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Modeling Future Prospects for Food & Fuel: Biofuels and Global Agricultural Growth

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"Intersection of Energy & Agriculture" Conference
UC Berkeley Campus
4-5 October 2007

Overview

- Biomass in the Energy Balance
- Energy and Agricultural Markets
- Quantitative Framework for Examining Linkages
- Results and Implications for Food Security
- Other Implications (e.g. Asia) and Conclusions

Not necessarily a new idea…

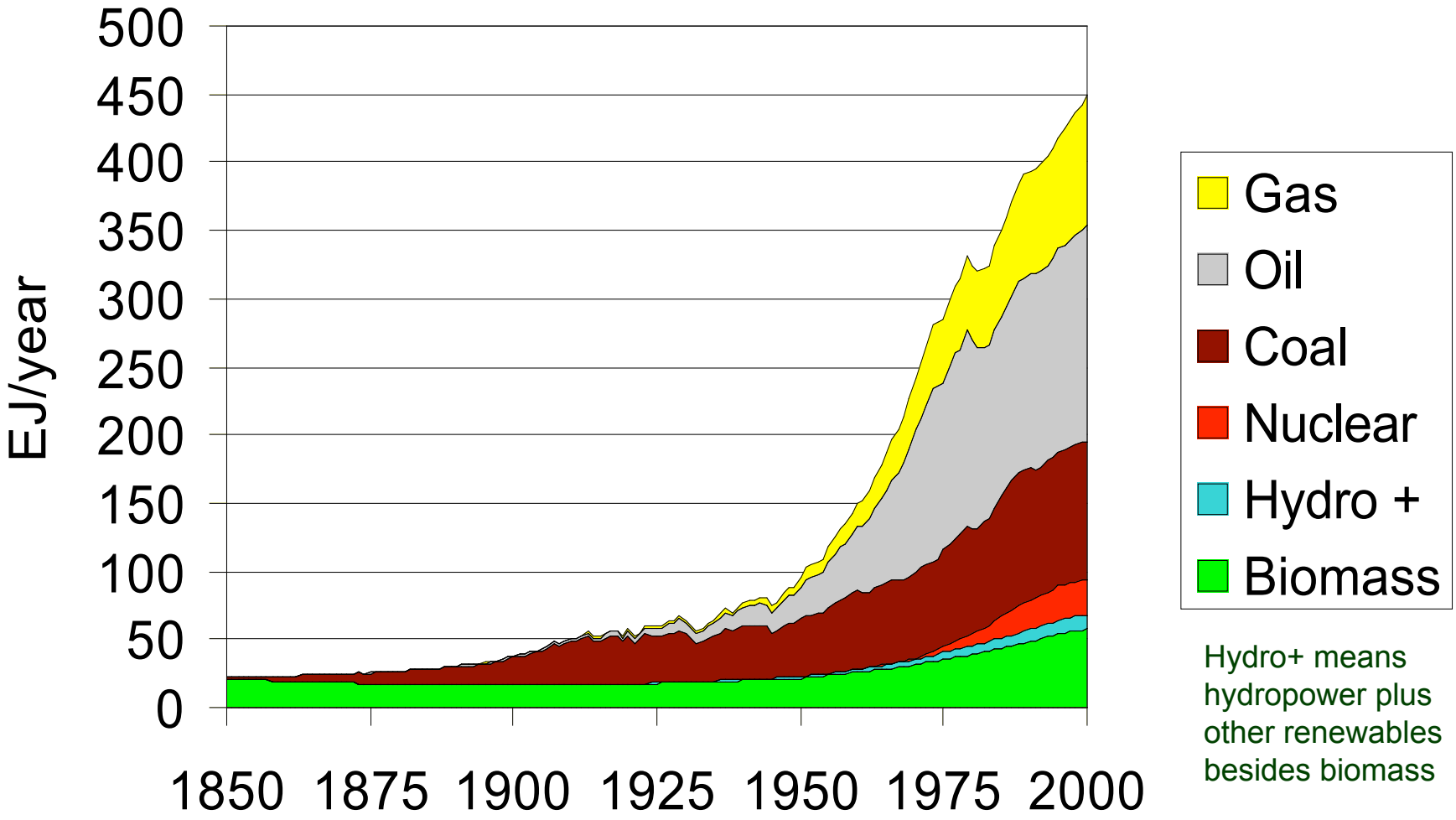
"We can get fuel from fruit, from that shrub by the roadside, or from apples, weeds, saw-dust—almost anything! There is fuel in every bit of vegetable matter that can be fermented … And it remains for someone to find out how this fuel can be produced commercially—better fuel at a cheaper price than we know now."

~ Henry Ford, 1925

Energy from Biomass

- The idea of getting energy from plant matter is certainly not new – it has been around for as long as humans have had energy needs
- The paradigm of “plenty” that has prevailed in the past has taken for granted that there would always be enough cheap energy to meet human needs – even into the 1960s and ‘70s. Perhaps not as much research on non-fossil biomass occurred in that period
- In more recent times there has been intensive rethinking of our energy futures and the role the agriculture can play in it

History of world supply of primary energy



Hydro+ means hydropower plus other renewables besides biomass

Energy supply grew 20-fold between 1850 and 2000. Fossil fuels supplied 80% of the world's energy in 2000. (Holdren 2007)

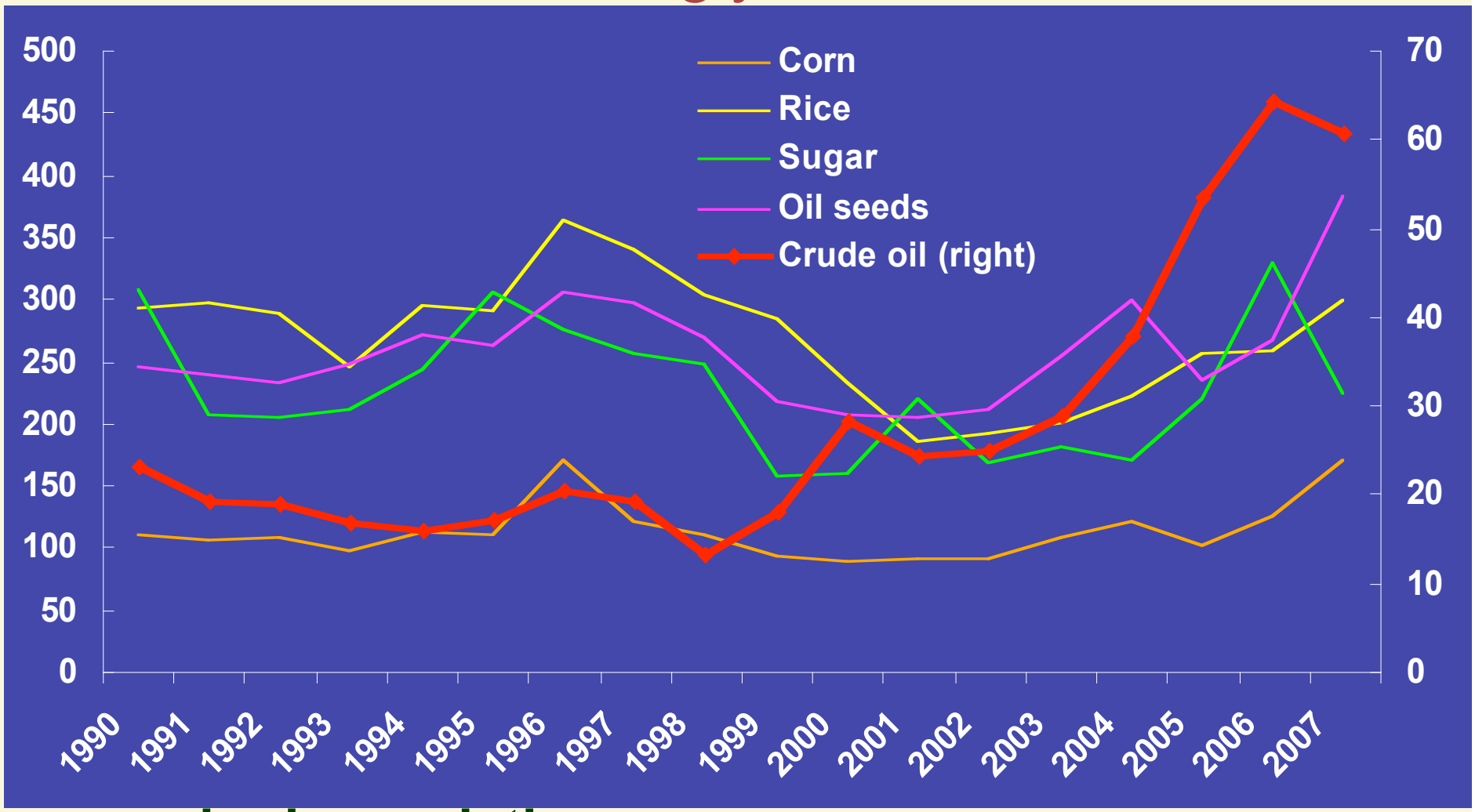
Agriculture and Energy Linked Asymmetrically

- Agriculture is linked to Energy markets through
  - Costs of fossil-based inputs like fertilizer
  - Direct costs of fuel in agricultural production and processing
  - Competition for base resources – land and water
- We see more discussion and analysis of the first two then the last… but all are important
- This linkage is asymmetric → the contribution of ag-based biofuels to world energy economies is relatively small relative to the impact that biofuels could have on the ag sector and world food economies

A New Driver for Global Food Markets

- The linkages between the functioning of food and energy economies is becoming more closely linked and apparent
- The prices of food commodities are likely to become closely-tied to their use (and implicit value) in biofuel production processes
- We've seen this connection most strongly in the interplay between sugar and ethanol in Brazil – and how sugar and ethanol producers respond to world sugar and oil prices
- Yet another stressor for food economies (besides climate, water and land quality degradation)

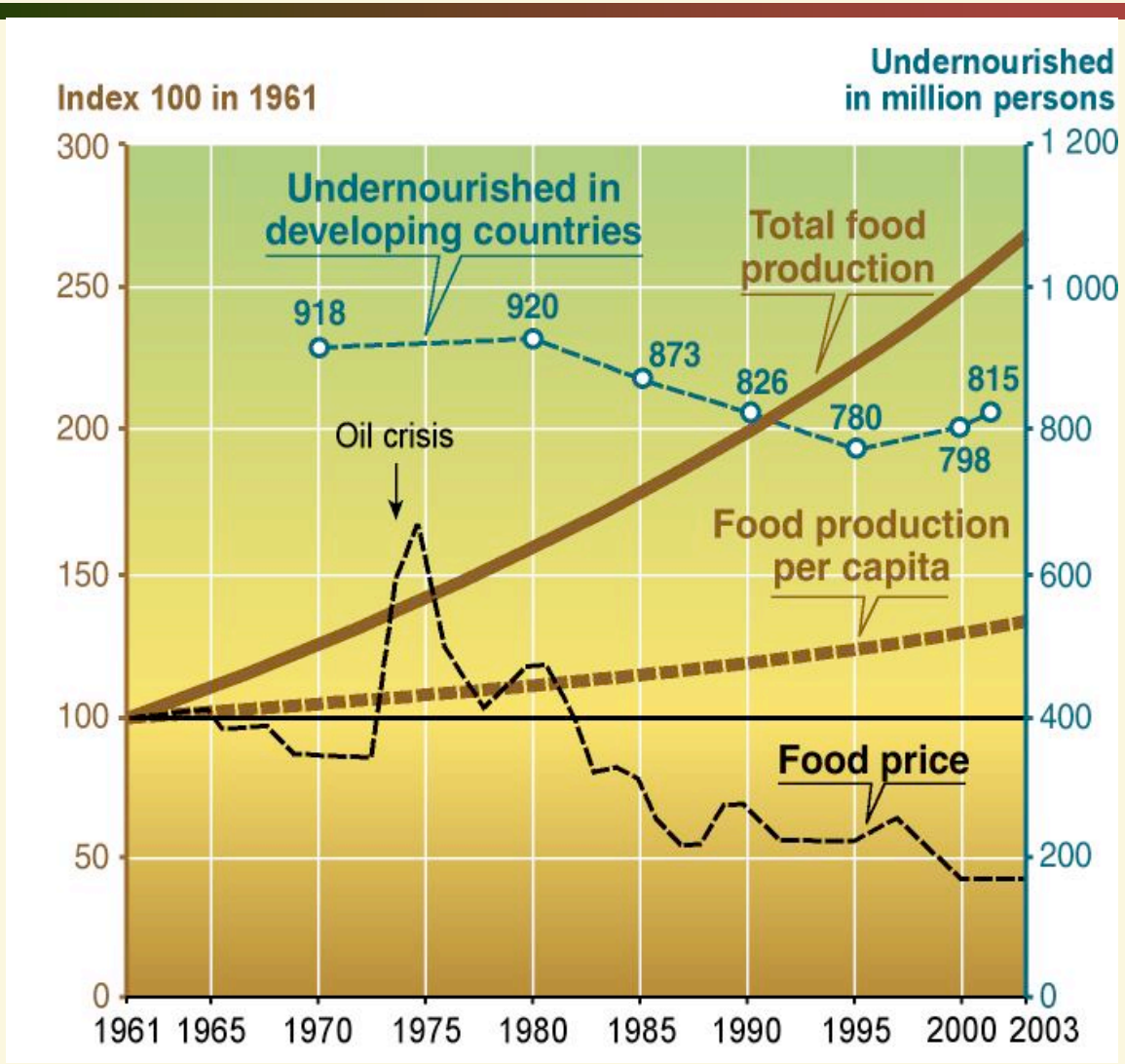
Prices: Agricultural and Energy Prices Increasingly Correlate



…and price variations are up

Source: IMF, 2007; OECD, 2005; World Bank, 2007

Food Production, Malnourishment & Price Trends



More food price spikes ahead? →

Reversal of downward trend in food prices?

Source: from Wood and Ehui (Chapter 8 "Food". Millennium Ecosystem Assessment 2005)

Why Biofuels Are of Interest/Concern to Us

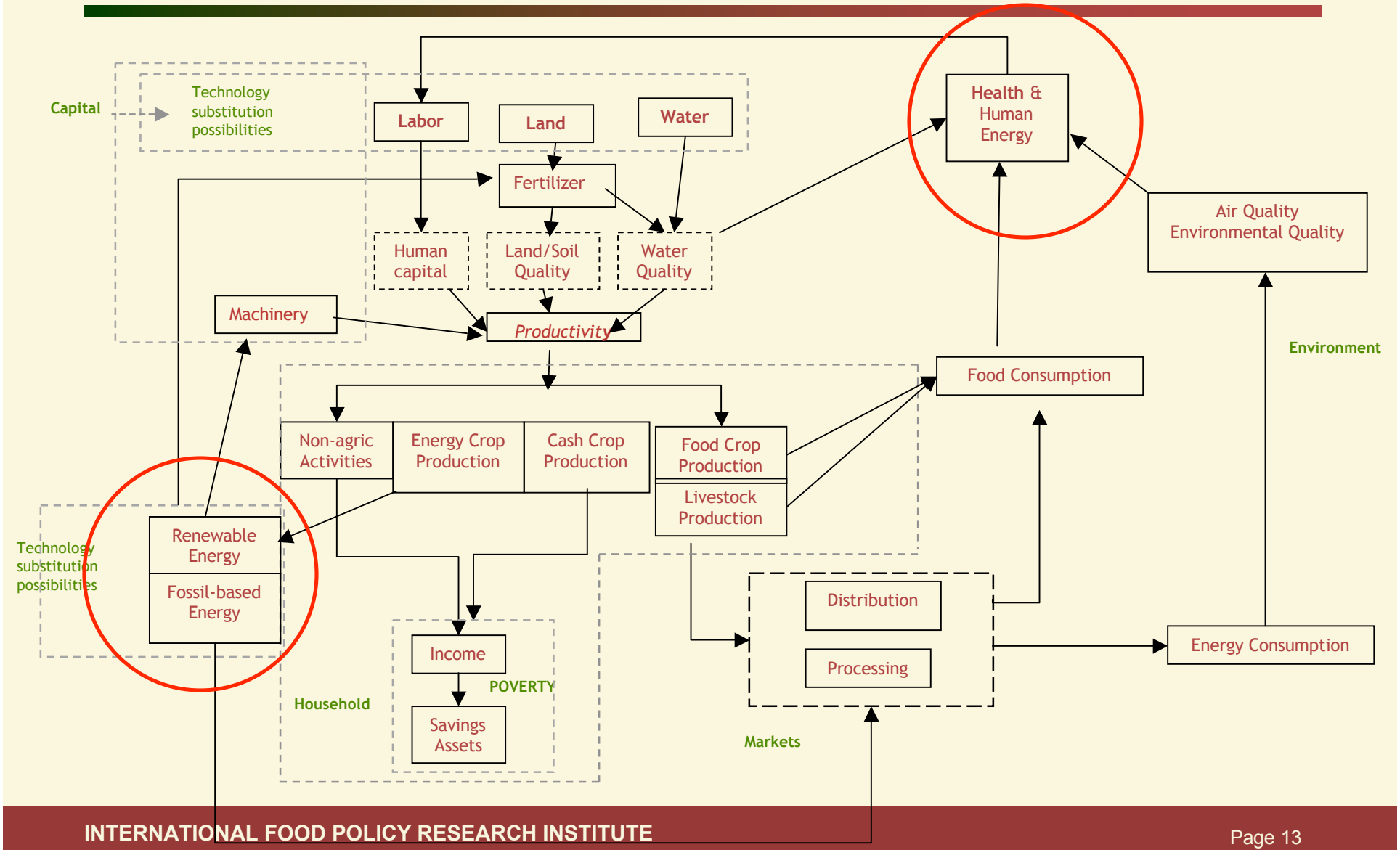
- Biofuel production in industrialized nations
  - Reduce surplus of grain stocks that would otherwise be put on food markets in lean years or distributed as food aid
  - Could affect the support policies of developed countries for key export crops which have impact on developing c'ty farmers
- Possible negative food security impacts
  - Displacement of food producers through land pressures
  - Higher food prices for net consumers and attendant negative effects on poor, vulnerable and food-insecure households
- Possible benefits for developing regions
  - Opportunities for income beyond just producing raw biomass for biofuel production – share in the value chain
  - Higher market prices for farmers, wages for ag laborers
  - Including developing agricultural economies into 'clean', market-based mechanisms for improving the environment

Approaching These Linkages Quantitatively

Model-Based Analyses of Biofuel Futures

- A number of issues raised relate directly to the linkages between energy markets and agricultural market economies
- The linkages are complex and varied in nature, depending on the nature of the farm system, food system and energy system
- The issue of scarcity comes up at key points – such as the availability of land and water – besides the underlying scarcity of fossil-based energy resources, which is a major driver of technological innovation and sets the threshold for conversion efficiency and cost thresholds
- In order to address all of these issues together, we need an analytical framework which can allow us to see how the dynamics of energy and food markets can interact, and the nature of the various components
- Given the complex nature of these interactions, we need to simplify greatly in some areas and go into more detail in others – depending on what our ultimate interest is (such as human well-being)

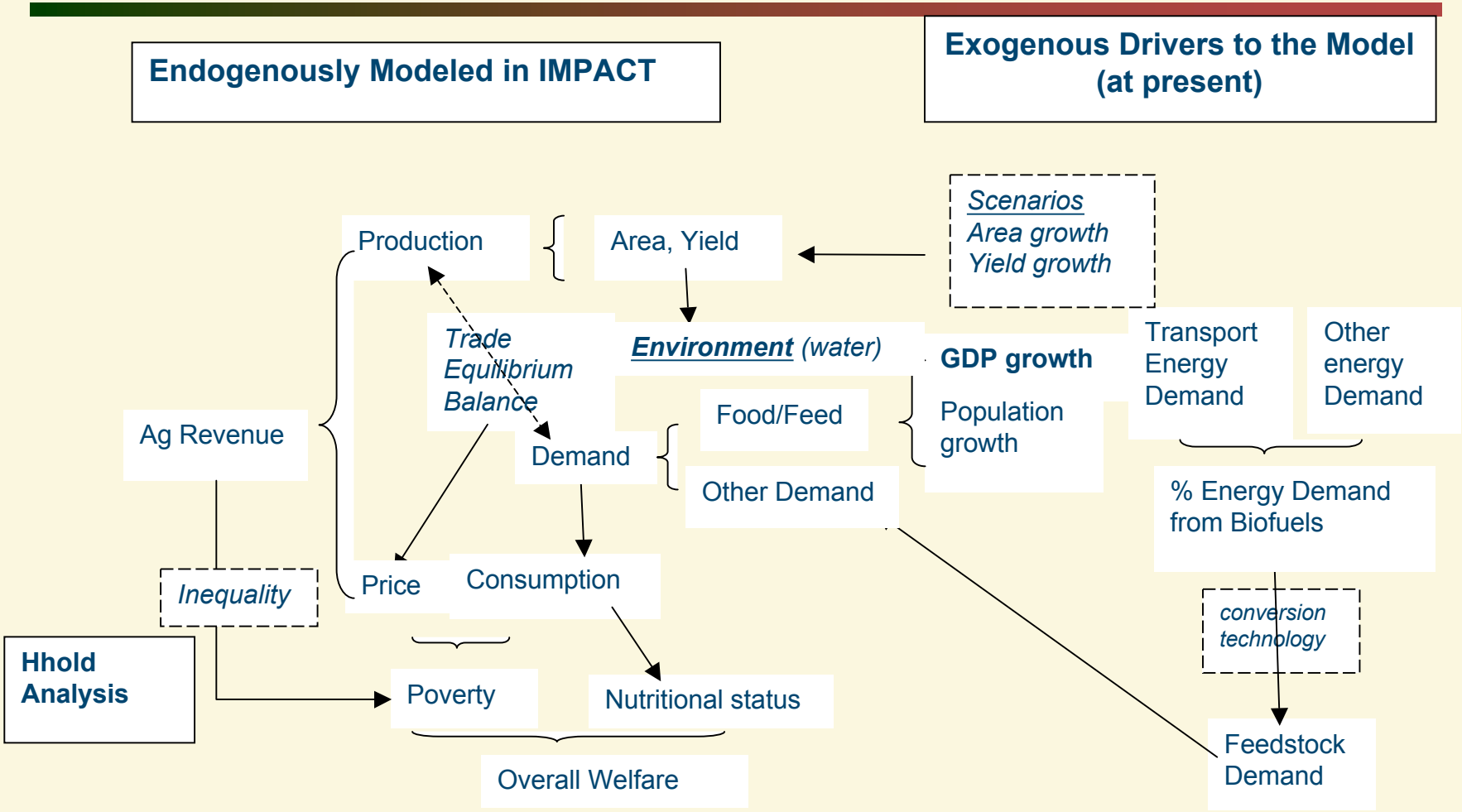
Linkages b/w Energy and Agriculture



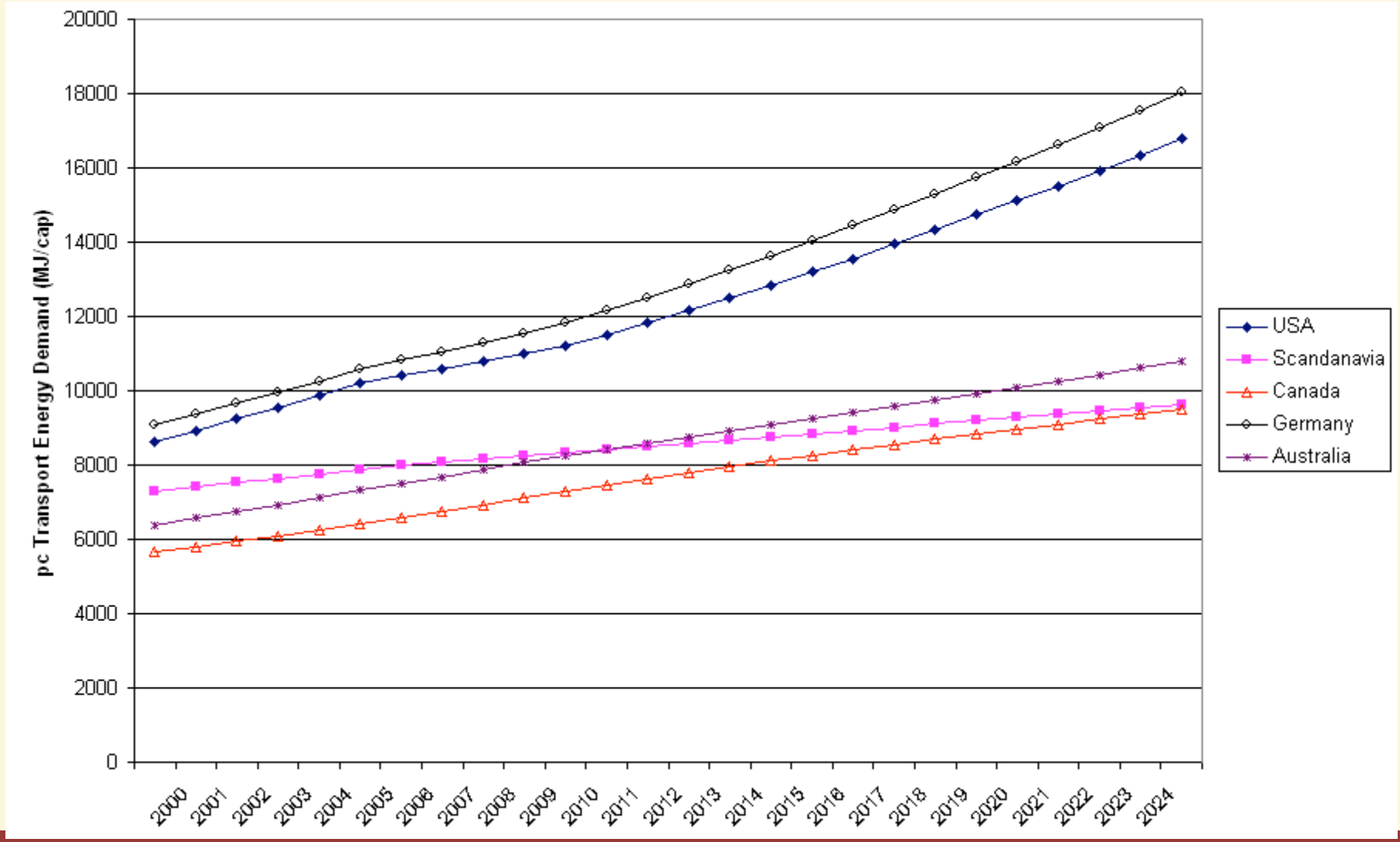
Focusing on the Important Linkages

- Economic Growth and Energy Demand (for Transport)
  - Energy demand is closely linked to economy-wide dynamics of growth, and comes from a variety of sectors and uses
  - Transport is an especially important one, wrt biofuels
- Linking (Transport) Energy Demand to Biofuels
  - Based on country-level policy (e.g. blending)
  - Also based on country-level capacity to produce
- Linking Biofuel production to feedstock demand
  - Biofuels can come from a range of feedstocks – some are more appropriate to regions than others
  - Need to pick up the degree of flexibility that is possible
- Linking Ag Commodity Demands to Food Outcomes
  - An obvious price effect of increased demand for products
  - Perhaps other second-round effects that ultimately affect food security, nutrition and overall welfare

Simplified Analytical Framework

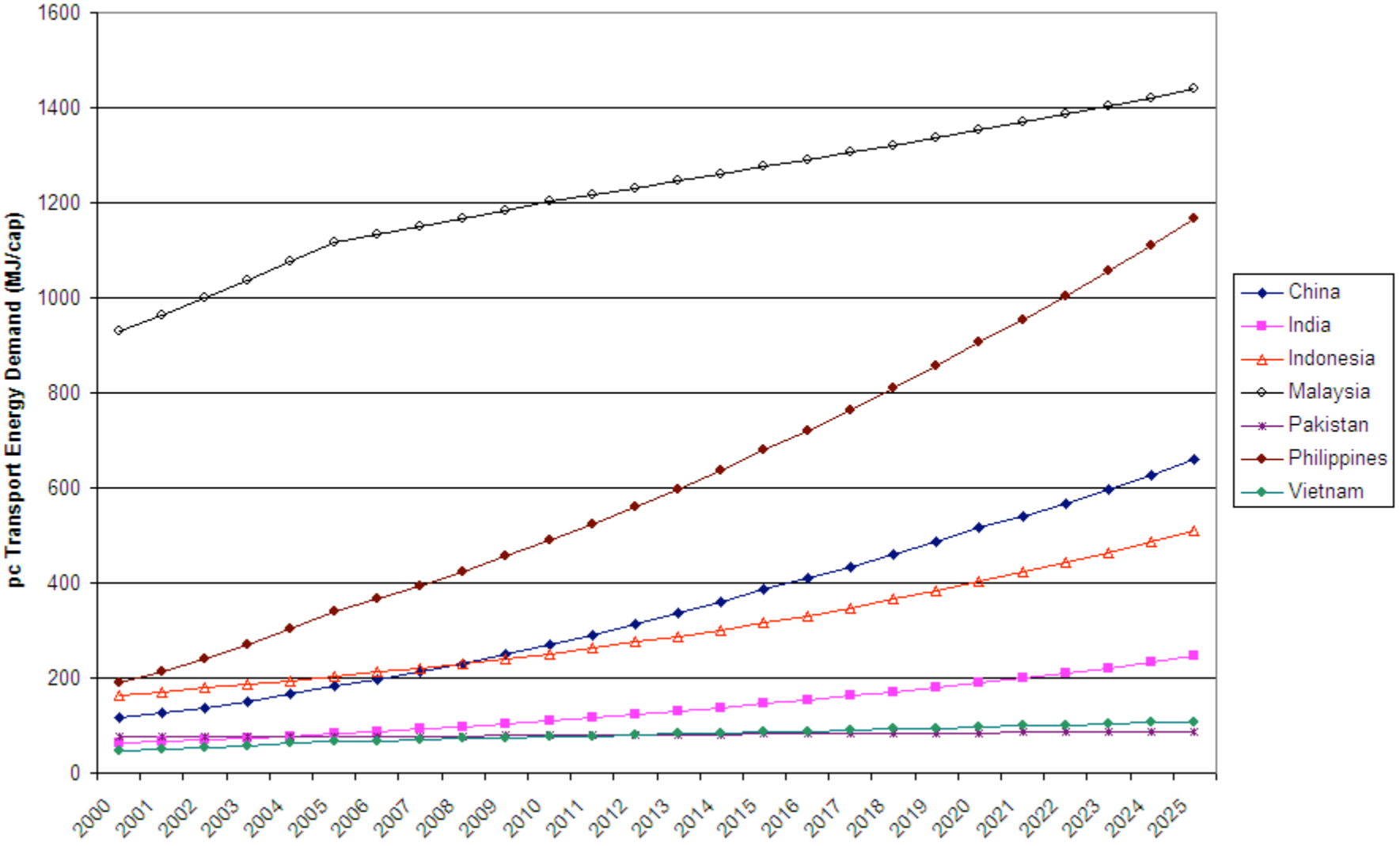


Per Capita Transport Energy Demand



Source: Own Projections

Per Capita Transport Energy Demand (Asia)



Source: Own Projections

Scenario Development

- Based on data of production capacity (and projected growth in capacity)
- Main “drivers” are that of country-level GDP and population -- which determine overall level of transportation energy demand
- Policy-driven blending requirements give rise to projections of ethanol and biodiesel demand & production out to 2020
- Simple ethanol and biodiesel trade representation
- Basic scenarios represent displacement of gasoline and diesel with biofuels according to current trajectories as well as more ‘aggressive’ levels of adoption

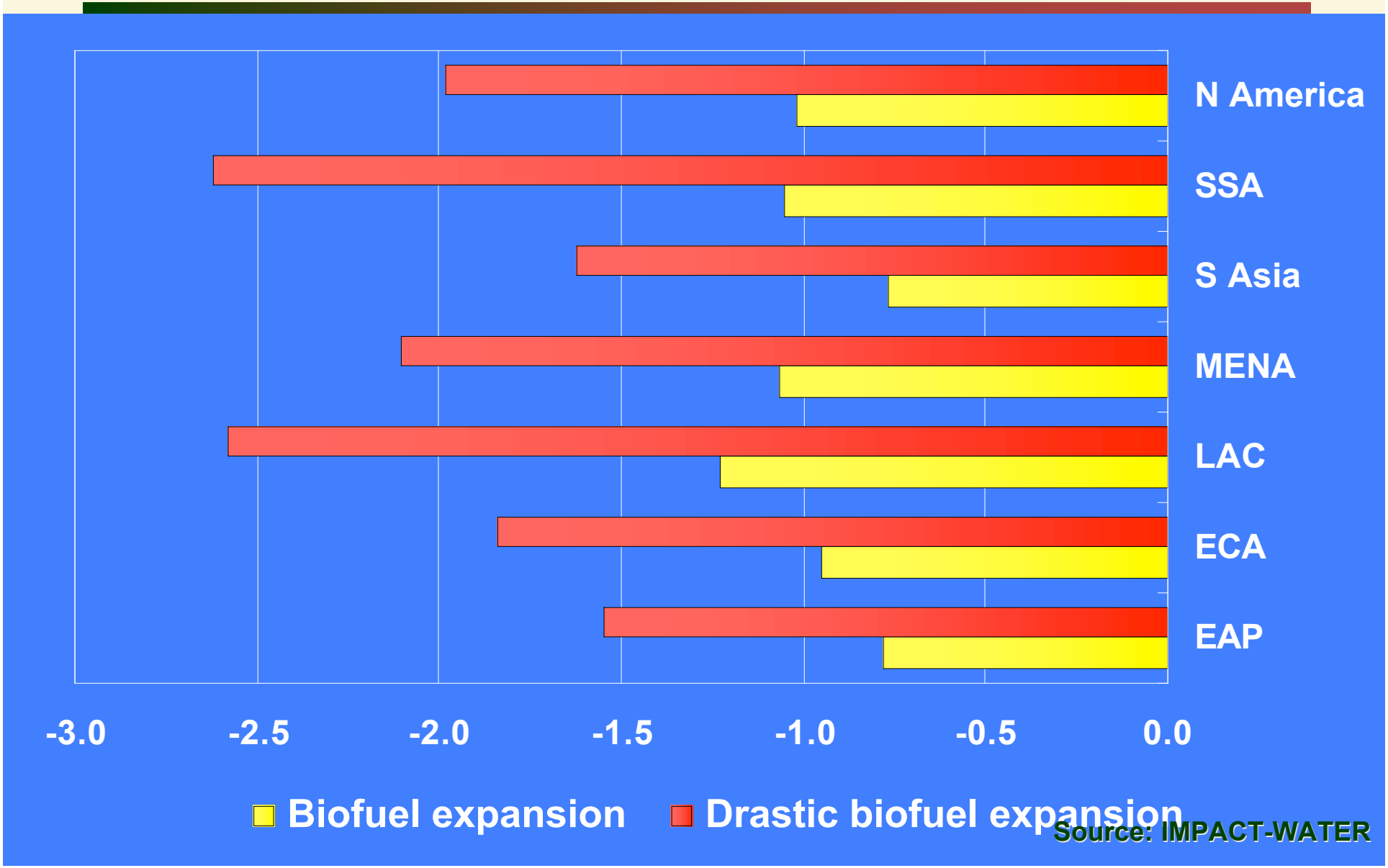
Biofuel Details

- Biodiesel projections focus mainly on the European Union 15 (EU-15) countries
  - Because the EU accounts for almost 90 percent of global production volume
- Biodiesel feedstock crops are mostly oilseeds (haven't examined plantation oil trees in detail)
- For bioethanol production, feedstock crops include
  - Maize
  - Sugarcane/beet
  - Wheat
  - Cassava

IMPACT-Model: biofuel scenarios by 2020

	Biofuel Expansion	Price changes % by 2020
Scenario 1	Actual plans and assumed expansions	corn: + 3 oilseeds: +8
Scenario 2	Doubling of Scen.1 expansion	corn: + 13 oilseeds: +17
another scenario	Neglect of technology and expansion	Corn: +20–41 Oilseeds: +26-76

Calorie availability changes in 2020 compared to baseline (%)



Source: IMPACT-WATER

Price-effects for Bangladesh five-person household living on one dollar-a-day per person

How they would spend…their 5 $

3.00 *$* on food

.50 $ on energy

1.50 $ on nonfood

>a 20 percent increase in food and energy prices requires them to *cut 70 cents* from their other expenditures.

Cuts will be made most in food expenditures:

>reduced diet quality, and

>increased micronutrient malnutrition

Food & Energy Expenditure Shares (for $1/day poor)

Country/year	Rural	Urban
Ethiopia, 1999		
Food	69.5	63.8
Energy	10.4	7.7
Bangladesh, 2000		
Food	65.6	60.1
Energy	9.3	9.4
Guatemala, 2000		
Food	50.5	47.6
Energy	1.3	1.3
Tajikistan, 2003		
Food	70.7	73.7
Energy	4.9	4.2

source: Ahmed *et al.*, 2007 (cited in von Braun, 2007)

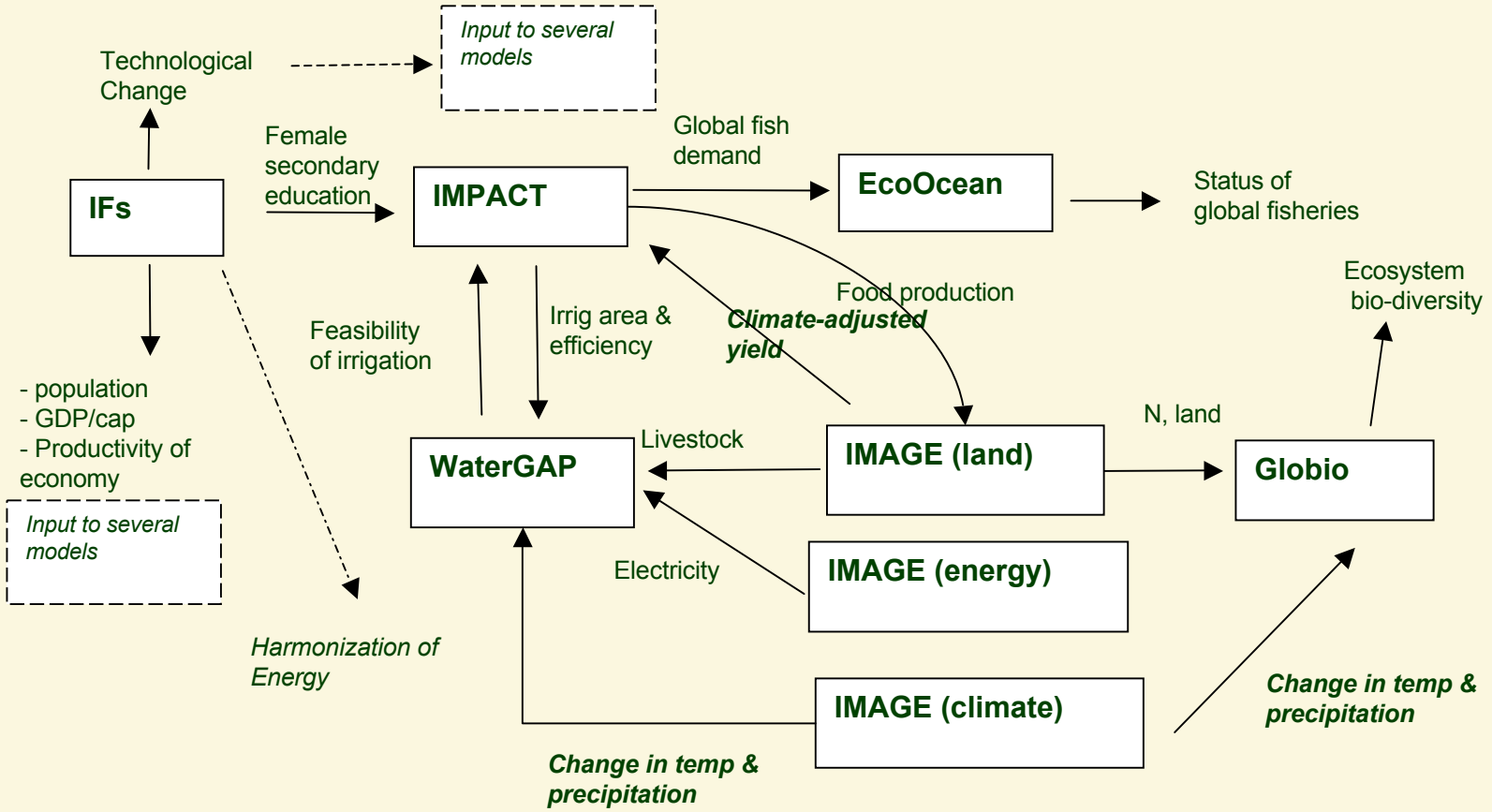
Main Messages

- There will be increasing pressure on agricultural markets in future if crop-based energy production continues on the current path (with present technologies)
- There are direct implications for crop breeding for productivity improvement and quality in wheat, maize, and sugar crops
- Although there is uncertainty about the timing of eventual large-scale use of cellulosic conversion technologies for biofuel production this will be a critical factor for development of biofuels market
- Other factors behind a “food-versus-fuel” trade-off such as land and water (both quantity and quality)

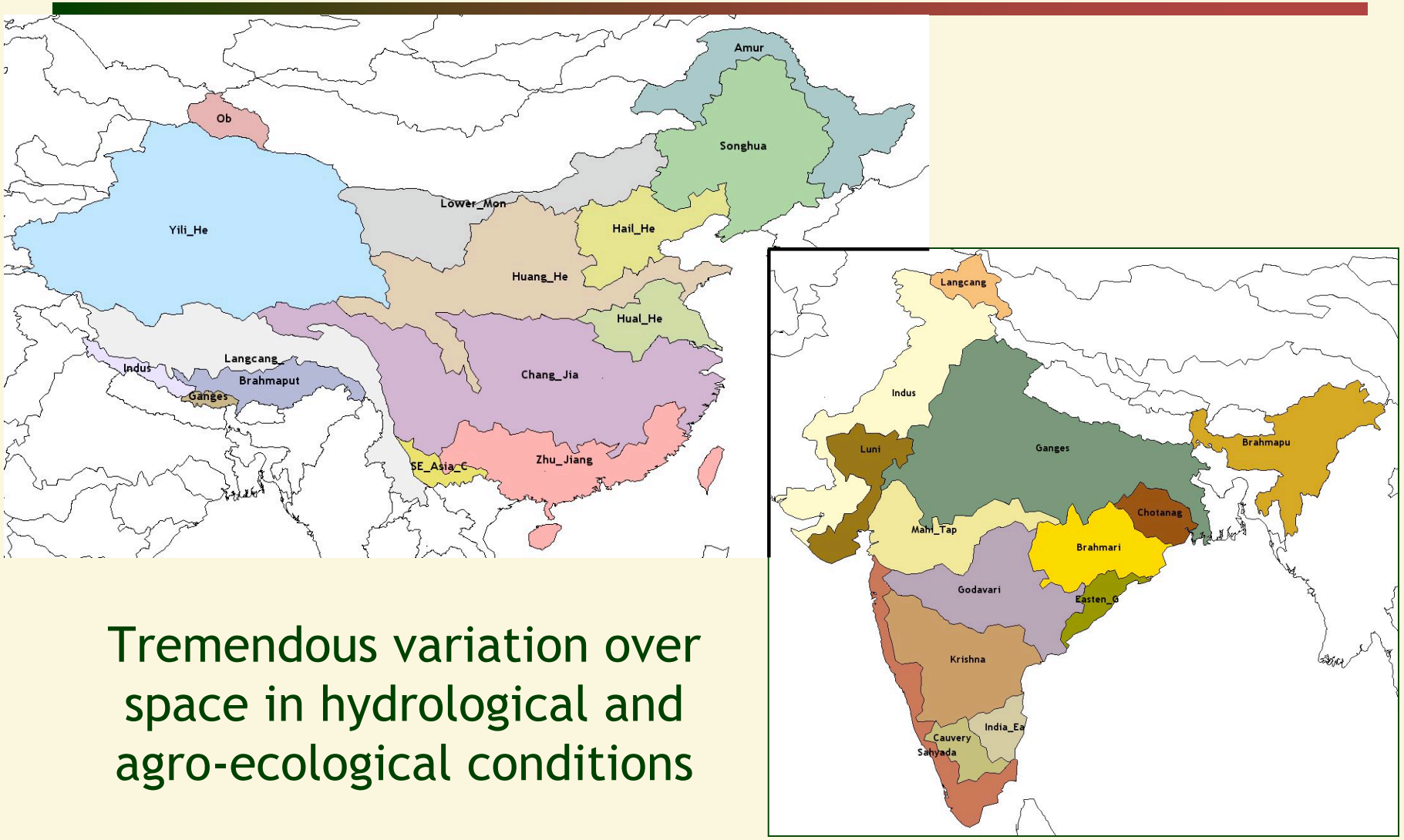
Important Bio-Physical Constraints

- While some crops may be more favorable from the perspective of profitability, they may encounter binding environmental constraints such as water (e.g. sugarcane in India, maize in Northern China)
- Even where water might be available, there might also be constraints on available land for expansion (e.g. Southern China)
- A more detailed look at land-use is necessary in order to project trade-offs between alternative uses into the future
- Need to add account for water balance, as well

Linkages in Multi-Model Assessment: GEO-4

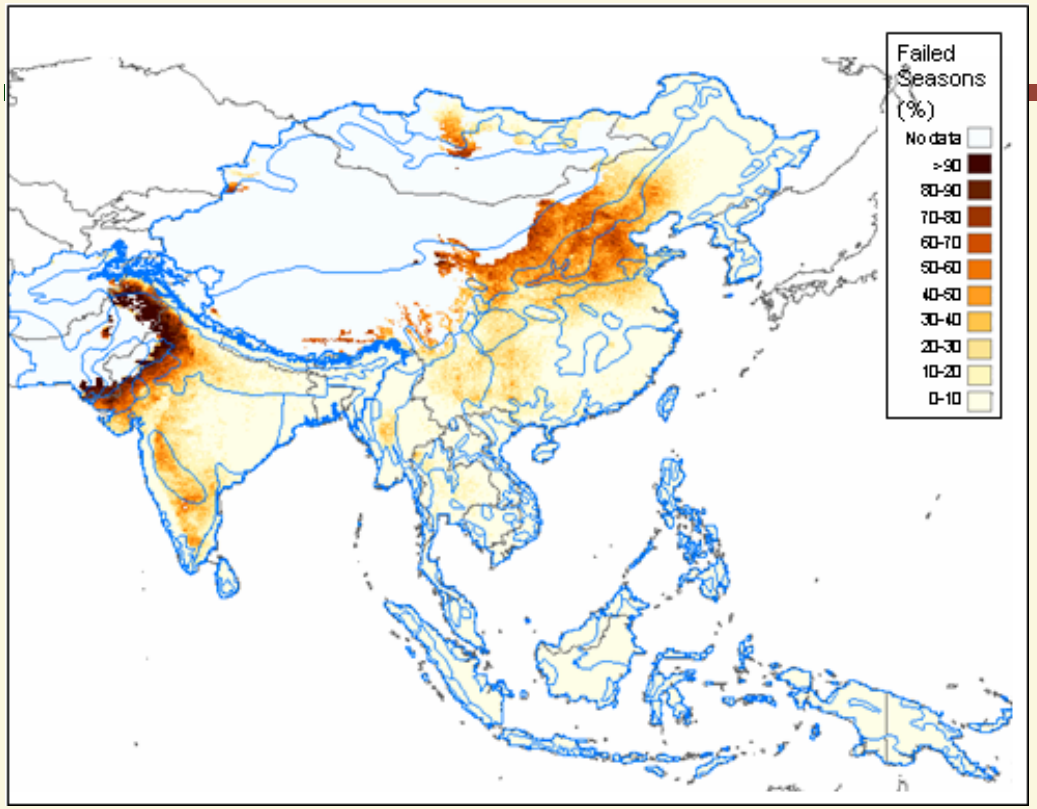


Basin-level representation of China & India



Tremendous variation over space in hydrological and agro-ecological conditions

Water Scarcity and Drought Stresses in Asia



Proportion of failed growing seasons for rainfed cultivation, 100 year weather simulation

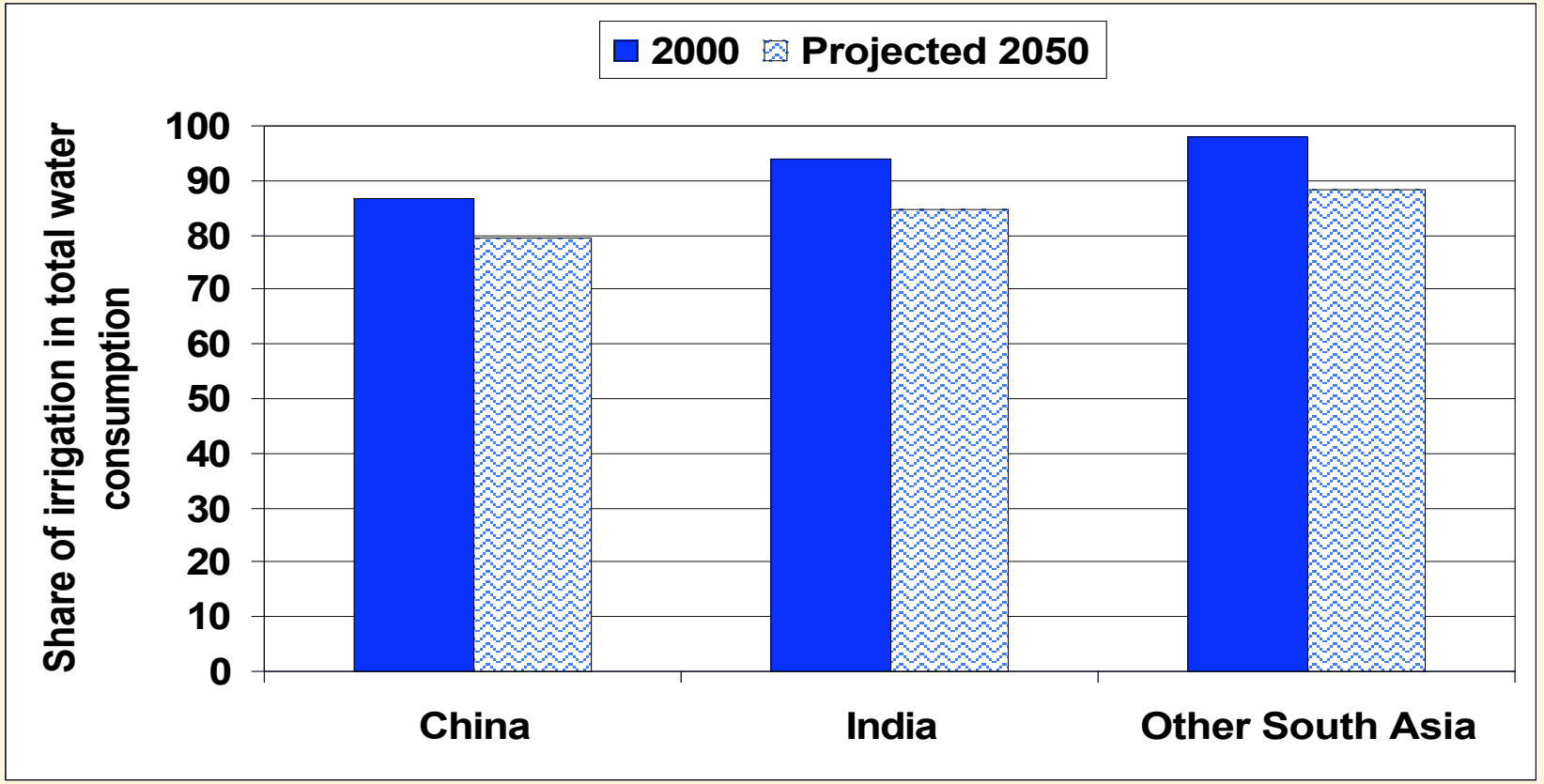
Source: Hyman et al. forthcoming

Note: The figure illustrates 100 year weather simulation based on historic data analysis

- Drought
  - lowers average expected yields
  - exacerbates other production uncertainties, reducing technology adoption of the poorest farmers
- Drought impacts need to be mitigated by investments in irrigation

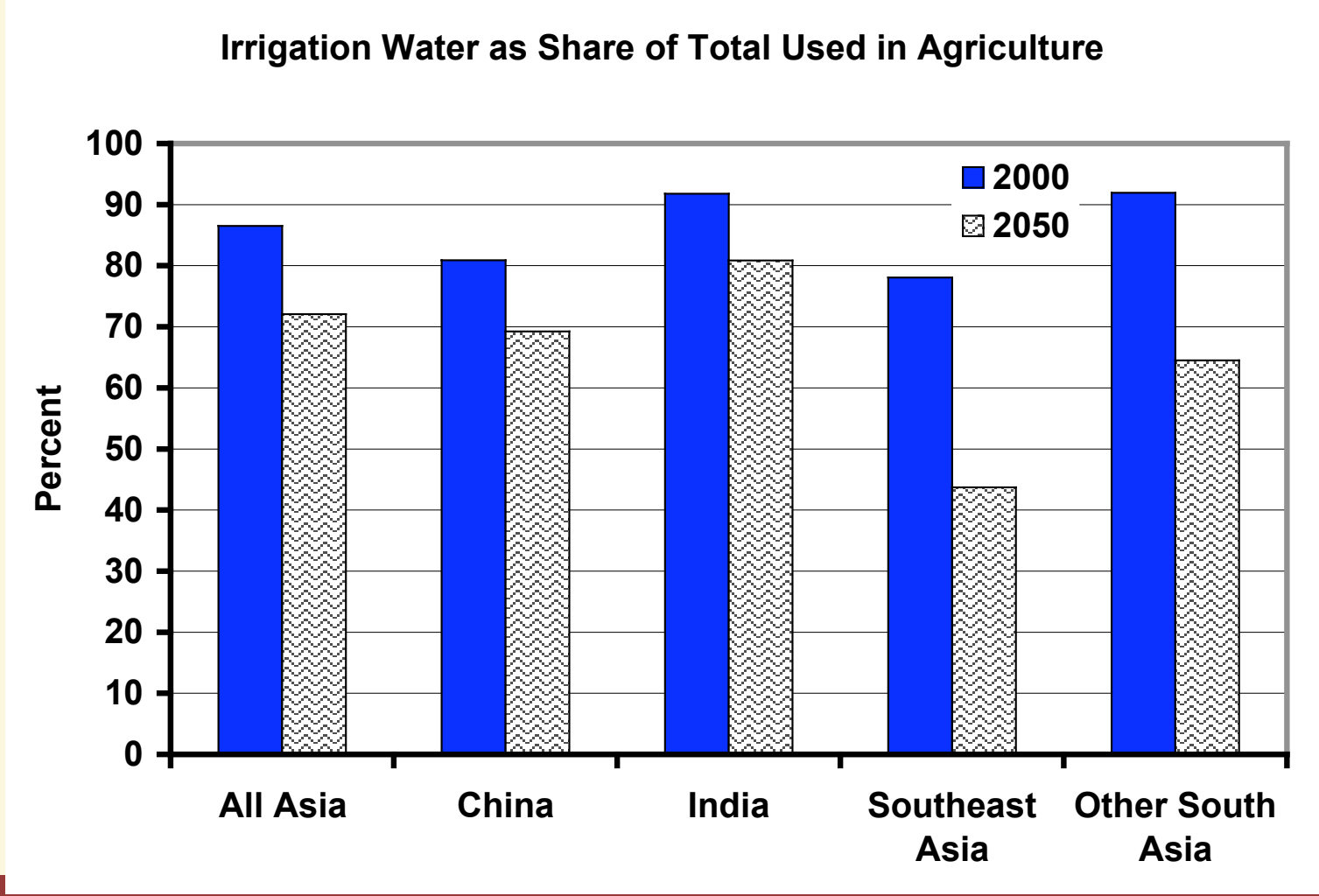
Water Scarcity and Drought Stresses

Share of irrigation in total water consumption expected to decrease

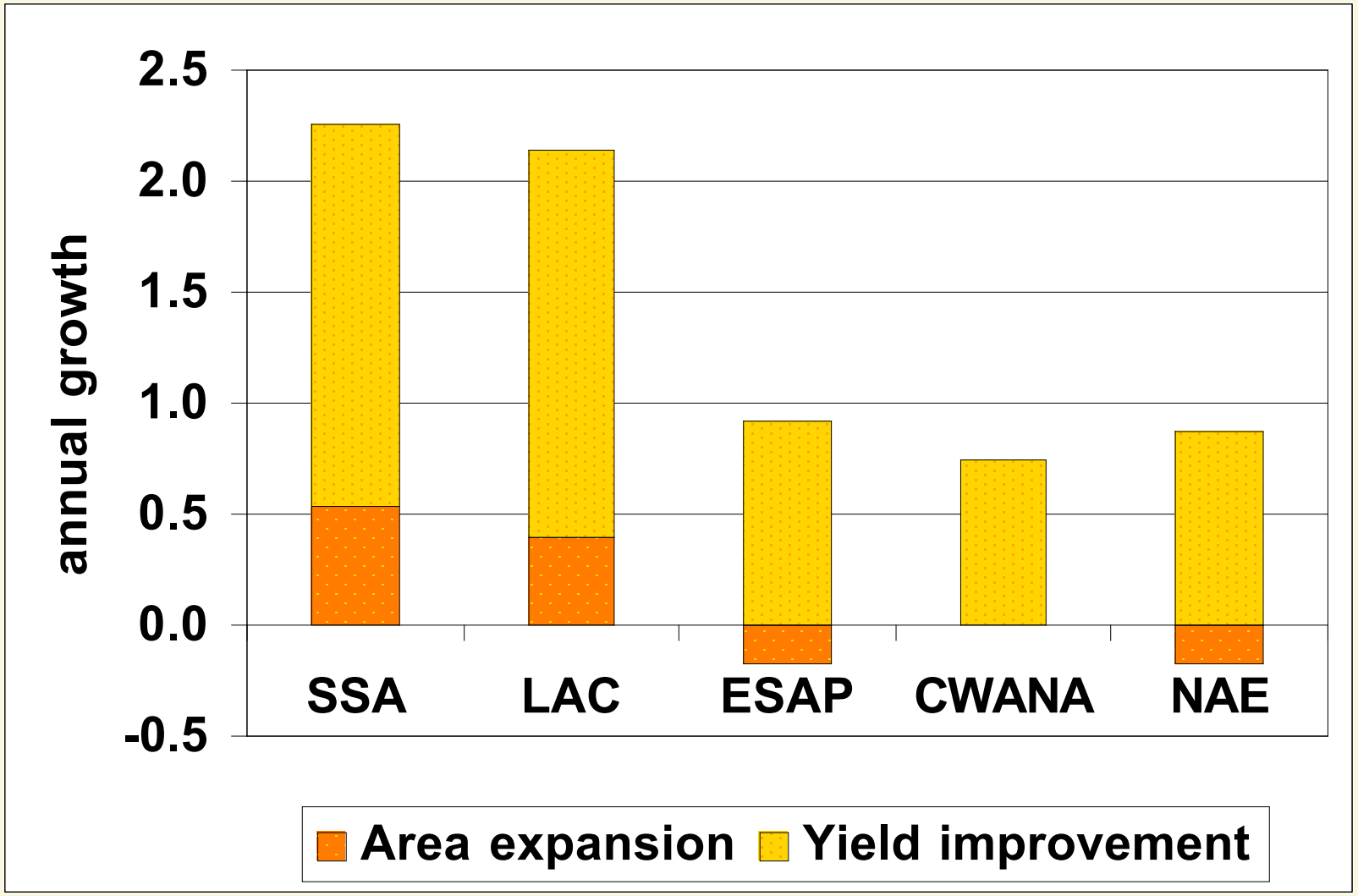


Water Scarcity and Drought Stresses

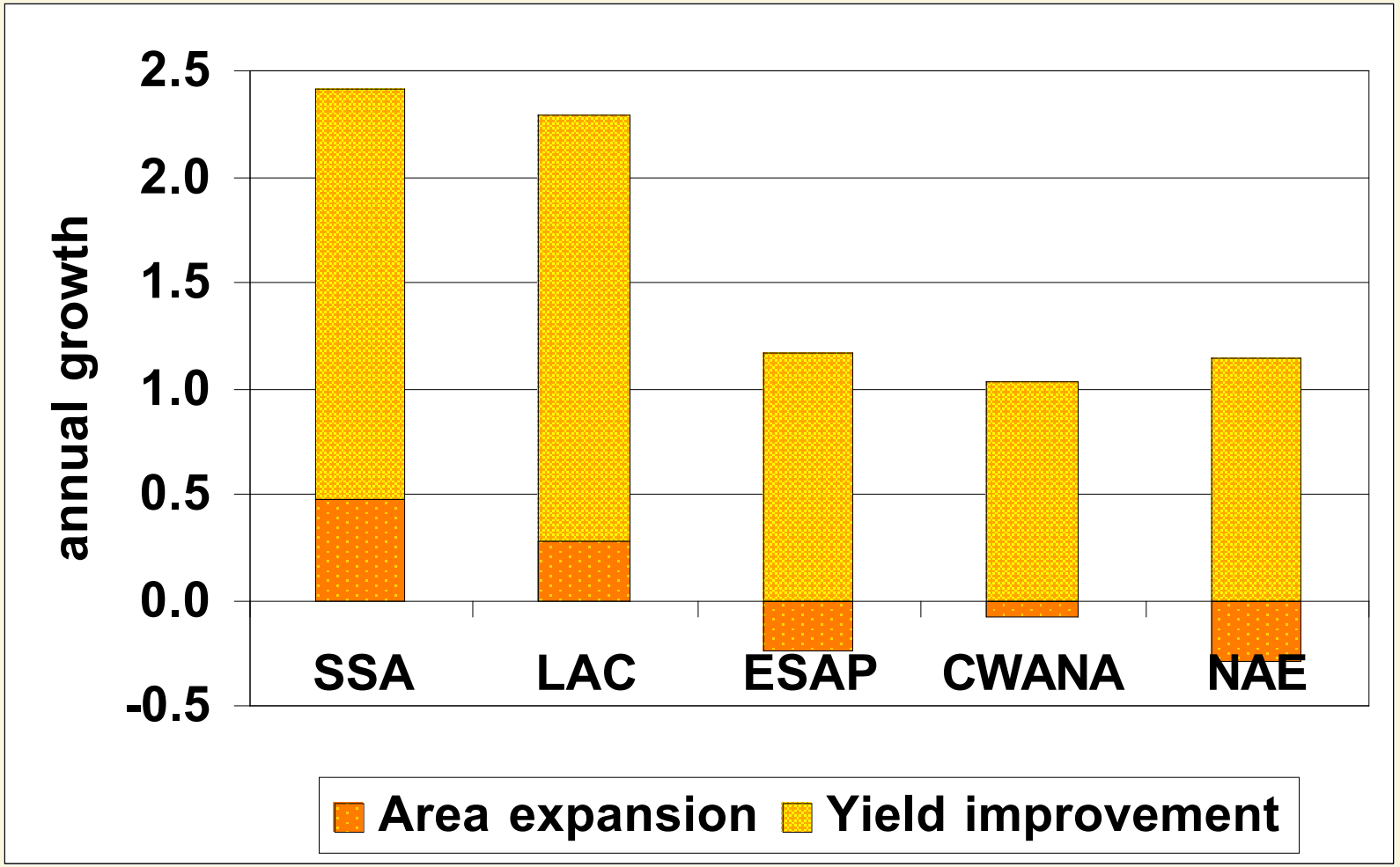
At the same time, water availability for irrigation is declining



Sources of Food Production Growth, BAU, 2050



Sources of Food Production Growth, high “ARK”, 2050



Overall Conclusions

- Impacts of global biofuel development and growth on rural poor are likely to be mixed and farming system-specific – both positive and negative – needs careful assessment
- There may not necessarily be a 'crowding-out' effect – there's room for complementarities and synergy
- There are a common set of conditions for promoting rural development and enhancing socio-economic growth and bio-fuel capacity potential
- CORE BUSINESS: Should stay focused on rural socio-economic growth and development as well as on agricultural research and productivity enhancement
- Energy-Agriculture linkages will continue to reduce surpluses and tighten market conditions – leaves room for policy intervention and social protection

Thank You !!