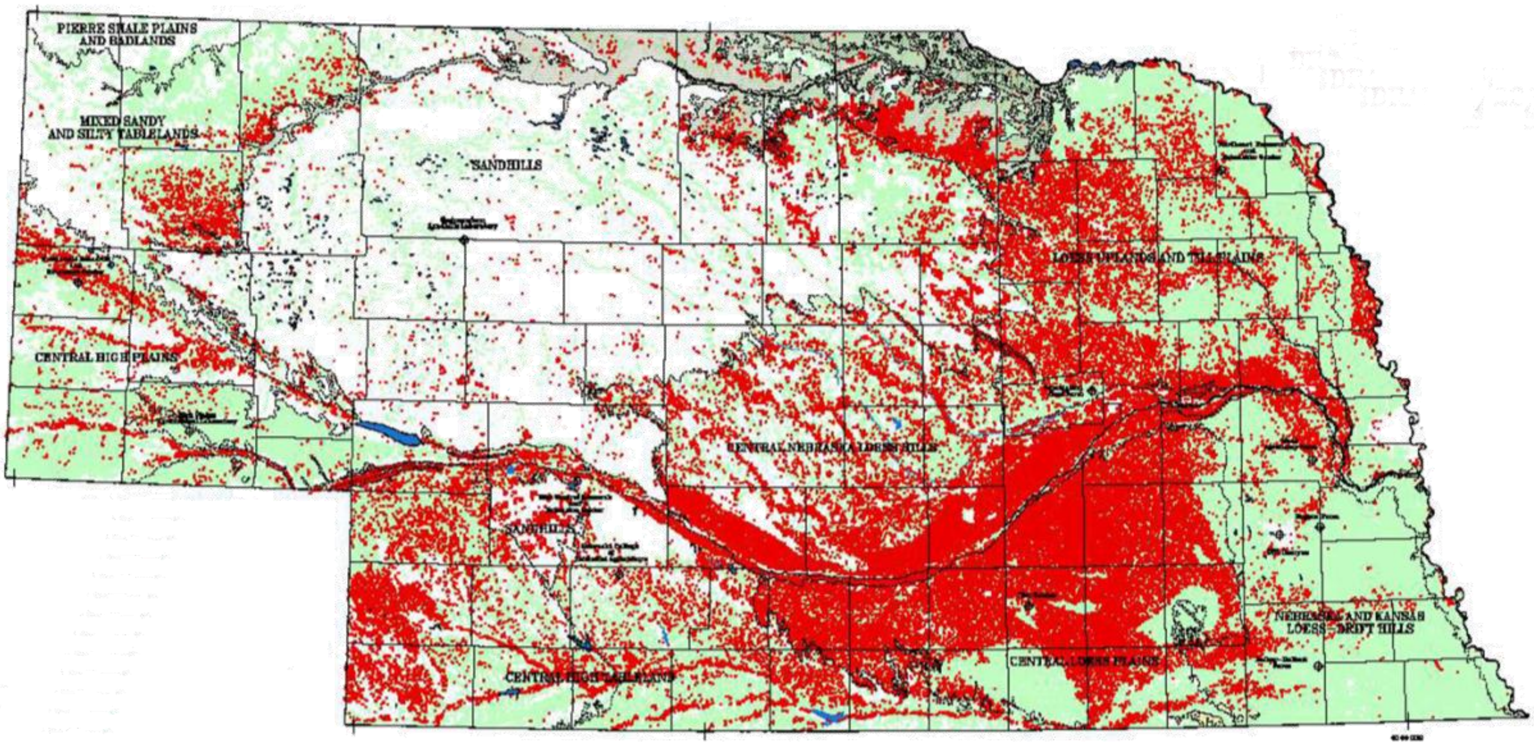


Based on WaterSim analysis for the CA

Precision Irrigation

Examples of Innovation in Nebraska

3.4 million hectares total; 115,000 active irrigation wells



Date source: USDA

Irrigation wells

University of Nebraska Lincoln

Eye on Asia

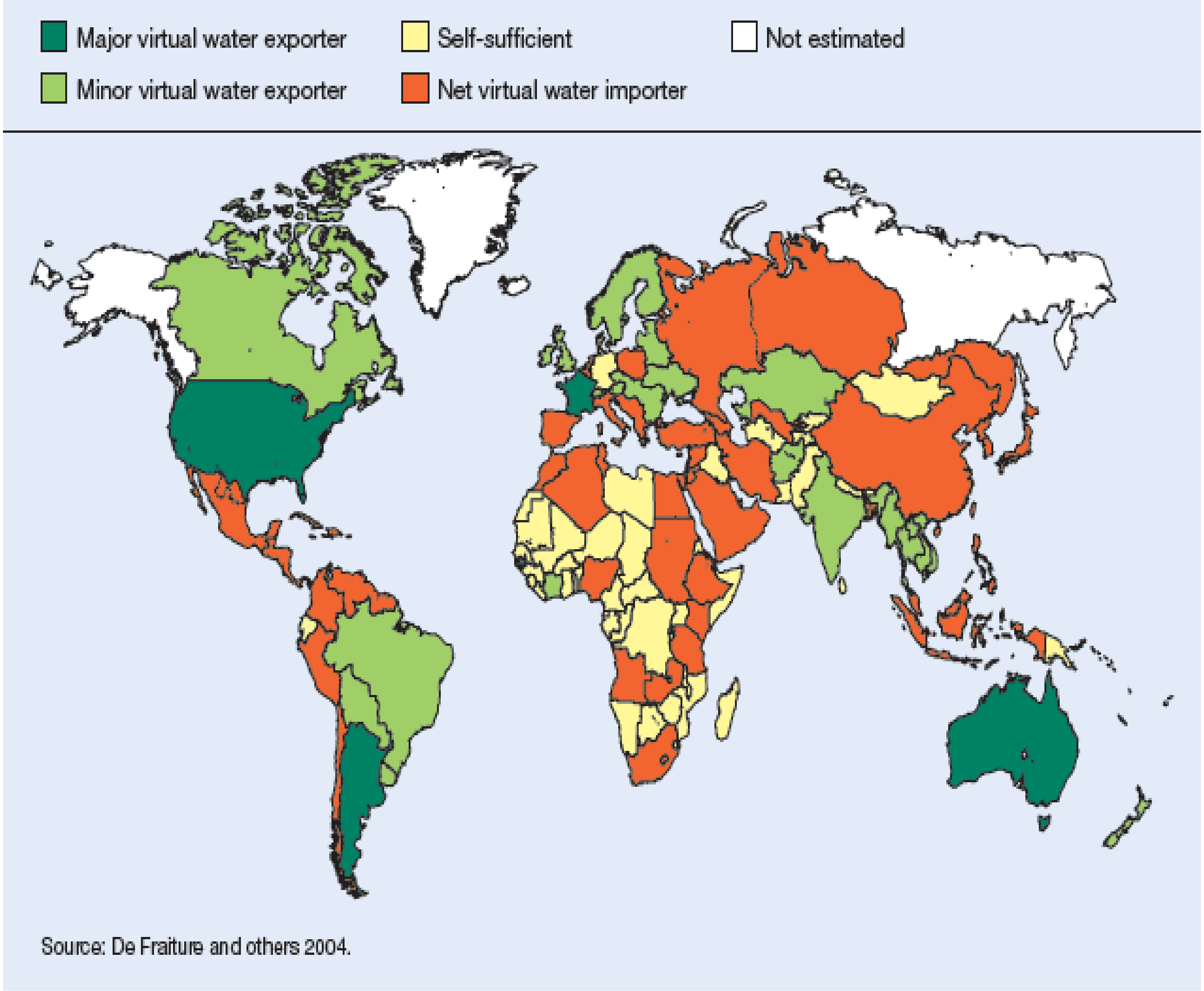
Some Other Technical Fixes

Virtual water

Desalination

Recycling Urban Wastewater

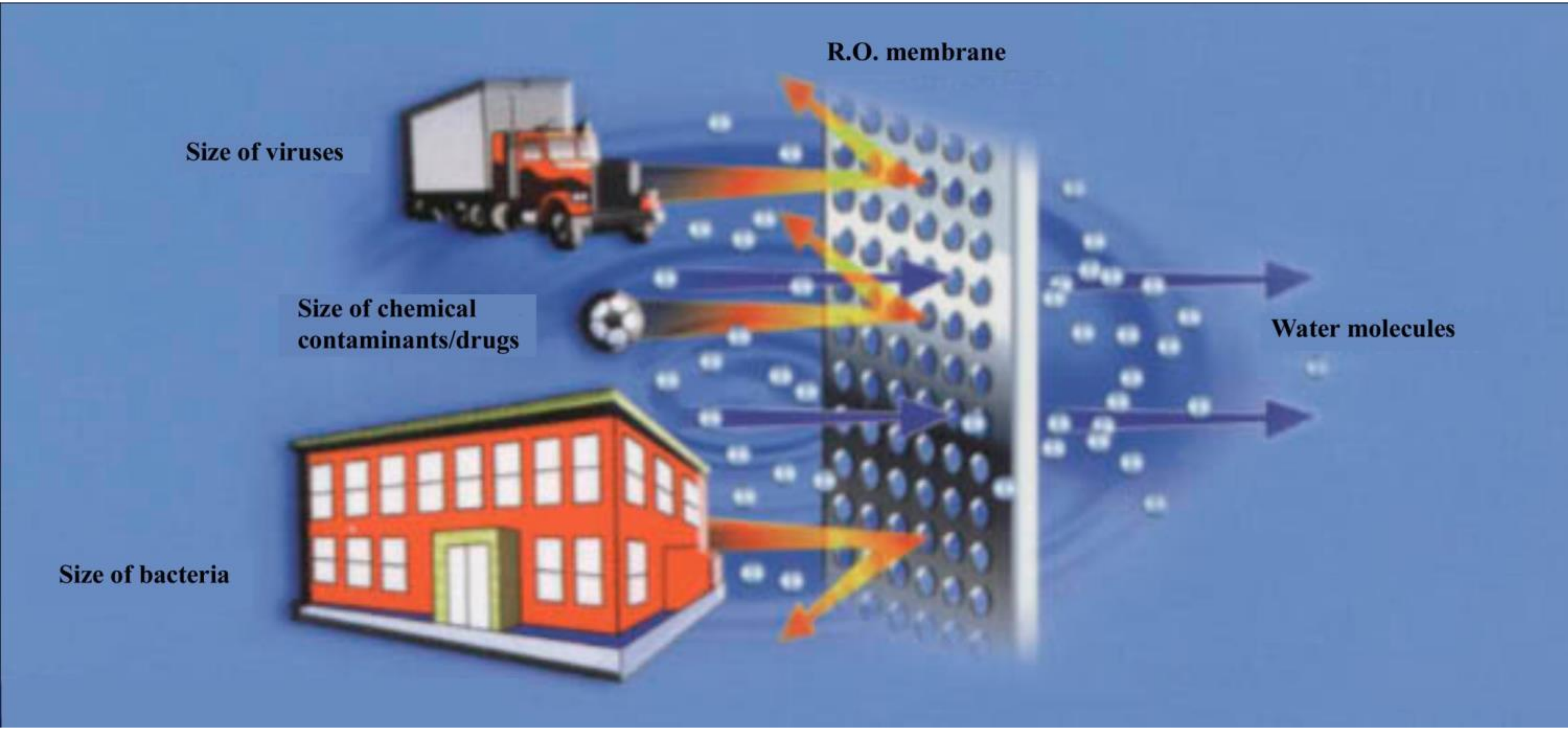
Economic and regulatory controls



In 2003 total "Virtual Water" trade amounted to 700-900 km^3. US was net exporter of 100 km^3

Toilet-to-Tap: Recycling Urban Wastewater

- Singapore NEWater. Classic water security
- Orange County, California (unfortunately provides water for another 500,000 people in the LA area!)
- Many other US urban areas following suit
- Option being taken-up because of competition for additional supplies and increased water quality standards


R.O. membrane
Size of viruses
Size of chemical contaminants/drugs
Water molecules
Size of bacteria

Surviving the Nexus: How to get into a "Safe Place?"

Accounting for shrinking water and energy supplies, improved production, reduced wastage, and nutrition policies

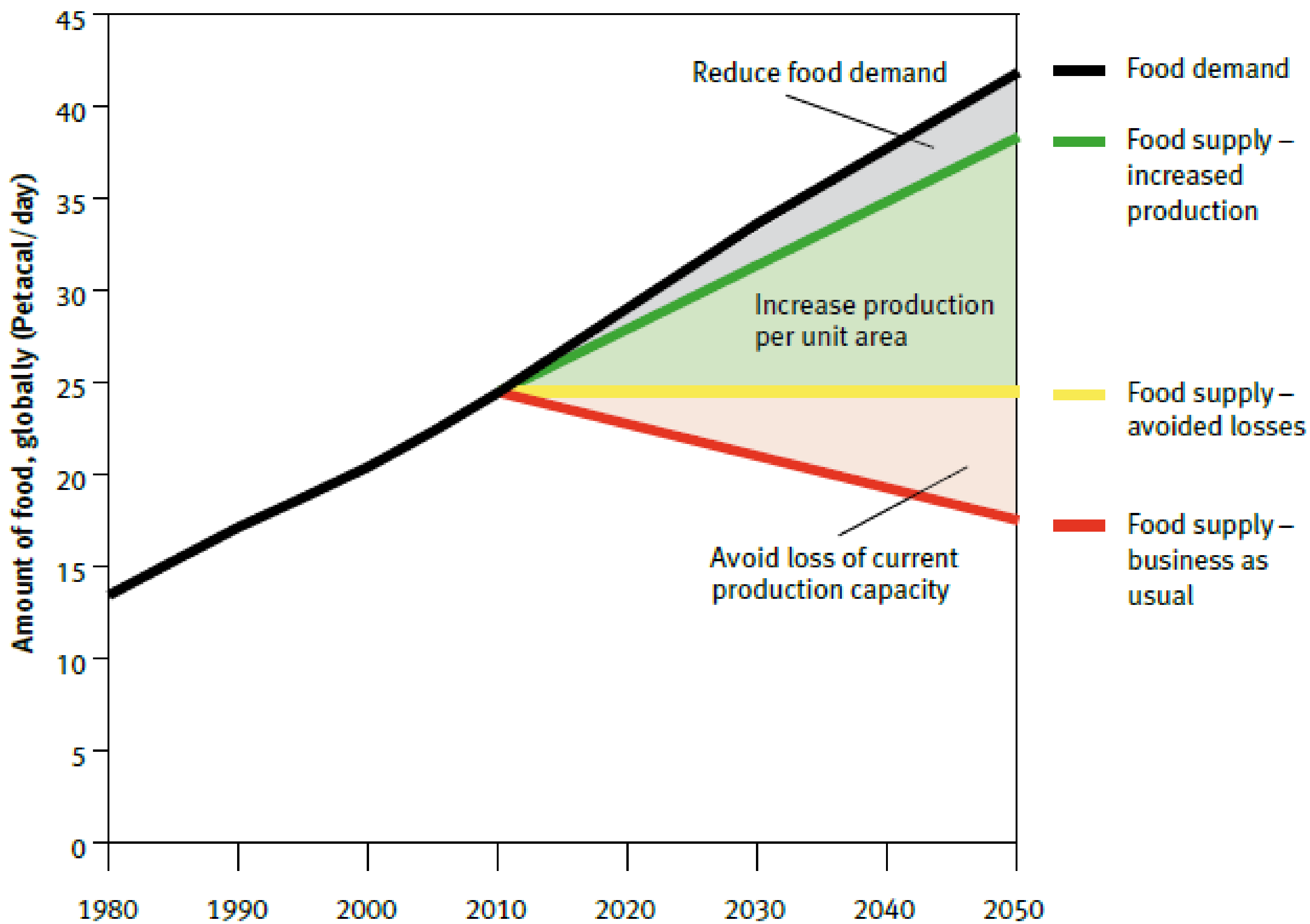
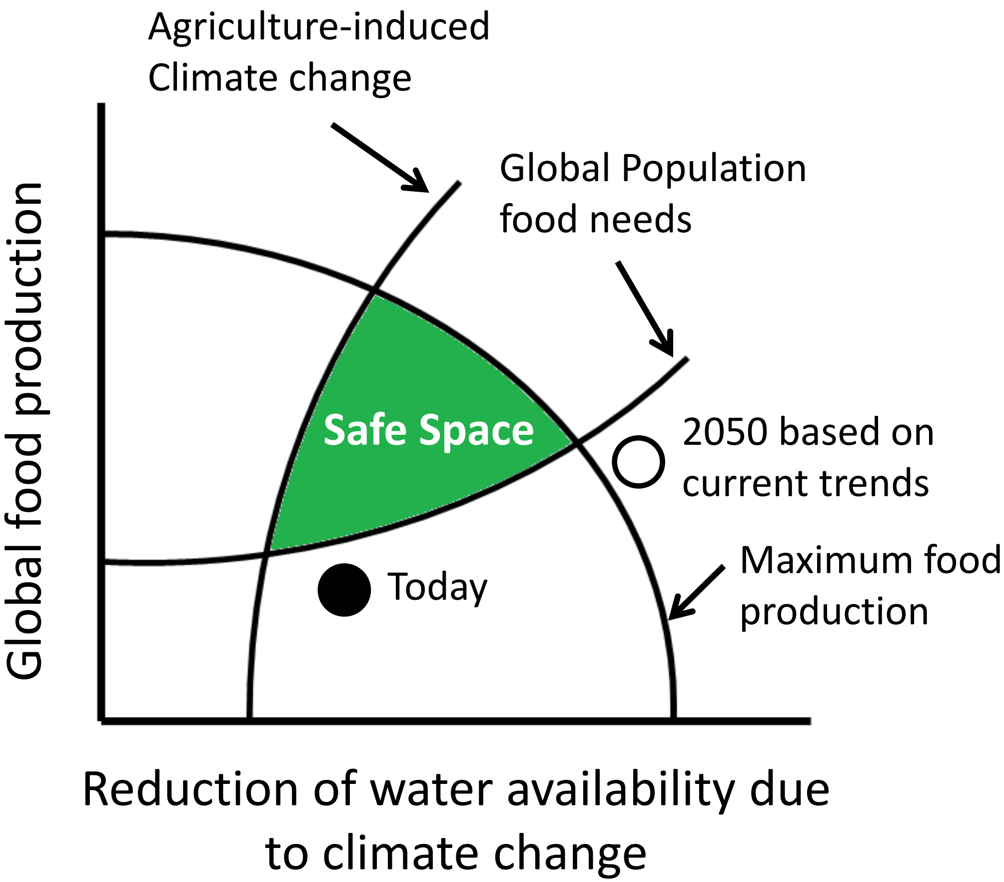
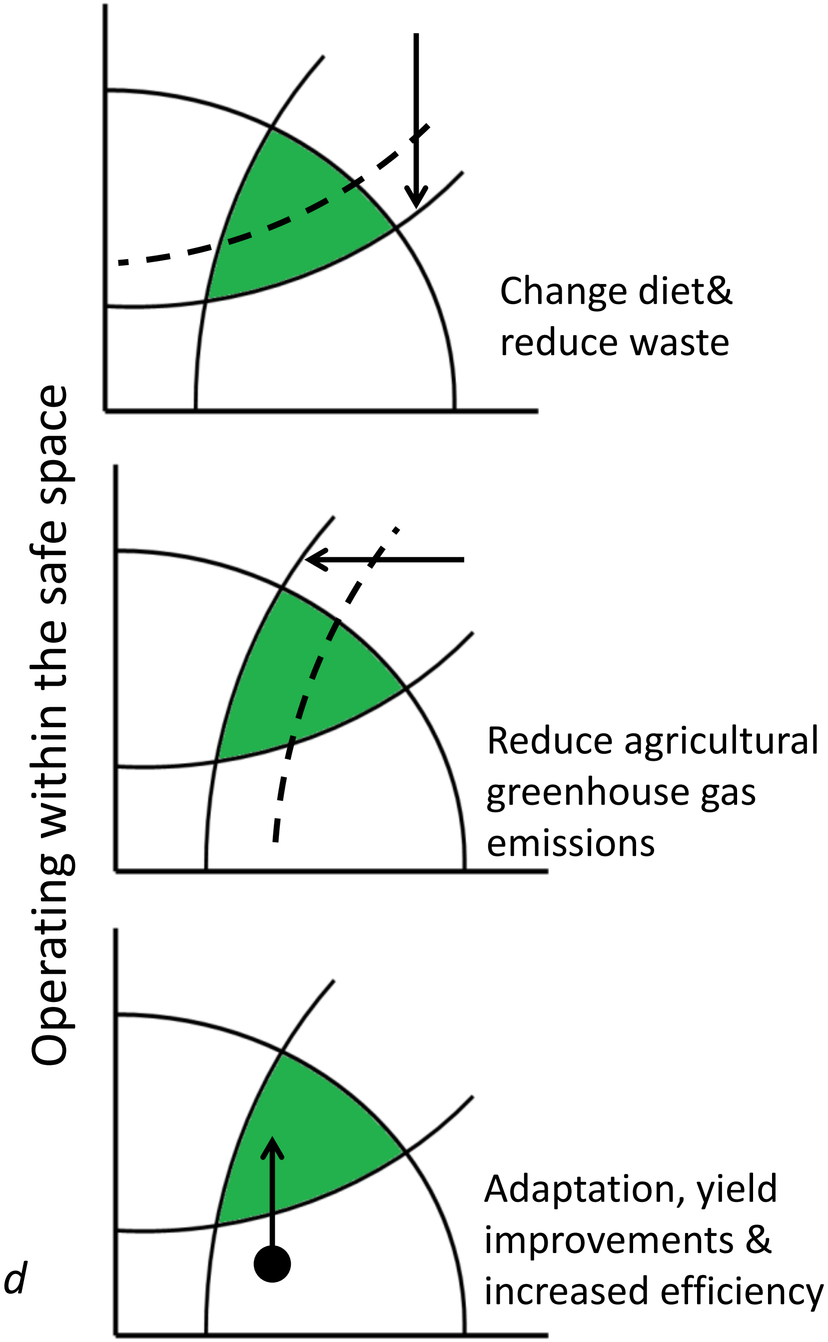


Figure 10. Balancing food supply and demand. Globally, food demand will grow in the future due to population growth and changing

Beddington, Sus Ag Climate, p. 19





Based on Commission on Sustainable Agriculture and Climate Change, p. 7, 2012.