Biofuels, Rural Development, and the Changing Nature of Agricultural Demand

Rosamond Naylor
Center on Food Security and the Environment
April 11, 2012

Thanks To

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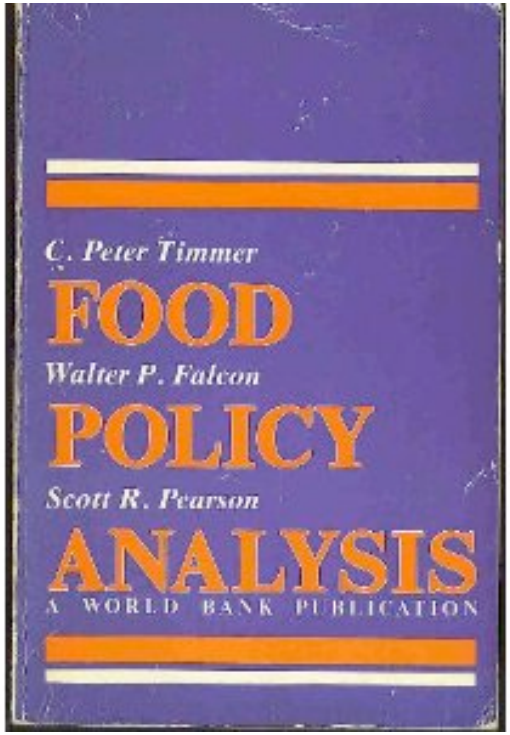
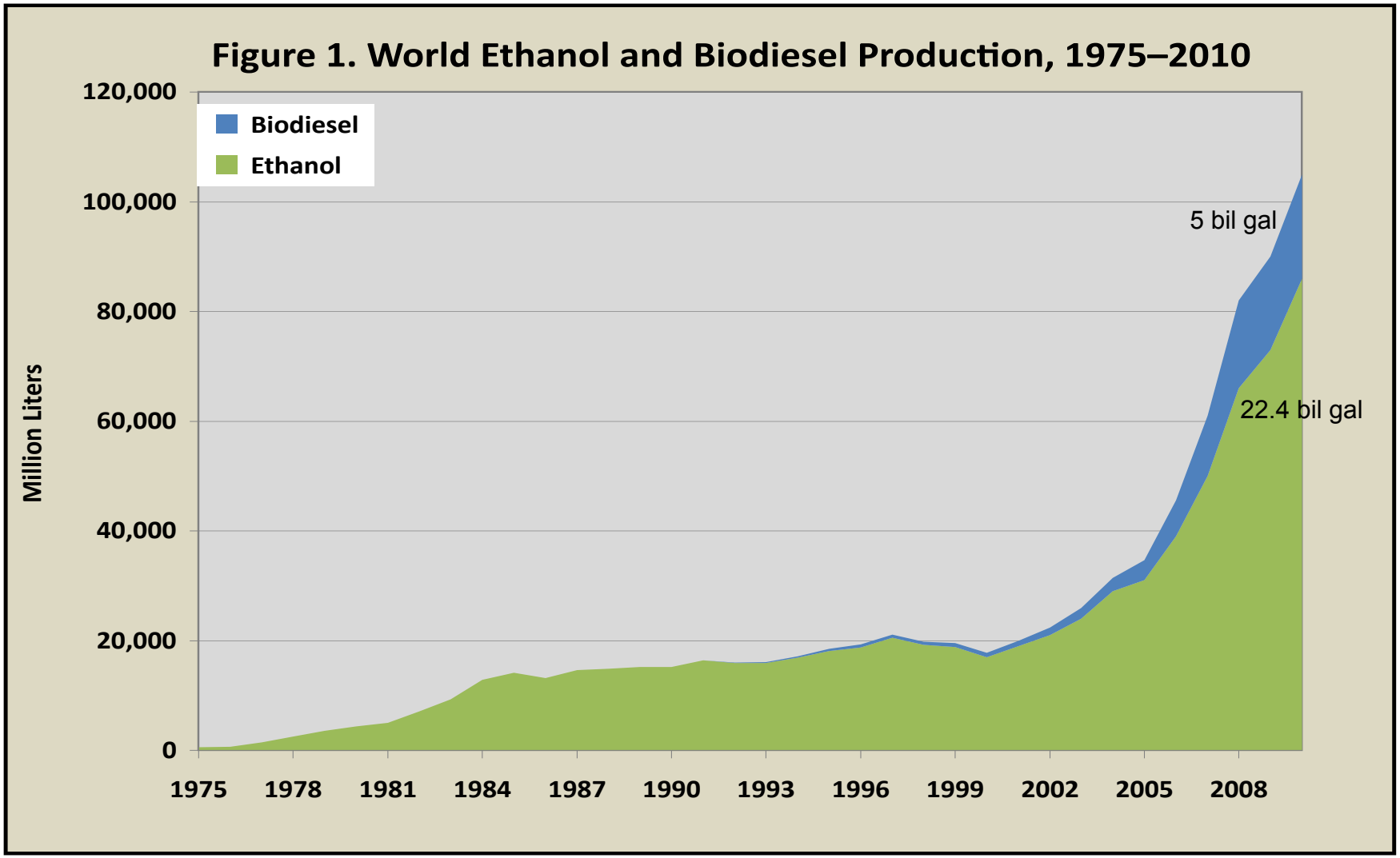
- GCEP (Global Climate and Energy Program)
  - **For funding research on biofuels at FSE**

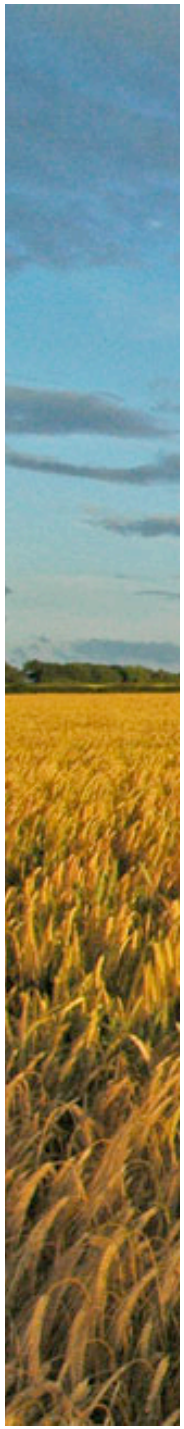
- Wally Falcon, Scott Rozelle, David Lobell, Tom Hertel, Joanne Gaskell, Kate Johnson, and Whitney Smith for substantive contributions


C. Peter Timmer
FOOD
Walter P. Falcon
POLICY
Scott R. Pearson
ANALYSIS
A WORLD BANK PUBLICATION

Global Biofuels Production, 1975-2010

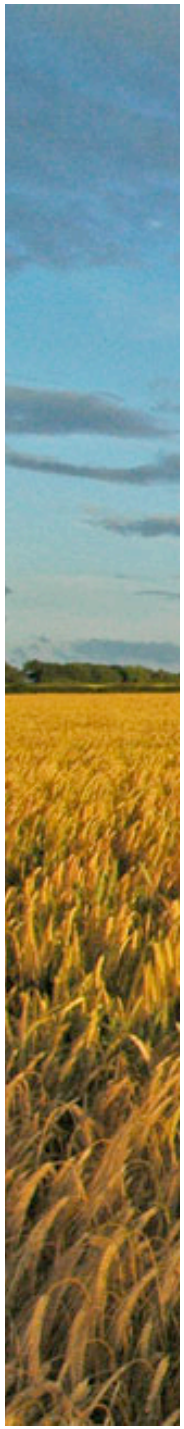


Src: Worldwatch Vital Signs, 2012



Biofuels

- 1st generation: ethanol derived from grains, starches and sugarcane (corn, wheat, rice, cassava, sugar, sweet sorghum); biodiesel from oil crops (oil palm, coconut, soy, rapeseed, jatropha)



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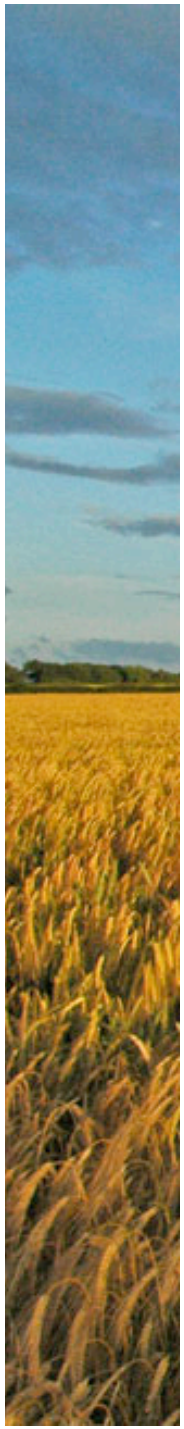
- 2nd generation: cellulosic-based fuels produced from ag residue (corn stover) or dedicated energy crops such as grasses (switchgrass) or fast-growing trees (poplar)



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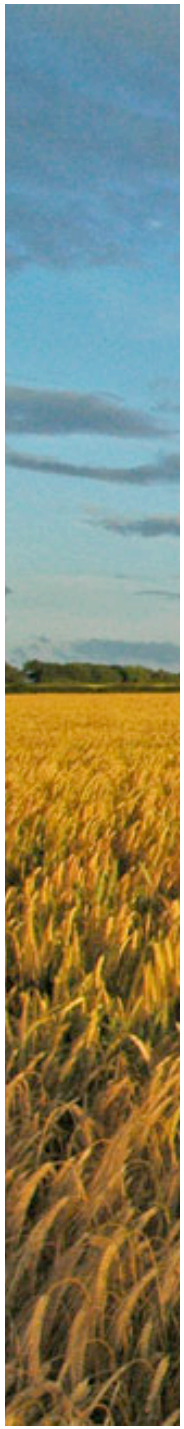
- 3rd generation: fuels mainly produced from algae

Algae Farming

Algae farms require vast water surface areas to efficiently convert sunlight into an oil used as a biofuel.

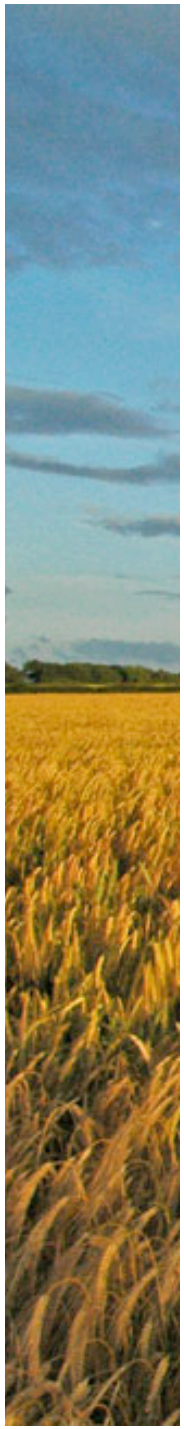
Water, energy, and land requirements

Src: N. Savage, Nature, 23 June 2011



Today

- Focus on first generation biofuels
- Focus on role of policy in biofuel development
- Focus on food security implications for SSA and S. Asia (India)
  - Availability, Access, Utilization
  - Stability
  - Product and factor markets (land, labor, water)
  - Global to local scales; economy-wide to household level

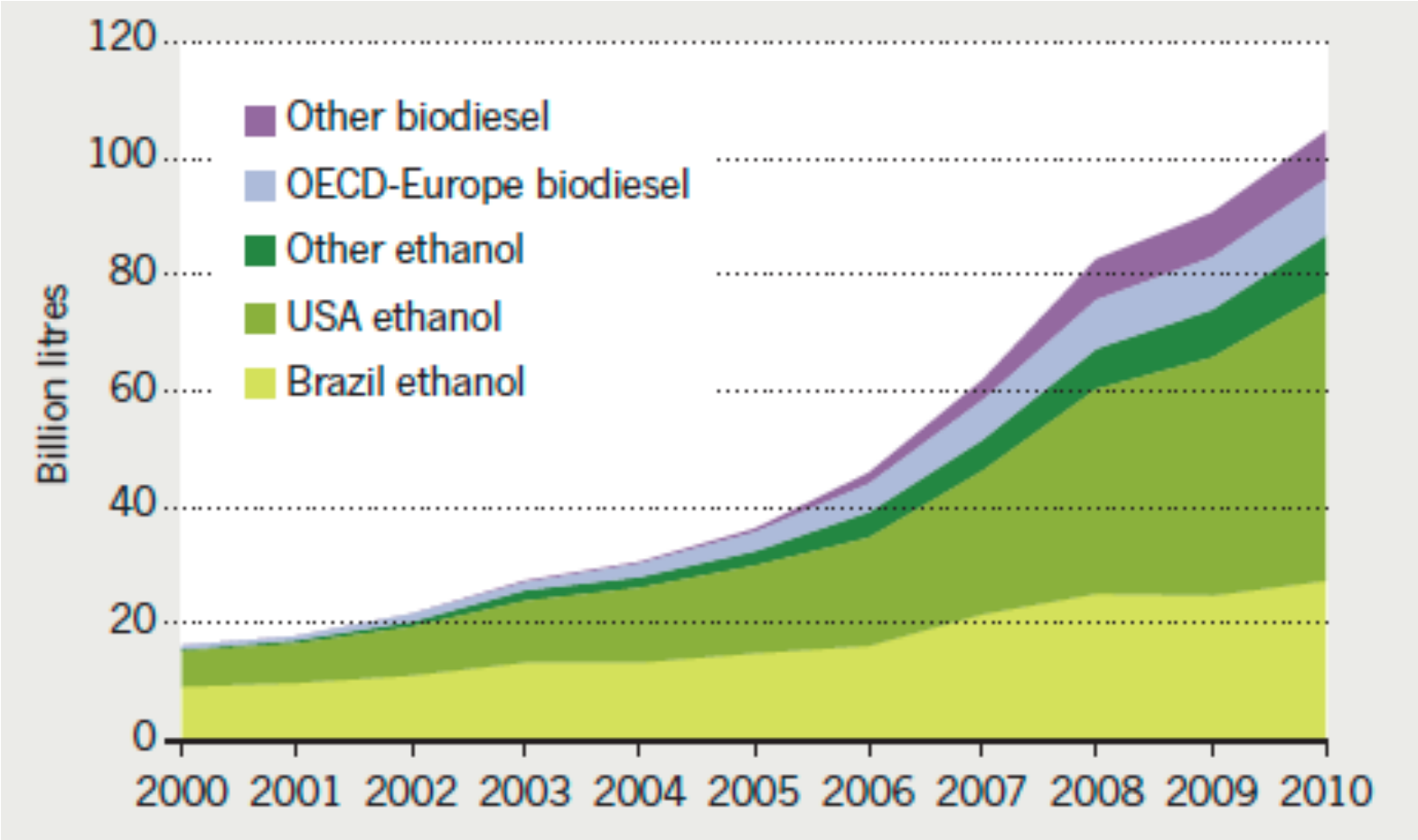


Biofuels and Food Security

1) Role of biofuels policies (mandates) on global food price level and variability

2) Role of biofuels in energy security, rural development and food security in Africa and South Asia

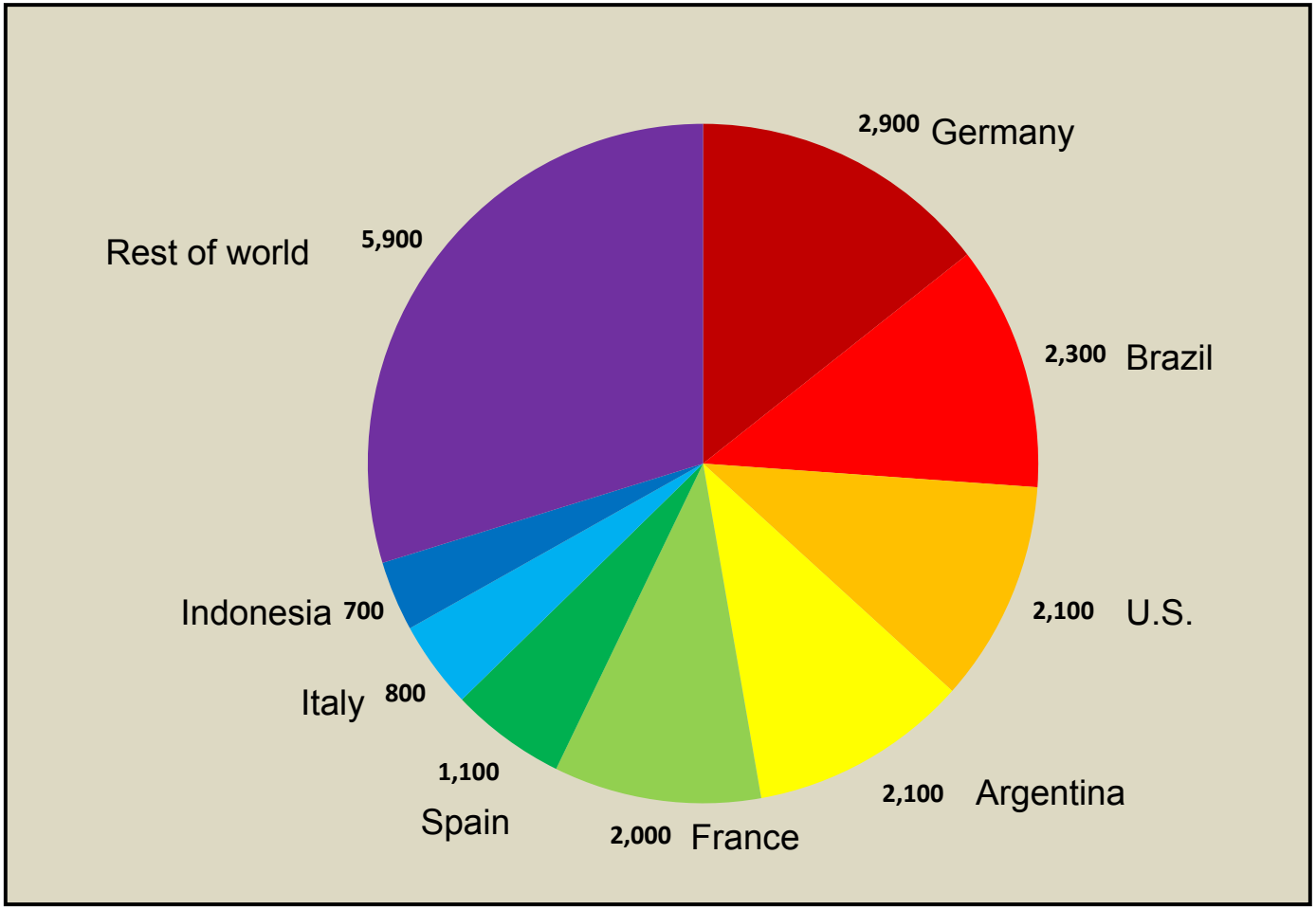
3) Role of biofuels in land, labor and water markets



Ethanol Production (2010):

- US: 57% (~13 bil gal)
- Brazil: 33% (~7 bil gal)
- China, Canada, France, Germany, Spain: @ < 2.5%

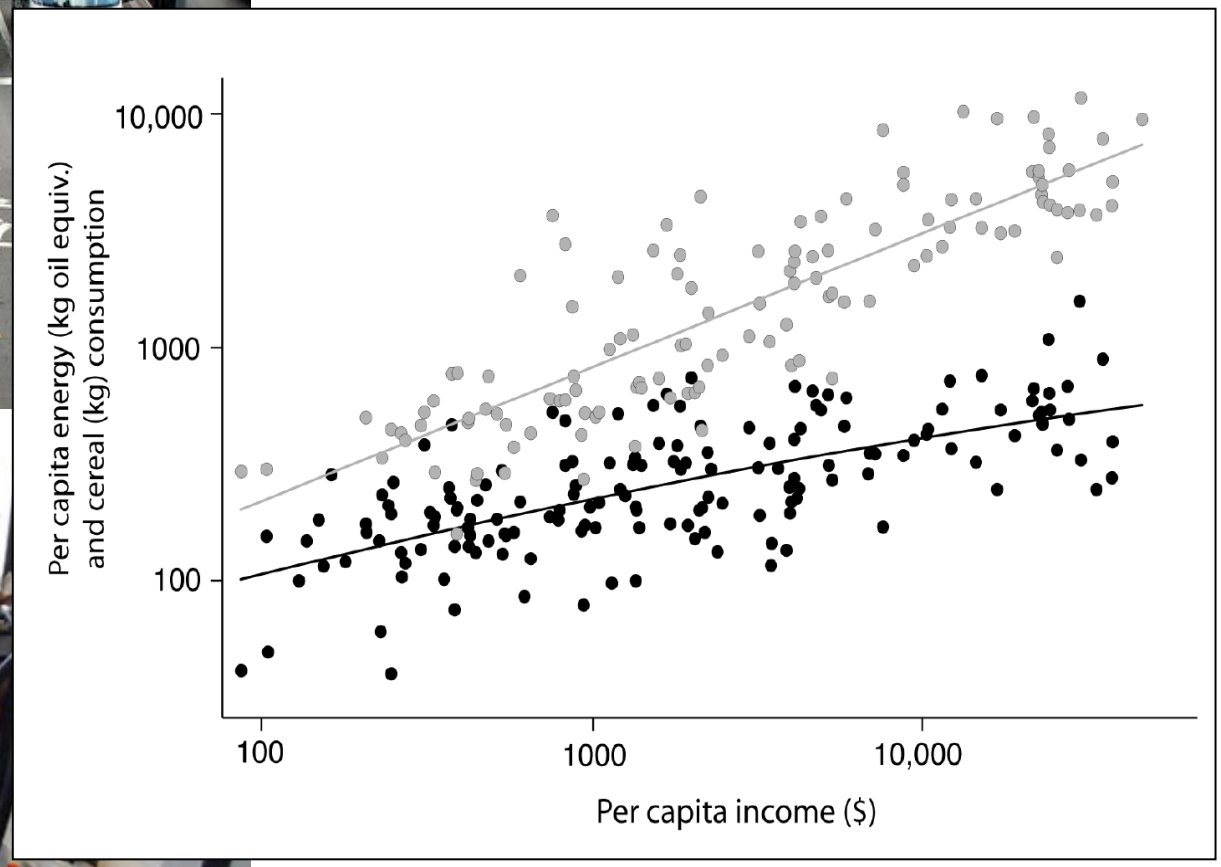
Biodiesel Production by Country, 2010



Rapeseed, soy, palm oil, other fats and oils

Source: REN21, Renewables 2011 Global Status Report (Paris: REN Secretariat, 2011) p. 75
Worldwatch Vital Signs Online 2011

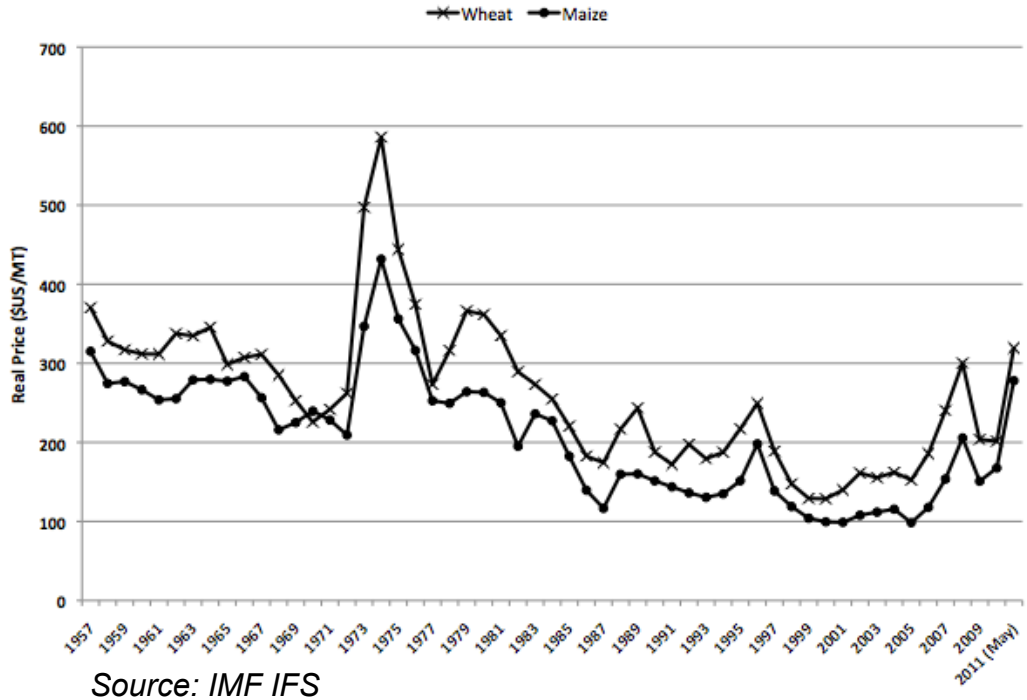
What's driving demand?



Income growth, population, prices, and policy

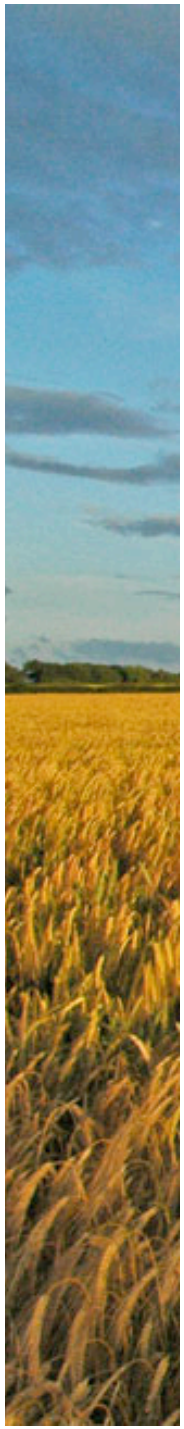
The Biofuels Policy Debate

Real Grain Prices, 1957-2011



Source: IMF IFS
Annual prices for US Gulf Ports, deflated with IMF US GDP deflator

The Biofuels Policy Debate

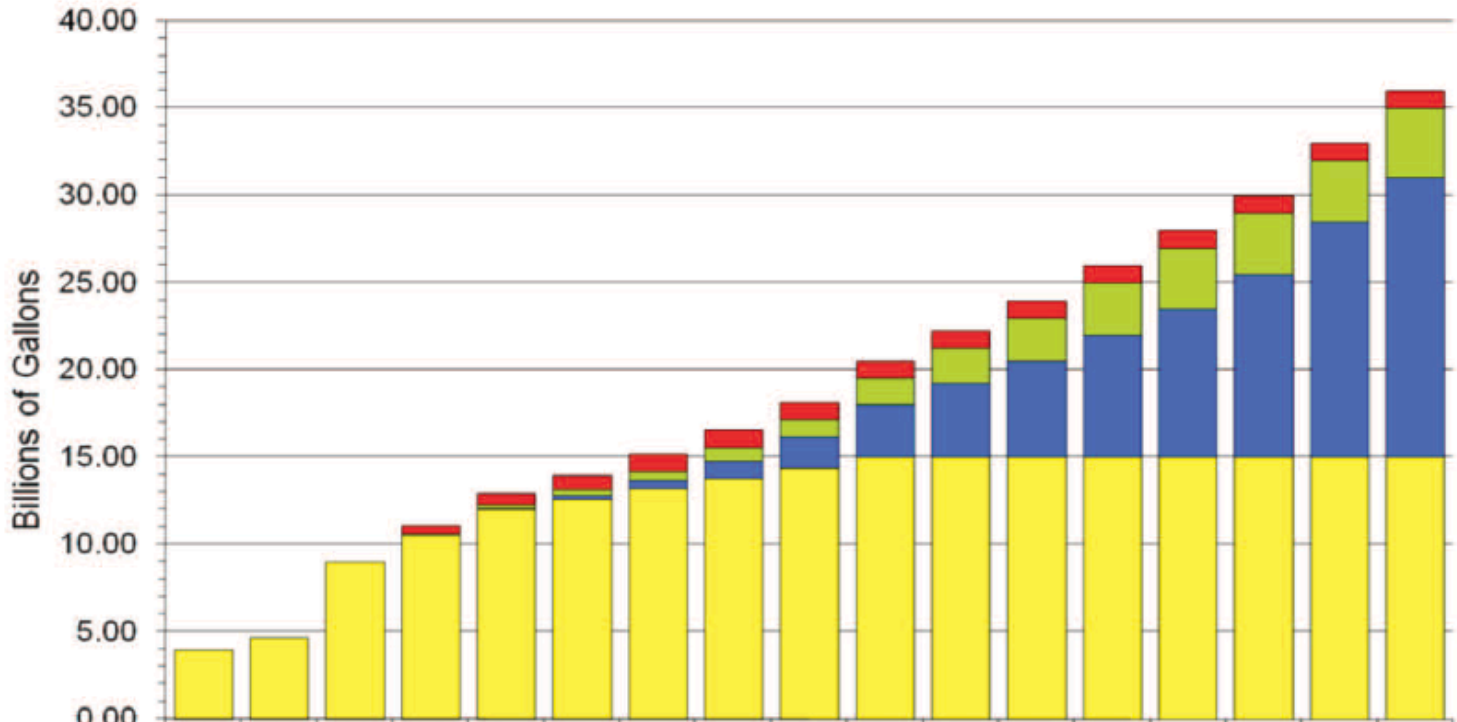


U.S. Biofuels Policy

- Renewable Fuels Standard (RFS): revised in 2010 in response to the 2007 Energy Independence and Security Act (EISA)
- Mandate: Use of renewable fuels must rise from 12.5 bil gallons in 2010 to 36 bil gal in 2022
  - 15 bil gal 1st generation biofuel by 2015 (corn)
  - Remaining 21 bil gal with advanced biofuels, biodiesel
- EPA: Phase out MTBE as oxygenate additive in gasoline in 2005; use ethanol as a replacement

U.S. Renewable Fuels Standard (RFS)

Mandates:



	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Biomass-based Diesel				0.50	0.65	0.80	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Non-celulosic Advanced				0.10	0.20	0.30	0.50	0.75	1.00	1.50	2.00	2.50	3.00	3.50	3.50	3.50	4.00
Celulosic Advanced					0.10	0.25	0.50	1.00	1.75	3.00	4.25	5.50	7.00	8.50	10.5	13.5	16.0
Conventional Biofuels	4.00	4.70	9.00	10.5	12.0	12.6	13.2	13.8	14.4	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0

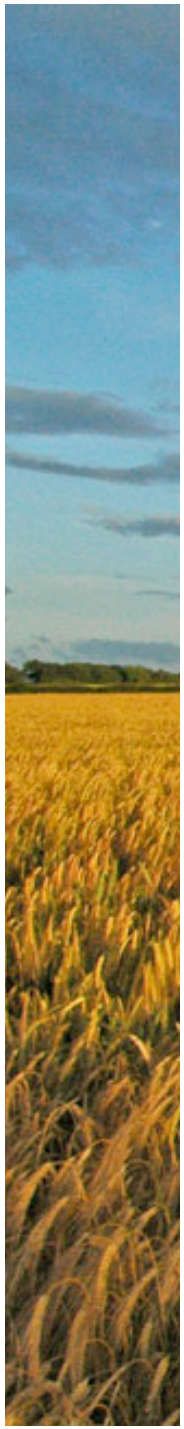
Source: Energy Independence and Security Act of 2007, U.S. Congress.

U.S. Biofuels Policy

- Renewable Fuels Reinvestment Act 2010 (HR 4940)
  - $0.45/gal blender credit (vol excise tax credit)
  - $0.54/gal tariff on imported ethanol, 2.5% ad valorem tariff
  - $1.00/gal blender credit for biodiesel

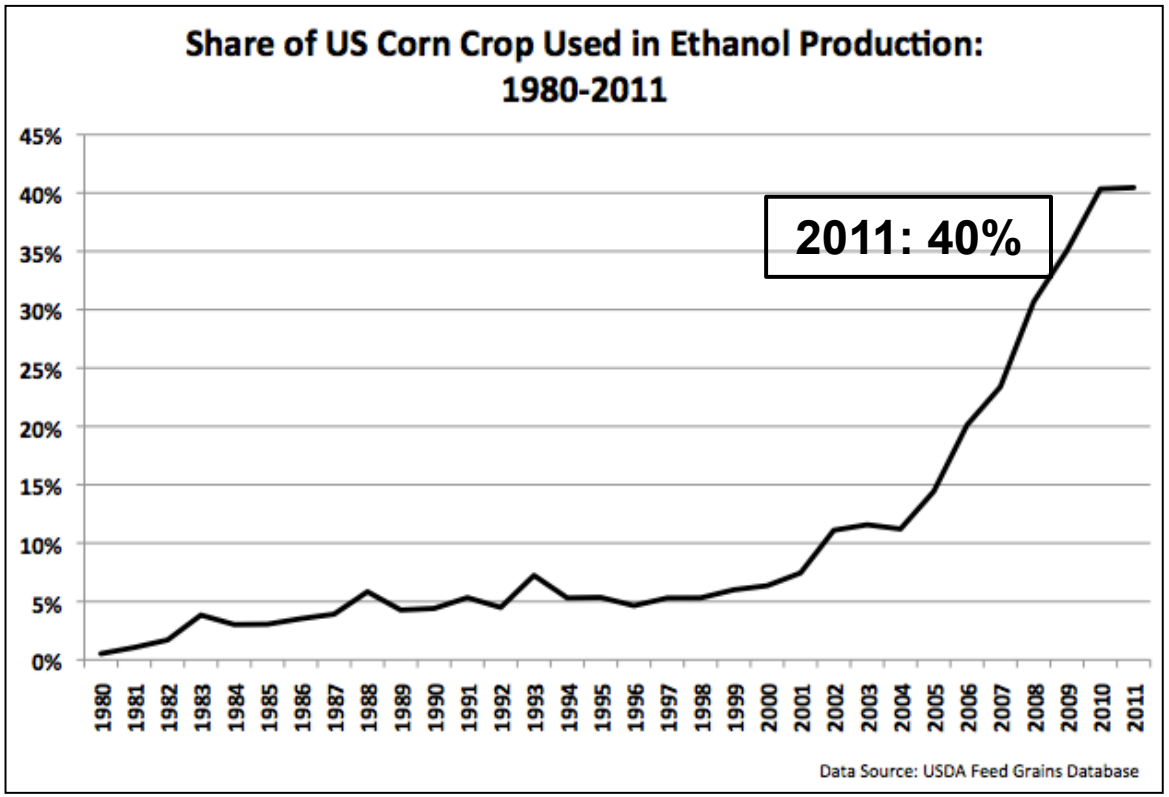
All of these supports expired at the end of 2011 – no extension

Renewable Fuels Marketing Act 2010 (HR 5778)
--EPA increased blending rate to 15% (E15)
--Passed October 2010



Renewable Fuels Standard (RFS) 2010

- Biofuels must have 20% lower life-cycle GHG emissions than gasoline, even accounting for indirect land use change
- Corn-based ethanol produced in a natural gas fired facility meets the new requirement
  - Ensures use of 15 bil gal corn-based ethanol
- By 2022, 20 bil gal must come from advanced biofuels with no more than *50% of GHG* emissions of gasoline.
  - Includes sugar-based ethanol from Brazil



More corn consumed in the U.S. went to ethanol than to livestock in 2011 for the first time ever--

Implications for the livestock sector?

Biofuels and Livestock Feed

Corn designated for ethanol production returns ~30% of its weight to the livestock sector (mainly cattle)

40% ethanol plants produce wet distiller grains

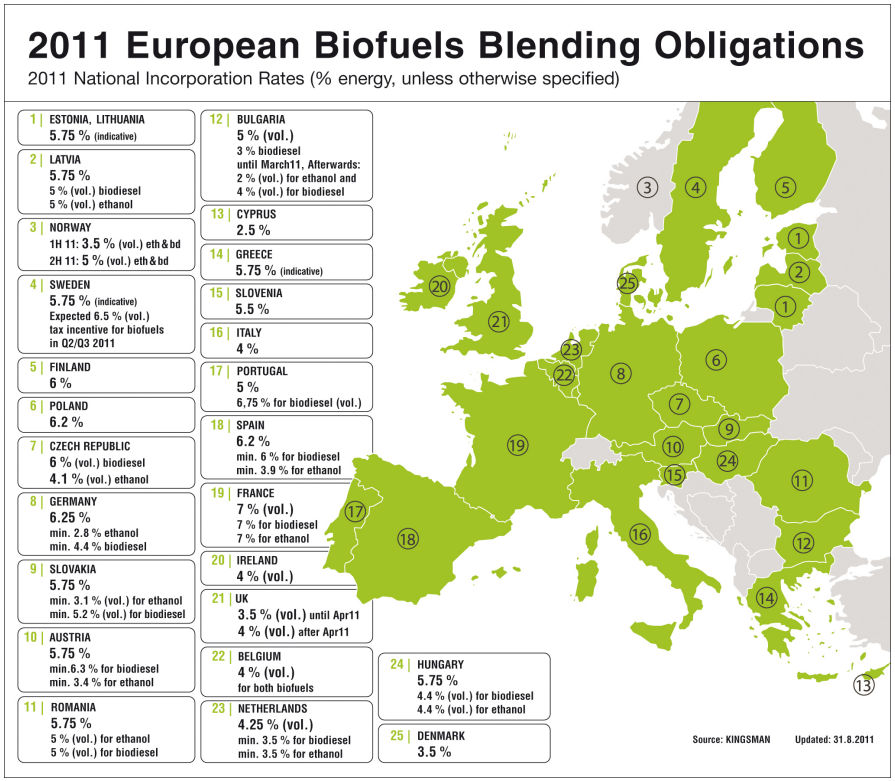
60% produce dry distiller grains

Distiller grains constitute ~15-20% of total revenue from ethanol processing

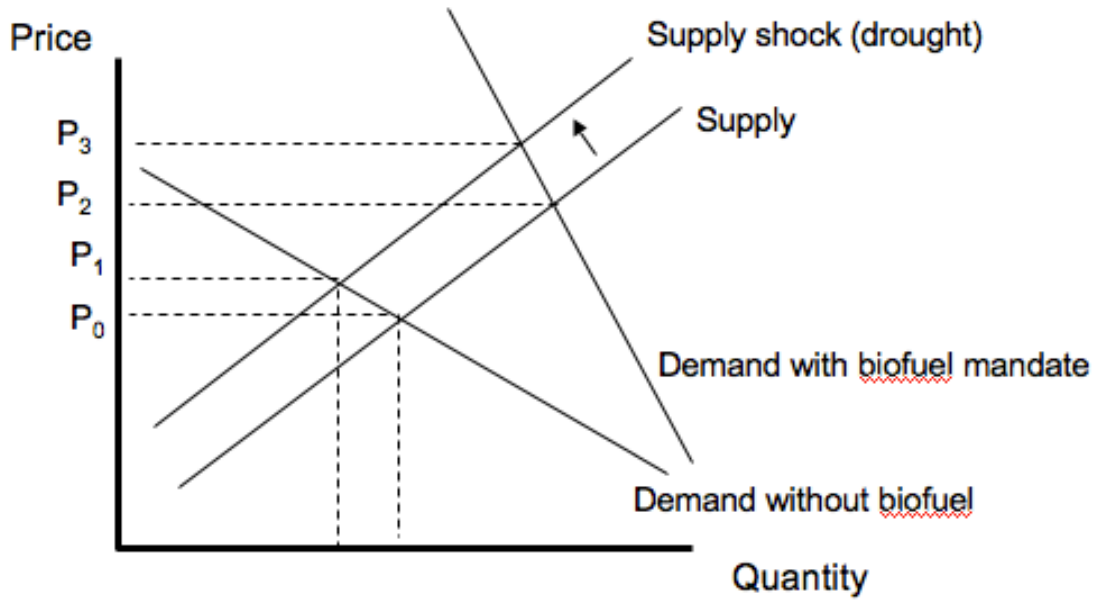
If biofuel by-products are ignored, overstate their negative impacts on markets (Taheripour et al 2010)

EU Biofuels Policy 2009

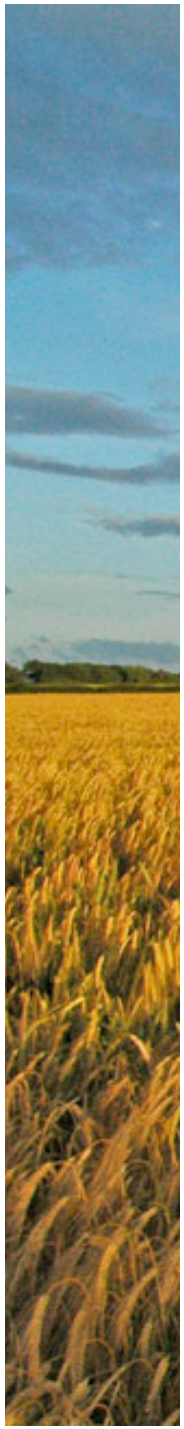
- Mandated target of 10% of transportation fuels from renewables by 2020
- Implementation method can be determined by each member state (subsidies, fines)
- Debate about GHG emissions from biofuels, especially with indirect land use change



Why do mandates matter?



- Quantity demanded is not responsive to price (inelastic demand)
- Leads to larger price swings with supply shocks



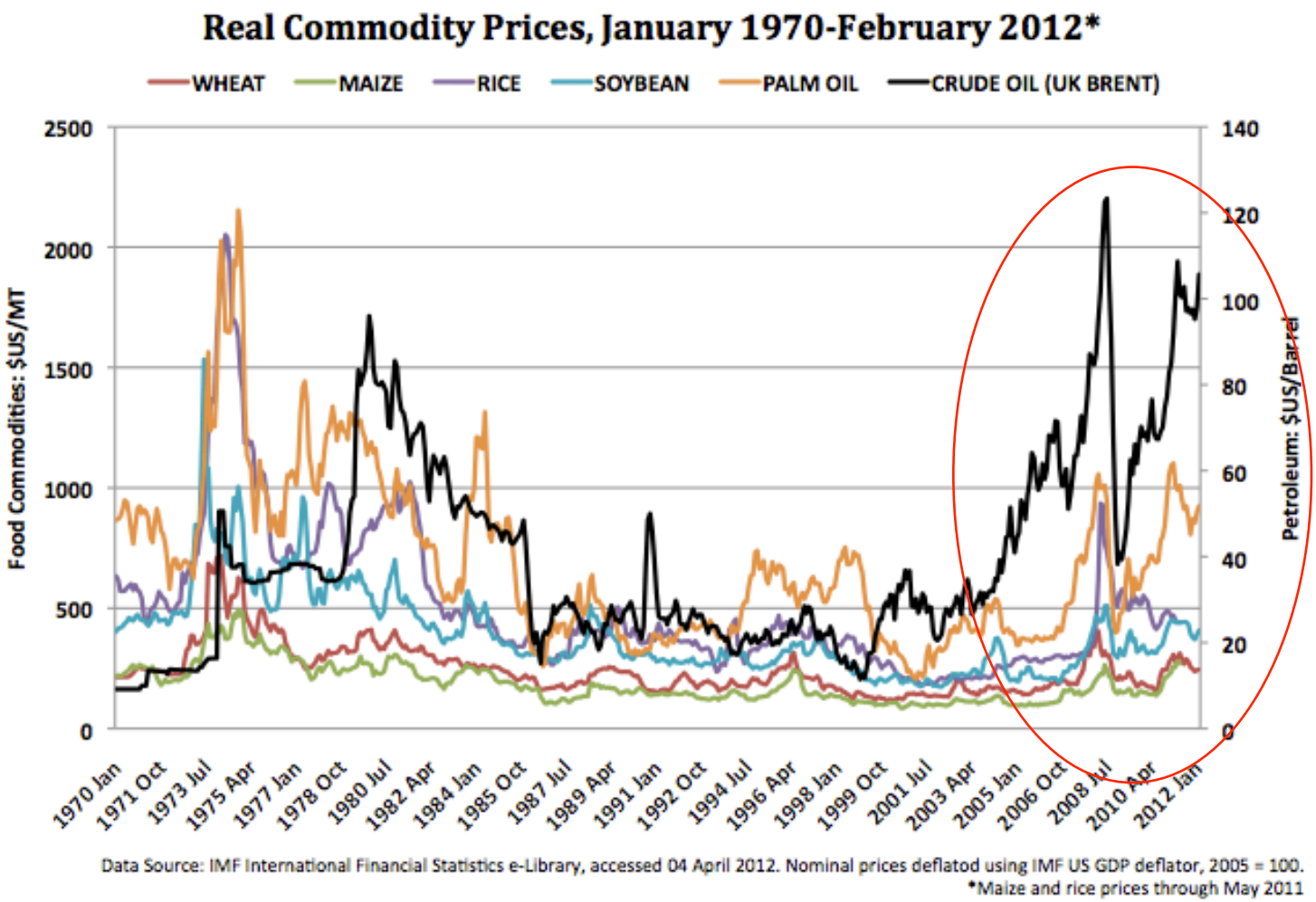
Why do mandates matter?

If implemented and enforced, mandates can:

- Increase grain and oilseed price level and volatility
- Reduce stocks and create price expectations
- Create import demand if feedstocks cannot be fully supplied domestically
- Increase land values
- Lead to rural income growth

Global food security?

What are the causes of high and volatile commodity prices?

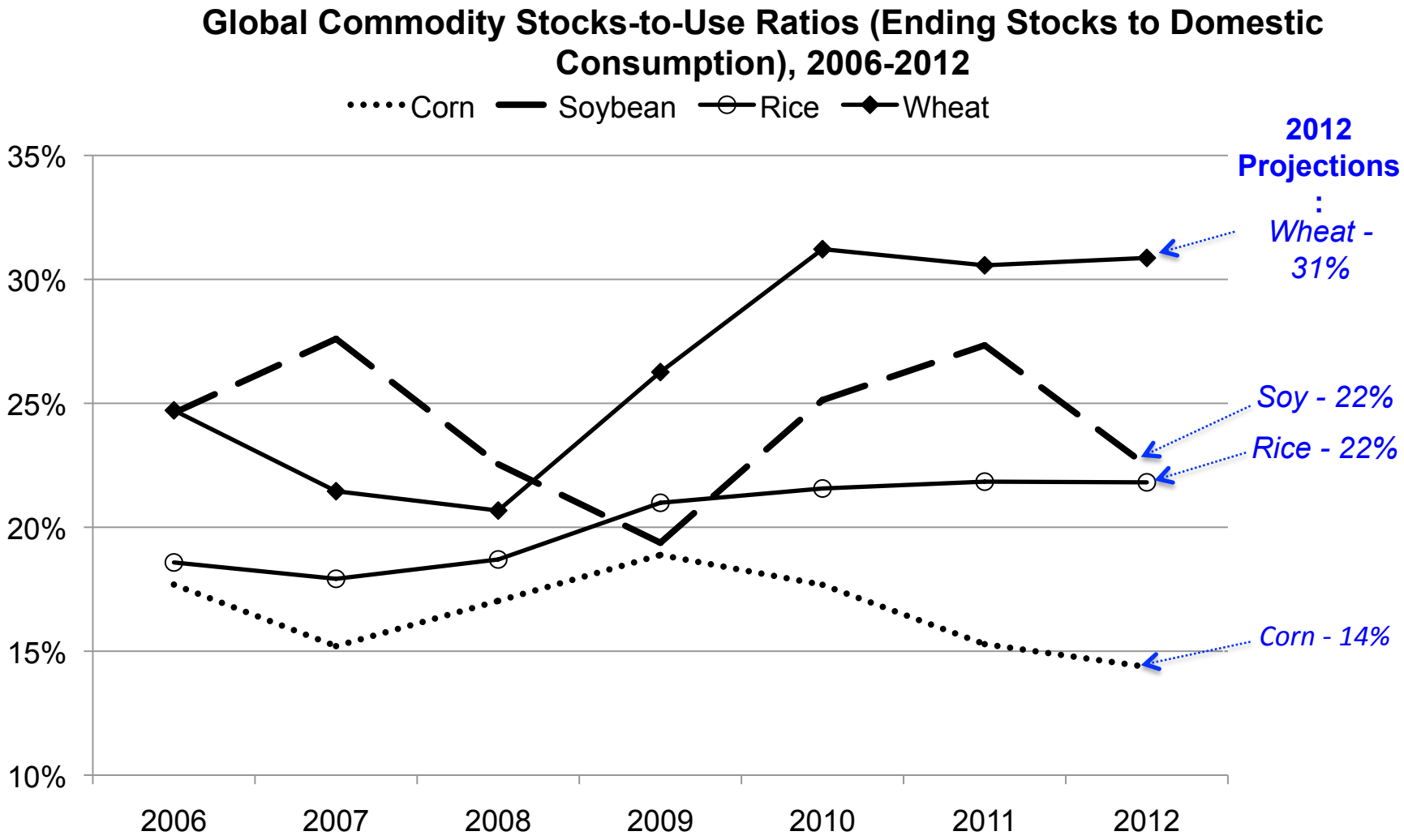


Data Source: IMF International Financial Statistics e-Library, accessed 04 April 2012. Nominal prices deflatod using IMF US GDP deflator, 2005 = 100.
*Maize and rice prices through May 2011

What are the causes of high and volatile commodity prices?

- Livestock demand, esp. from China
- Value of U.S. currency
- Supply disruptions/shocks
- Speculation
- Stocks
- Energy prices
- ***U.S. ethanol policy***

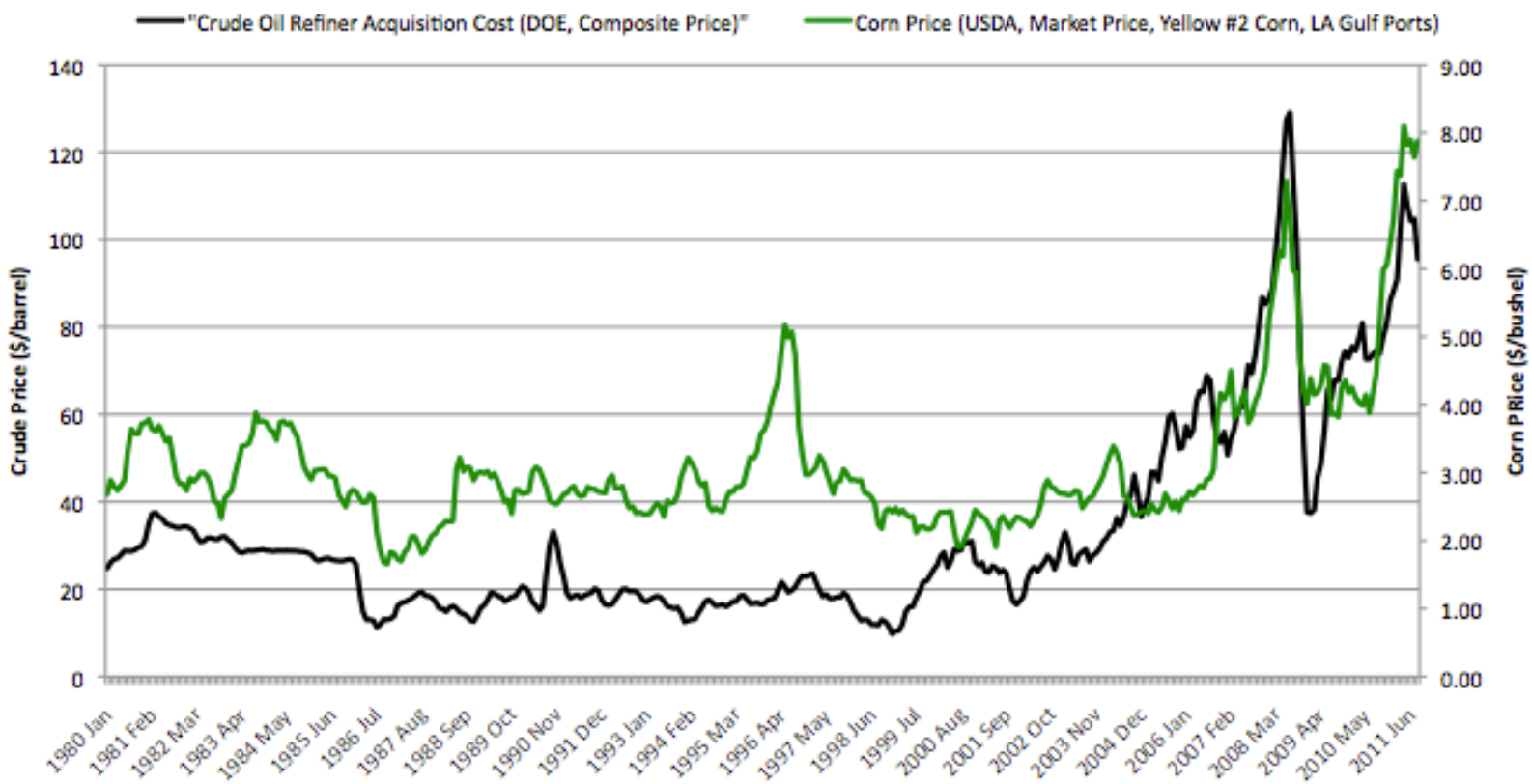
Reduced Corn Stocks



Data: USDA Production, Supply, and Distribution Database, accessed 13 March 2012

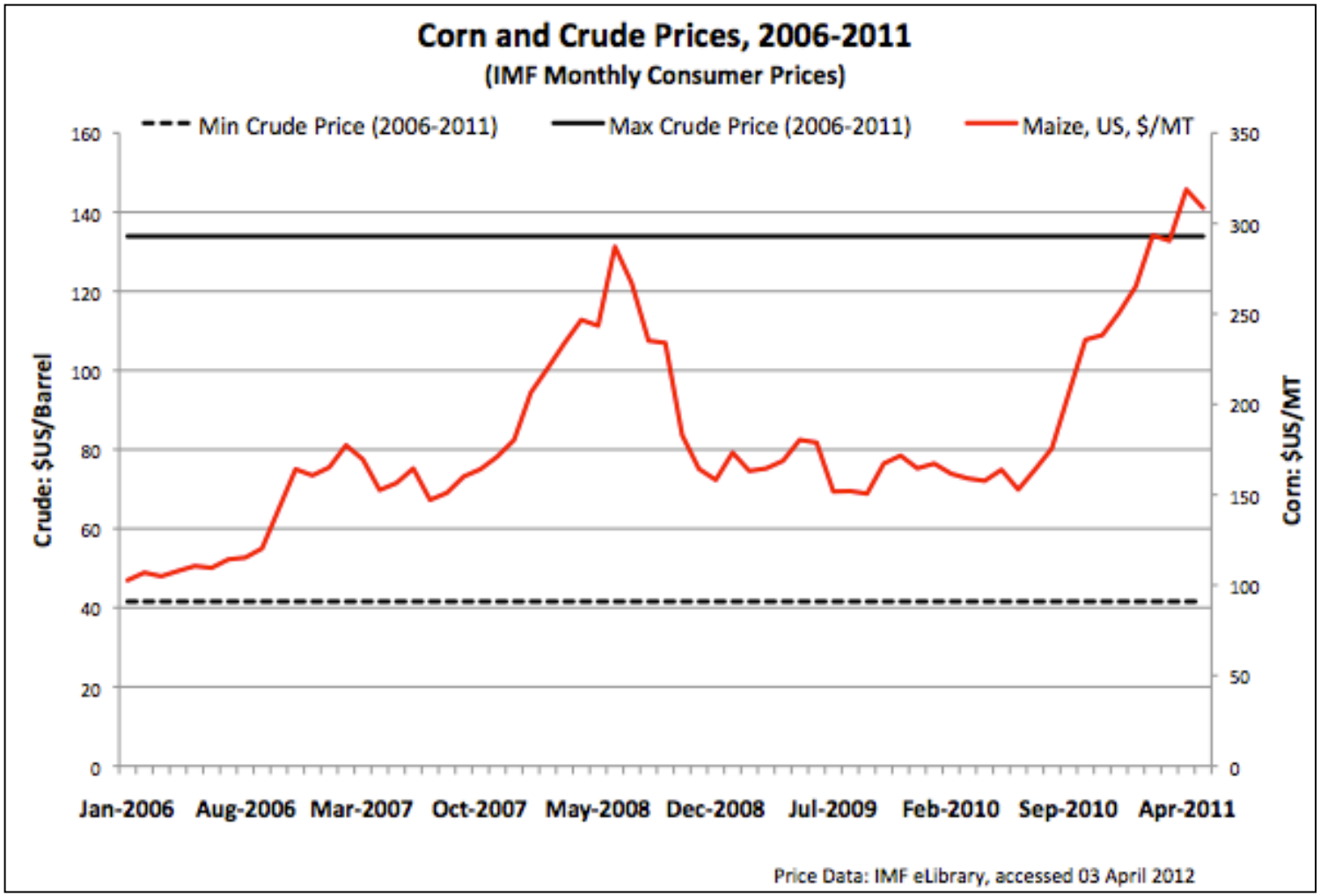
Energy Prices: Crude Oil in Relation to Corn

Correlations		
	Crude-Corn	Crude-Gasoline
1980-2005	0.12	0.82
2006-2011	0.77	0.94



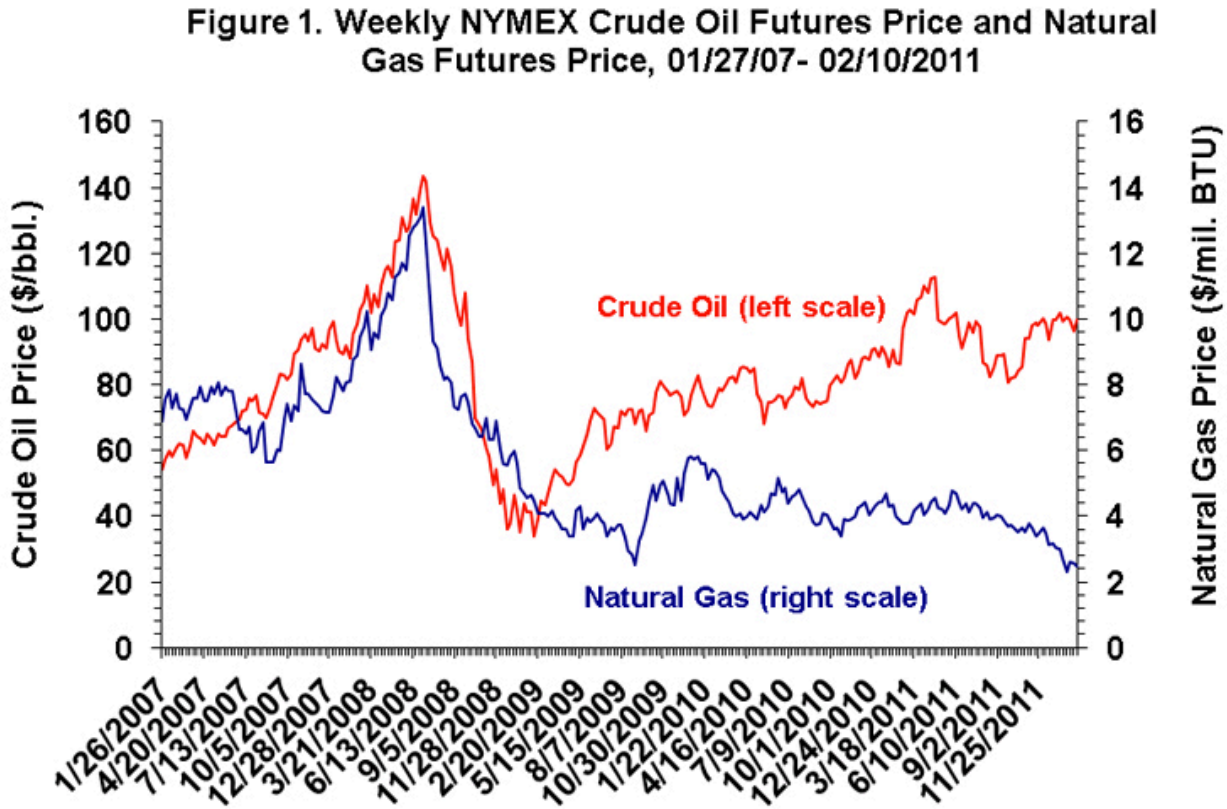
Energy Prices: US DOE; Corn Price: USDA

Crude Sets Floor Price and Ceiling Price



Parity (break-even) price for biofuels is a function of:
crude price, processing cost, feedstock price, exchange rates

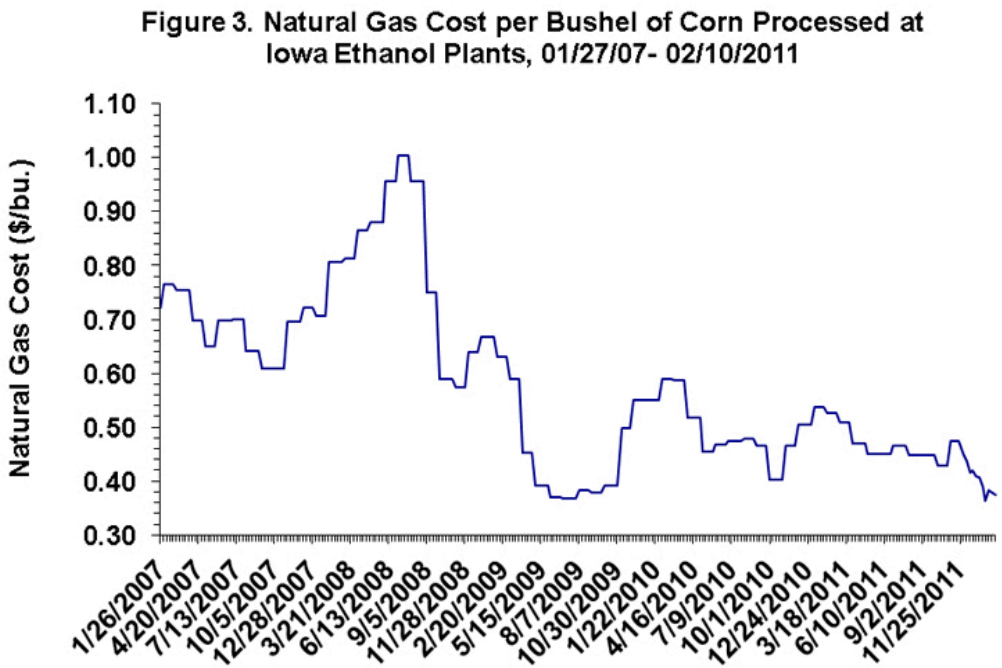
Decoupling of Crude and Natural Gas Prices



- Crude oil prices high and could rise further
- Natural gas prices declining with increased supply

Source: farmdocdaily (Feb 15, 2012)
http://www.farmdocdaily.illinois.edu/2012/02/the_truly_amazing_continuing_s.html

Implications for biofuel competitiveness

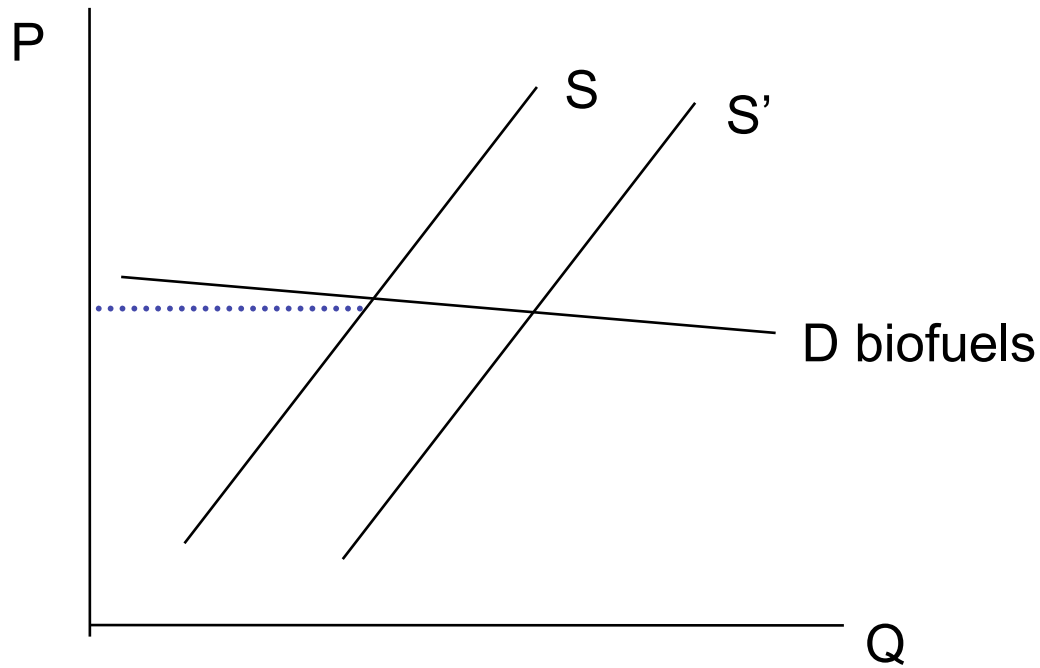


Source: farmdocdaily (Feb 15, 2012)

- Ethanol processing costs lower
- Fertilizer production costs lower
- Ethanol becoming increasingly competitive, but will natural gas substitutes emerge for transportation fuel?

With serious disruption in oil markets, demand for biofuels could expand almost indefinitely…

Relative price of biofuel to crude oil



U.S. Ethanol Policy

U.S. ethanol policy may be the single most significant contributor to world food price instability.

The Global Costs of

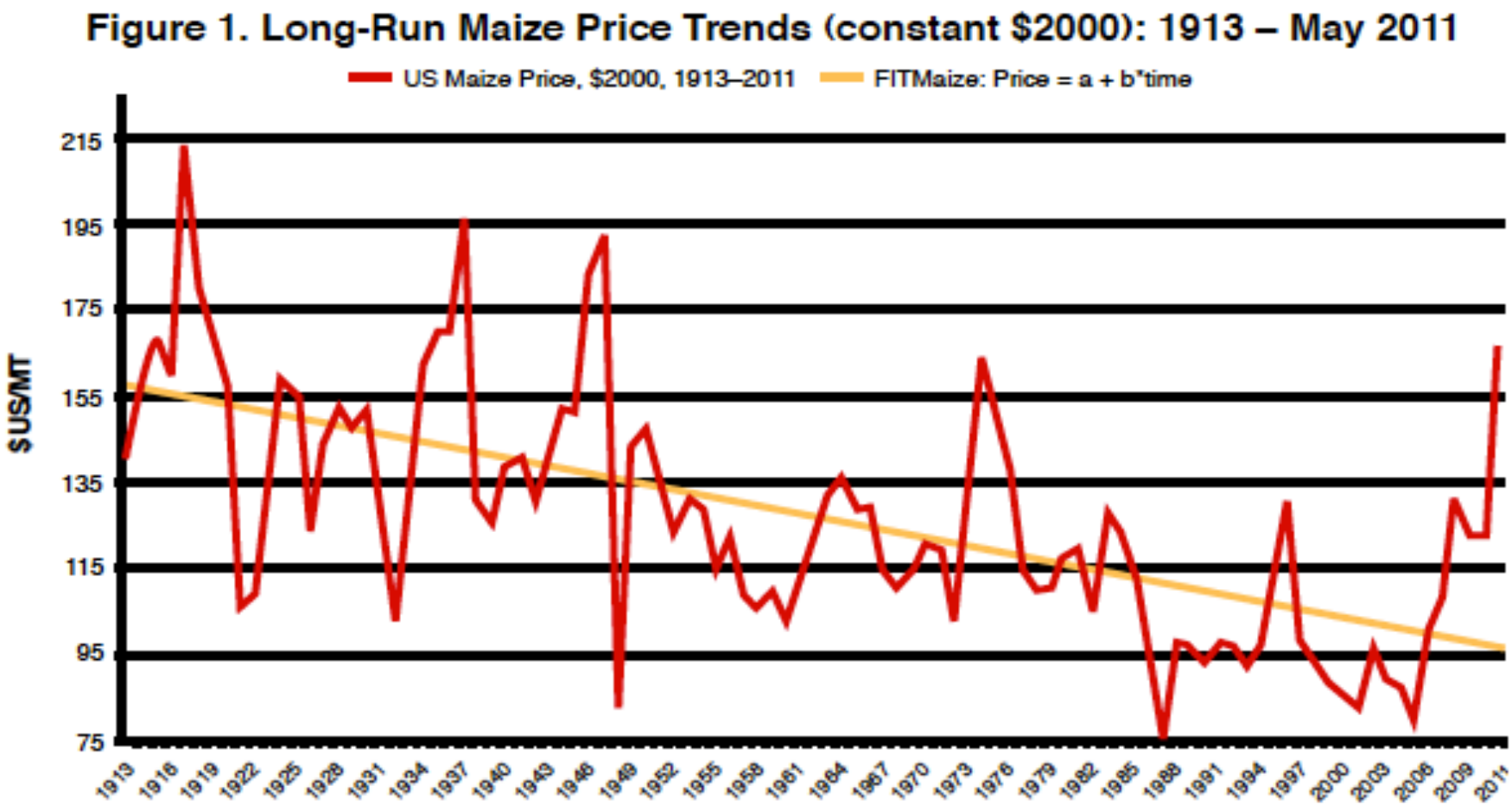
AMERICAN ETHANOL

by Rosamond L. Naylor & Walter P. Falcon

"Mess up the corn market, and you pretty much mess up everything…" (anon.)

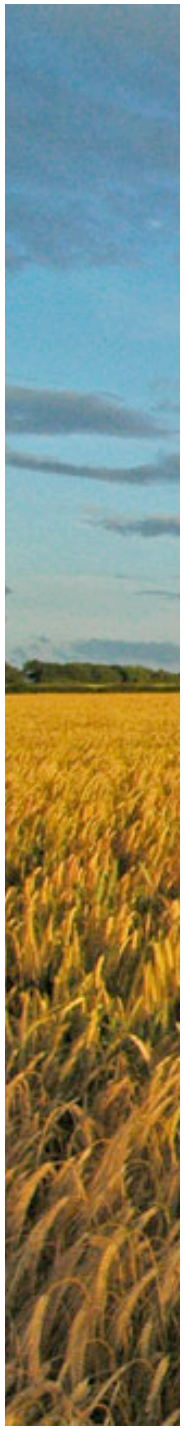
The American Interest, Nov/Dec 2011

Another Cyclical Spike or Long-Term Trend?



Price = 157.4 - 0.62 Time, Adj. R^2 = 0.40
Source: Updated and adapted by the authors from Nicholas Eberstadt, "Today's Global Food Crisis in the Mirror of Long-Term Development Trends", Conference Paper, Washington, D.C.: American Enterprise Institute, July 2, 2008.

Naylor and Falcon, 2011



How these prices ripple through the economy

- Own price effects (demand, supply)
- Cross prices effects (demand, supply)
- Income effects
  - Increased food prices hurt the household budget
  - Impacts are larger when the budget share for food is large
  - Poor households hurt the most (Timmers Law)

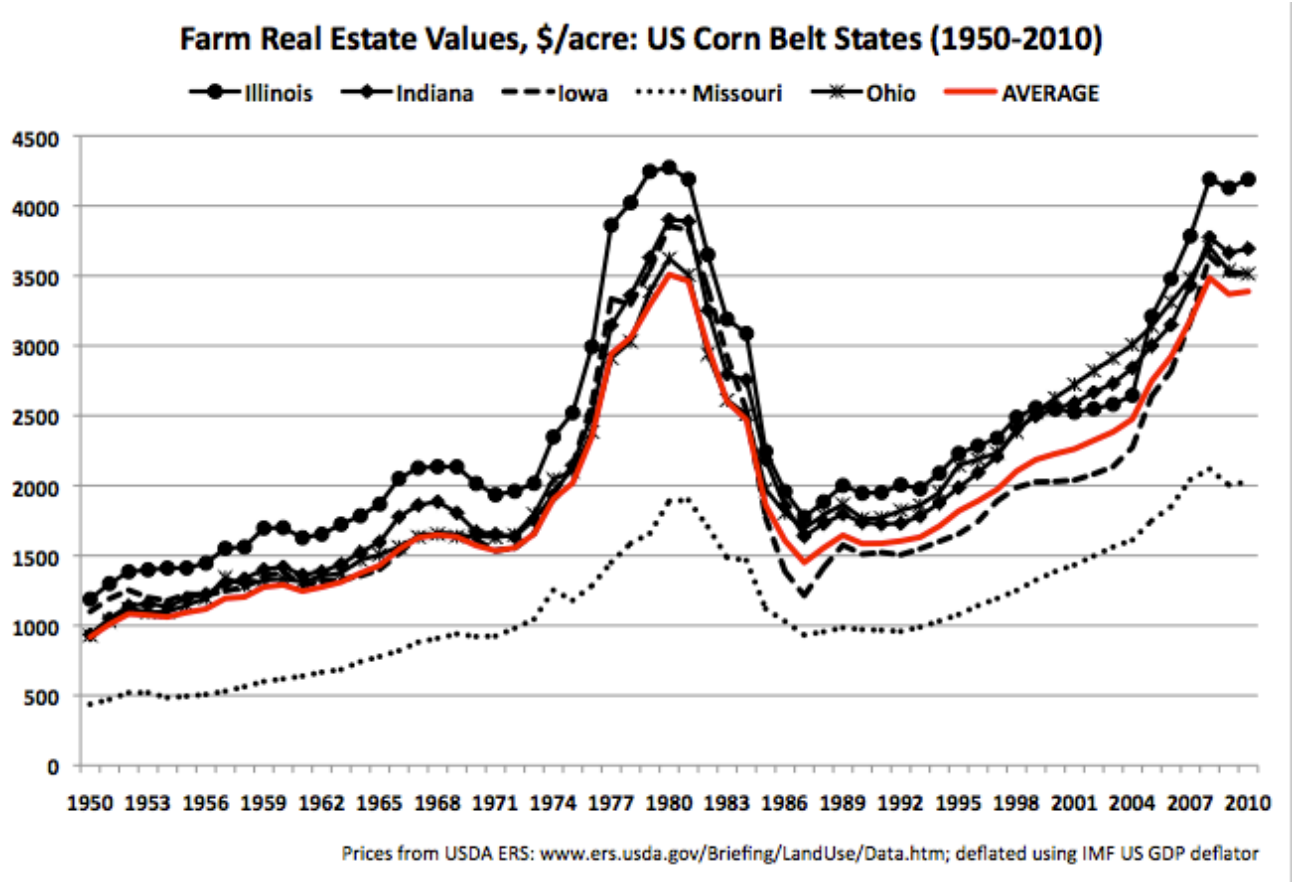
Substitutions in Production and Consumption

Corn-based ethanol in US:

- U.S. farmers grow more corn and less soy; Brazil takes up greater share of soy market (land use change)
- As demand for corn rises (food, feed, fuel), prices also rise; wheat substitutes for corn in livestock feeds; wheat prices up
- As wheat prices rise, consumers throughout world shift from bread to rice; rice prices rise…..



Corn Prices Capitalized Into Land Values



- Higher expected returns to land
- Good investment with low interest rates

Substitutions in Production and Consumption

Rapeseed biodiesel in EU:

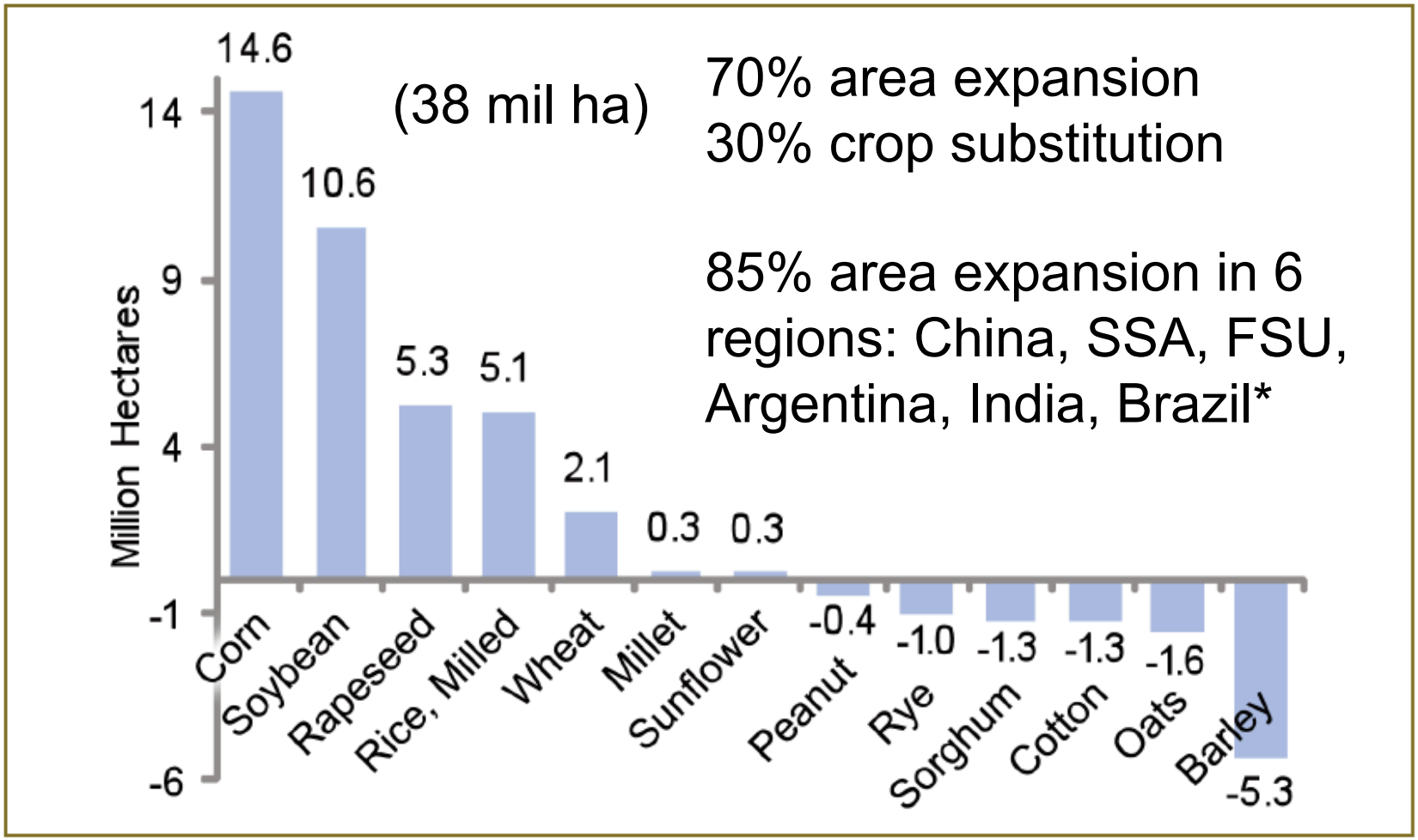
- More rapeseed used in fuels, prices rise, China's rapeseed imports fall
- China uses more soy oil and palm oil for cooking fuel

China expands biofuel production from imported feedstocks

- Cassava from SE Asia (Cambodia, Laos, Thailand); Africa (?)
- Speculation in land markets; area expansion, shift in food-fuel production

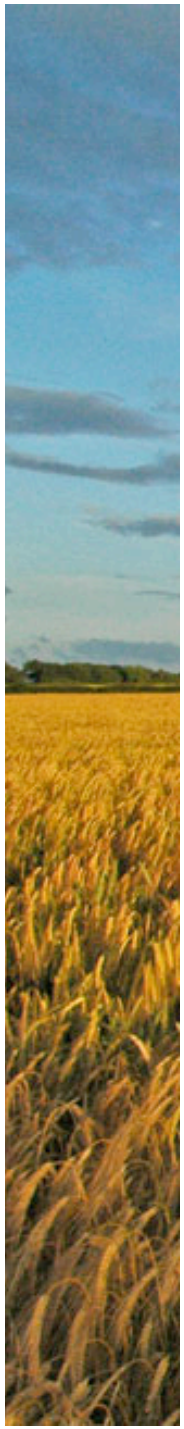
Change in Global Harvested Area

(13 major crops, 2010/11 vs. 2005/06)



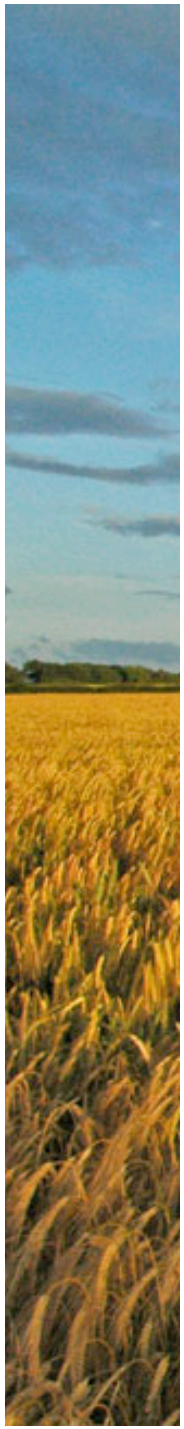
Source: FAS (2011) USDA PS&D online database

Src: Farm Foundation 2011
* In order of importance



Biofuel Mandates, Commodity Markets, and Global Food Security

- Rise in price levels for grains and oilseeds
- Decline in production and price stability for food commodities due to use of crops as biofuel feedstocks
- Ripple effects on many commodities via substitutions
- Impacts on food security: availability, access, stability



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- Price transmission from global to domestic markets
  - Exchange rates
  - Policies (protection)
- Price transmission from domestic to HH level
  - Infrastructure/roads/markets
  - Urban vs. rural
  - Net producers vs. consumers

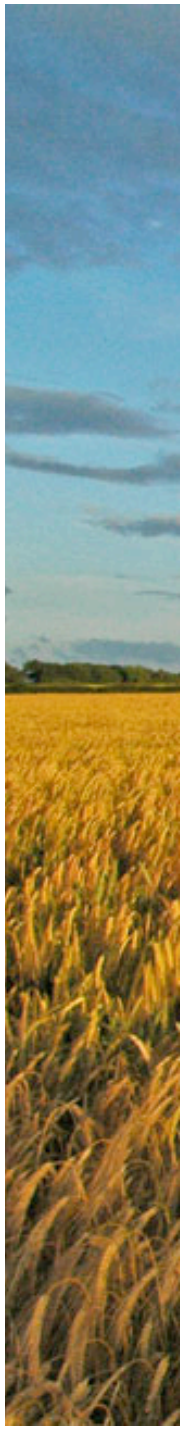
DIRECTIONS IN DEVELOPMENT
Countries and Regions

Biofuels in Africa

Opportunities, Prospects, and Challenges

Donald Mitchell

THE WORLD BANK



Rationale for Biofuel Investments

- Create employment and income opportunities
- Diversify cropping systems, smooth income
- Create supply chain spillovers for staple crops
- Create export industry
  - Export biofuel feedstock to countries with mandates
- Reduce dependence on imported energy
  - Rising domestic demand (~5% pa in some countries)
  - Landlocked countries with high CIF price for energy
- Reduce energy poverty

Alleviating Energy Poverty

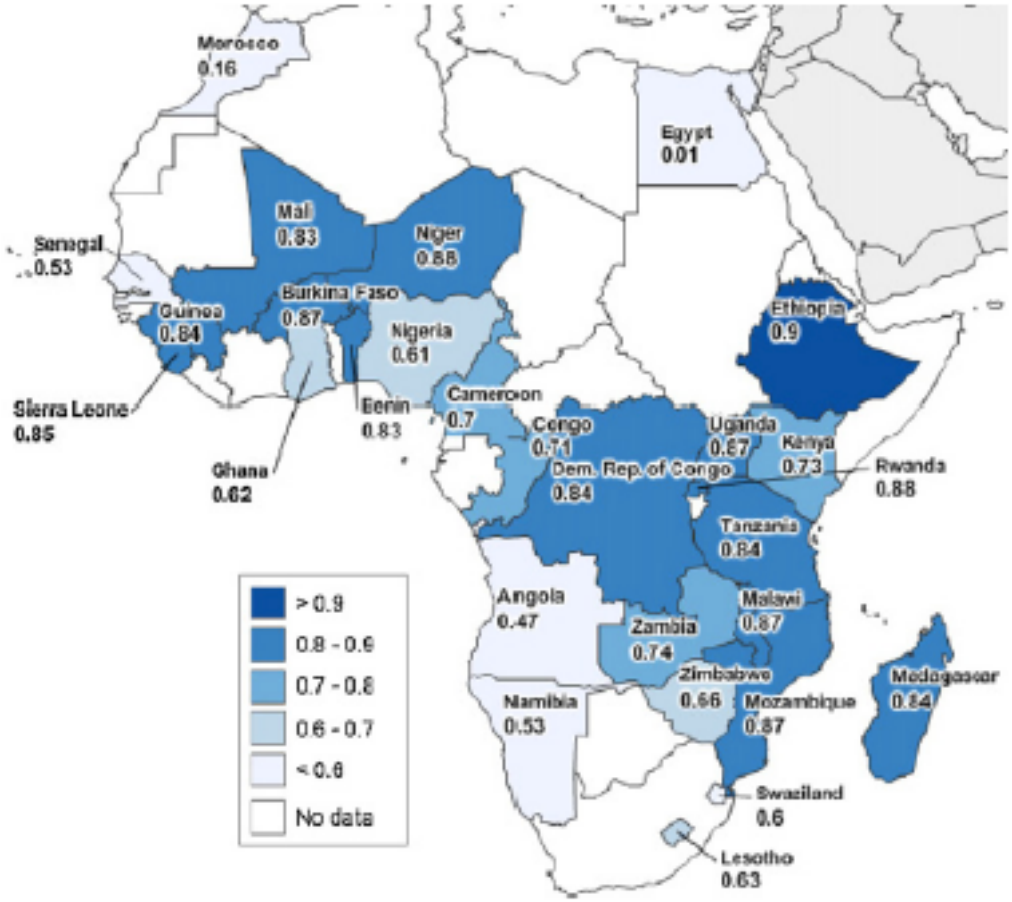
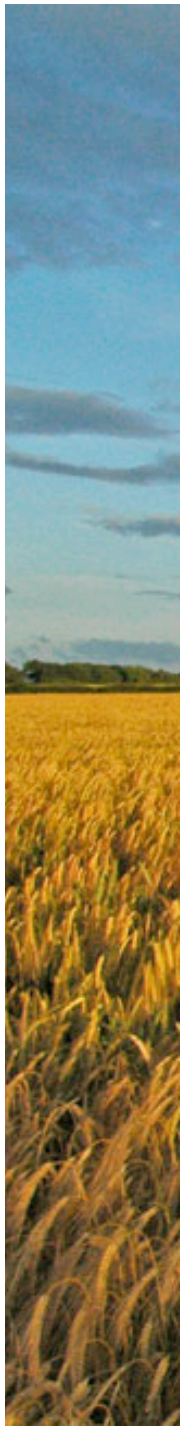


Fig. 1. MEPI for selected African countries. Visual created with van Cappelle [40].

Src: Nussbaumer, Bazilian, and Modi, “Measuring energy poverty”, *Renewable and Sustainable Energy Reviews* 16 (2012)

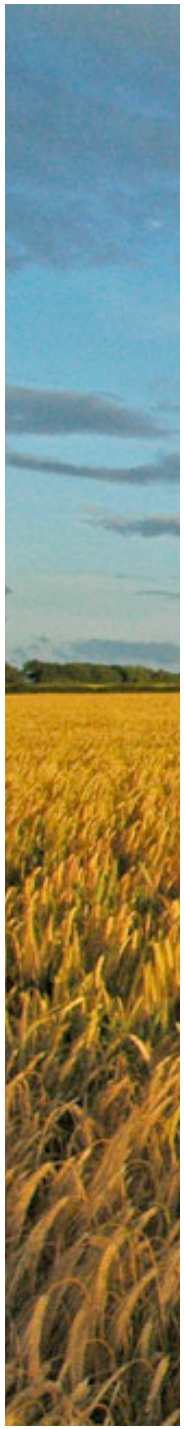


Phase-In Strategy

- Develop biofuel feedstocks for export
  - Duty-free trade access (EU, US)
- Develop biofuel feedstocks for export and domestic biofuel industry (B5, E5)
- Develop biofuel feedstock for domestic energy security (E85, B85)

- Sugar (molasses)
- Jatropha

- Cassava, sweet sorghum, castor, oil palm



Framework for evaluating investments

- Farm or firm level
  - Production costs, profitability, international competitiveness, price volatility
- Macroeconomic
  - Public investments, taxes, fiscal balances
  - Employment and resource constraints, growth linkages
  - Exchange rates, exports
- Household income and food security
- Resources and environment
  - Water and land requirements, wildlife corridors, pollution from burning, water pollution

Src: Arndt, Msangi & Thurlow (2010): “Are biofuels good for African development?”

Farm Scale: Jatropha

- Drought resistant shrub
- Non-edible seeds; leaves toxic to humans and animals
- Yields under marginal conditions are low; role of extension, supply chains
- Better yields with irrigation and fertilizers
- High labor costs

High labor costs for jatropha biodiesel

Table ES.1 Estimated Biofuel Production Costs in Sub-Saharan Africa
US$ per liter

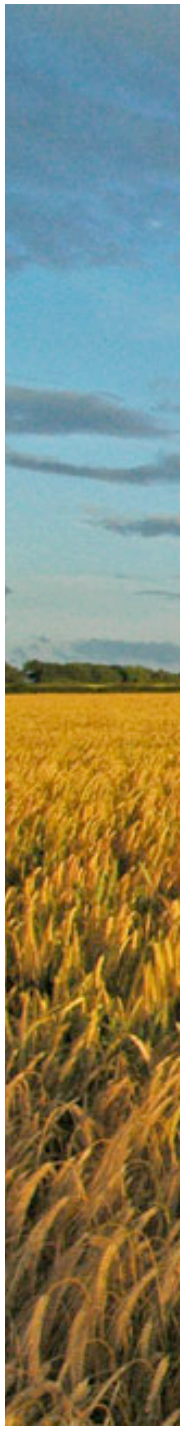
Biofuel	*Production cost*
Ethanol from molasses in an integrated plant	0.20
Ethanol from sugarcane in a state-of-the-art plant	0.50
Jatropha oil from the following sources:	
Collected seeds for village processing and use	0.42
Collected seeds for central processing	0.80
Plantation at US$2.00/day wages	0.63
Plantation at US$3.00/day wages	0.75
Plantation at US$4.00/day wages	0.87
Biodiesel from jatropha oil in a small-scale plant	0.11
Biodiesel from jatropha oil in a large-scale plant	0.08

Source: Author's calculations.

Src: Mitchell (2011), Biofuels in Africa

Organization of the Value Chain

- Lease land to biofuel companies
- Employment on estates
- Outgrower contracts with processors
- Extension and supply chains



Attracting foreign investment: What will it take?

Government commitments for:

- Land (mostly state controlled)
- Infrastructure: roads and ports
- Policies: support prices, no tax on biofuel revenue or exports
- Mandate for secure share of domestic market

Land Sales and Leases

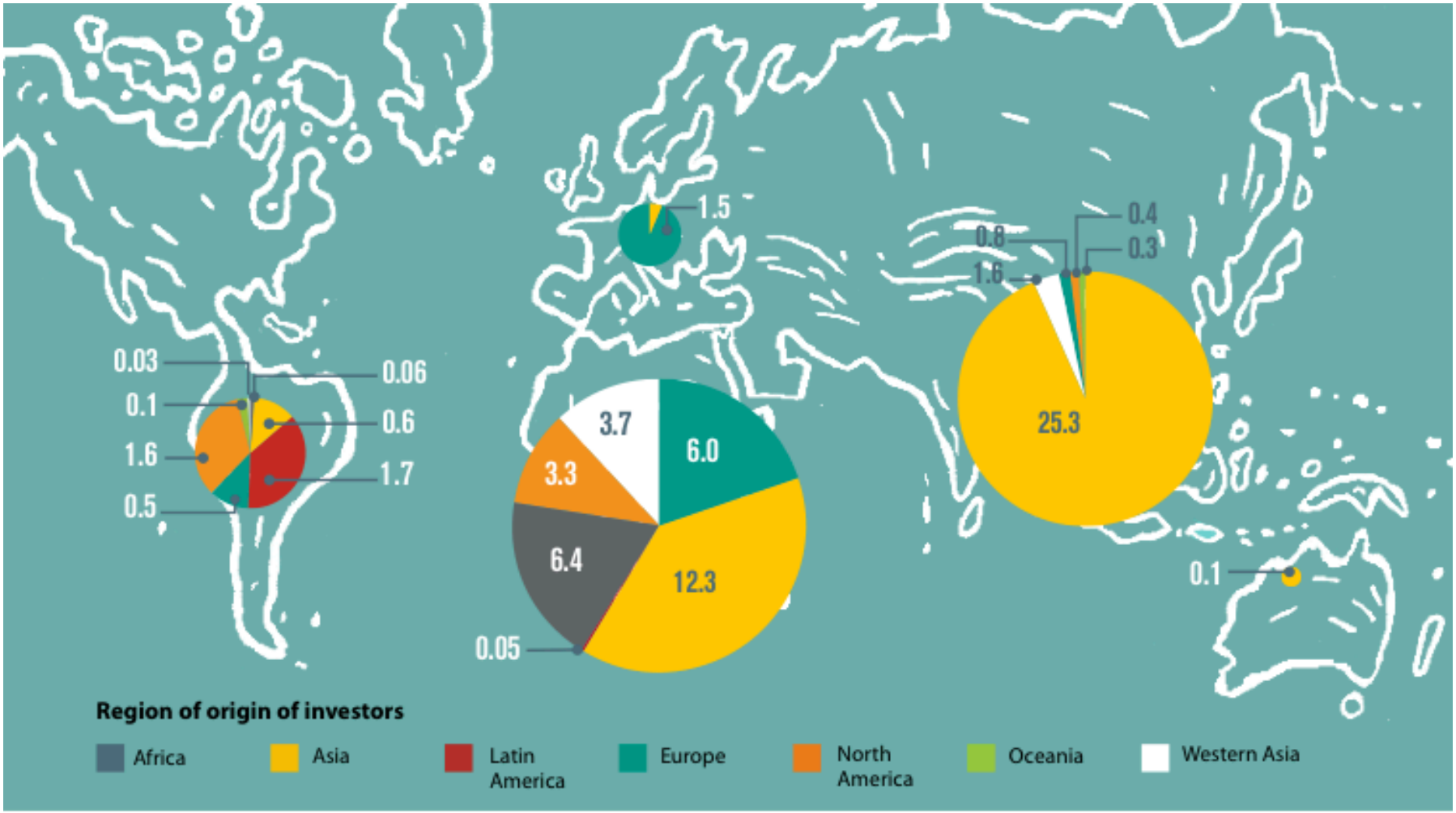
Variation in Key Land Institutions in SSA

Senegal	Mozambique	Tanzania	Zambia
Constitutional Right to Own Land as Individual	State Owns All Land Constitutional Right to Use and Benefit	Constitutional Right to Property but Not Real Property	Constitutional Right to Property but Not Real Property

- Mozambique uses ~10% of its arable land
- By 2009 it had received requests to buy or lease 12 mil ha for biofuel production
- 1997 Land Tenure Law: Aggressive law to protect customary land tenure, and to ensure consultation with communities prior to sales
- Mixed success on implementation

U.K. biofuel investment

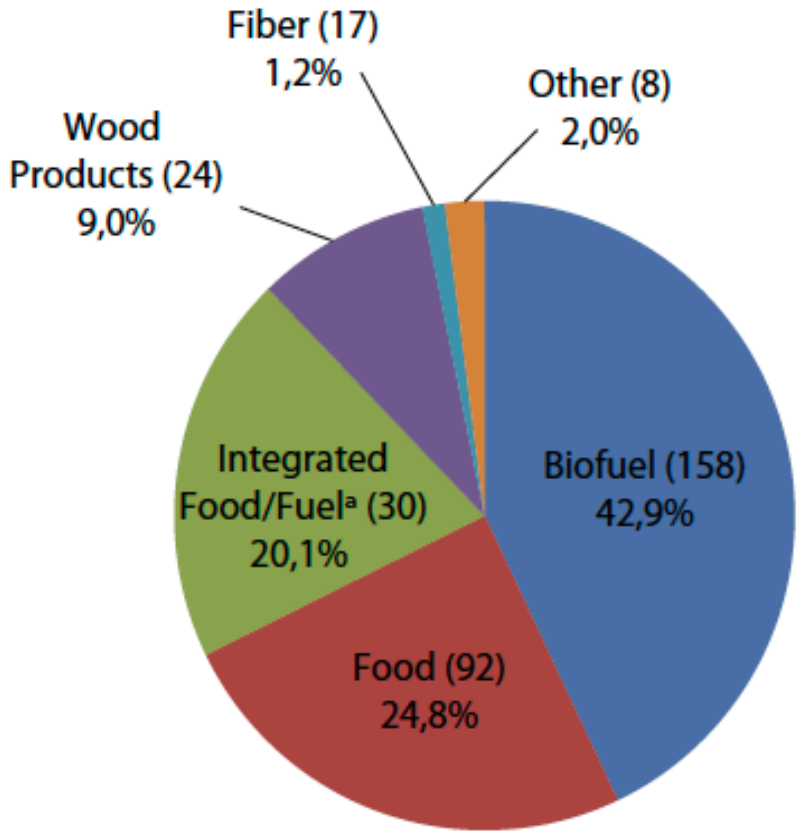
Investments in Agricultural Land



Source: Land Matrix

Numbers show millions of ha purchased.
Src: International Land Coalition, 2011 (http://www.landcoalition.org/cpl/CPL-synthesis-report)

Of the agricultural land in SSA purchased…



n = 329, ∑ha = 17 808 194

Figure 4. Primary type of end-market, proportion of total land area

Src: Schoneveld, CIFOR (2011)

Biofuels and Water Resources

Castor oil production: Ethiopia

- Over 800,000 ha devoted to biofuels
- Growing number of private projects
    - small/large plantations, outgrower schemes
- Long-established state ethanol project
- Government supports development of biofuel supply chains

Implications for rural incomes and food security

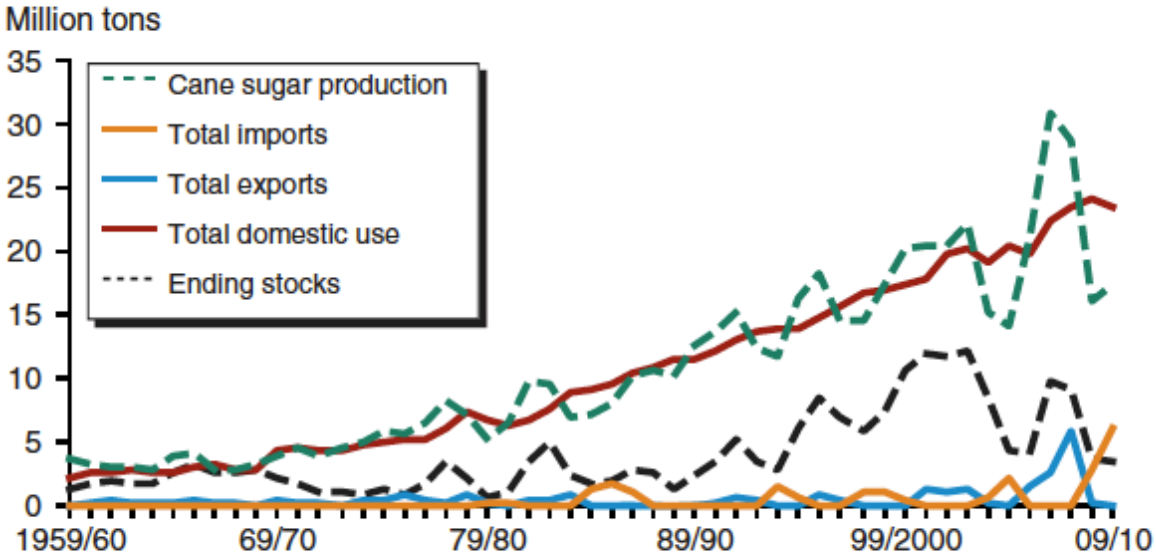
India's National Policy on Biofuels (2009)

- Target of 20% blending for both ethanol and biodiesel by 2017
- Focus on non-food crops
- Minimum purchasing prices for ethanol and biodiesel
- Minimum support price for jatropha seeds
- Minimizes taxes and duties on ethanol and biodiesel, unlike other transportation fuels

- Blending target for molasses-based ethanol difficult due to volatile sugar production

- Land ownership laws prevent vertical integration (blenders investing in feedstock; mills cannot own land); mostly small-scale producers

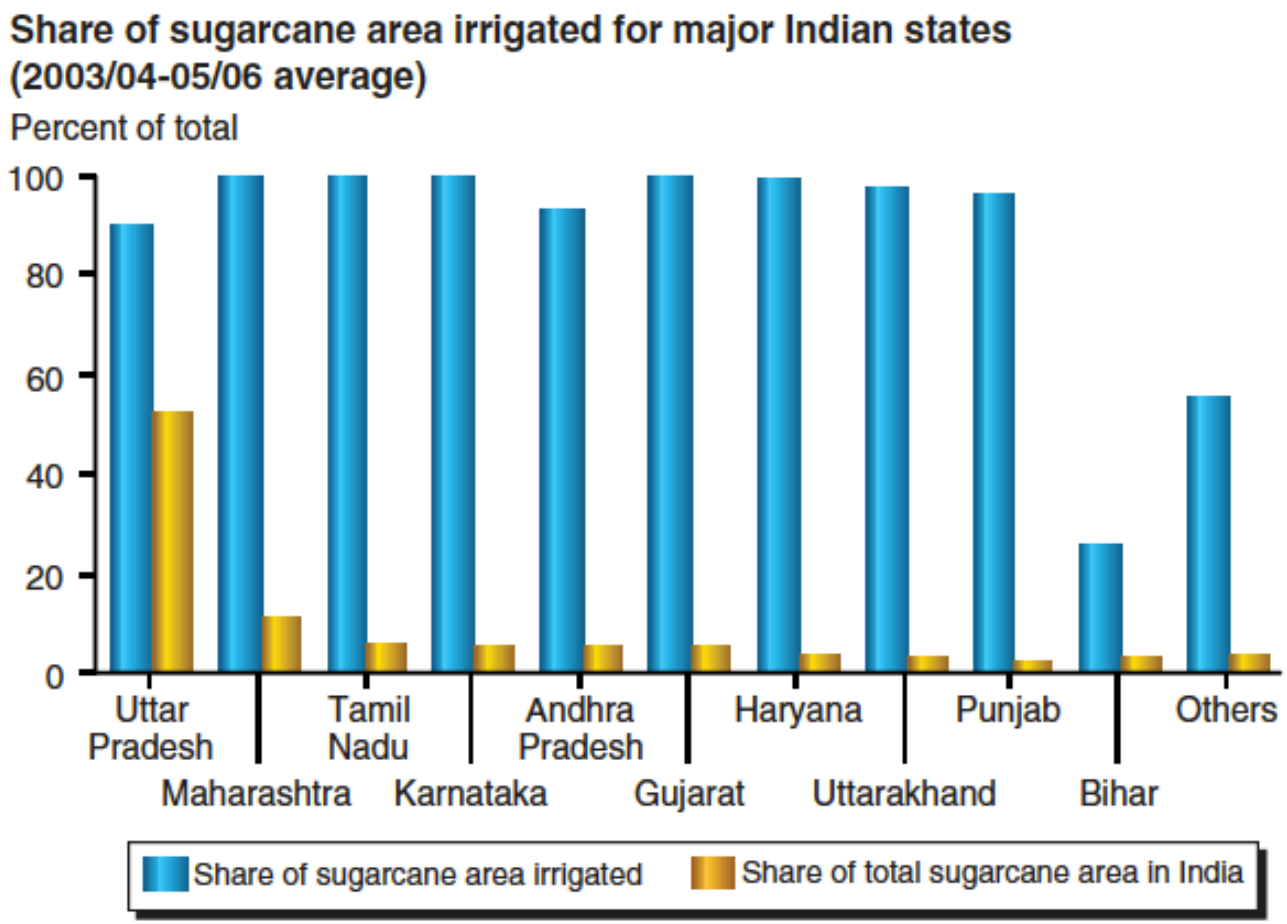
Supply and use of centrifugal sugar in India (October/September marketing years)



Source: USDA, Economic Research Service using data from USDA, Foreign Agricultural Service, PS&D Online.

Src: USDA/ERS, SSS-M-260-01, April 2010

Enough water for ethanol production?

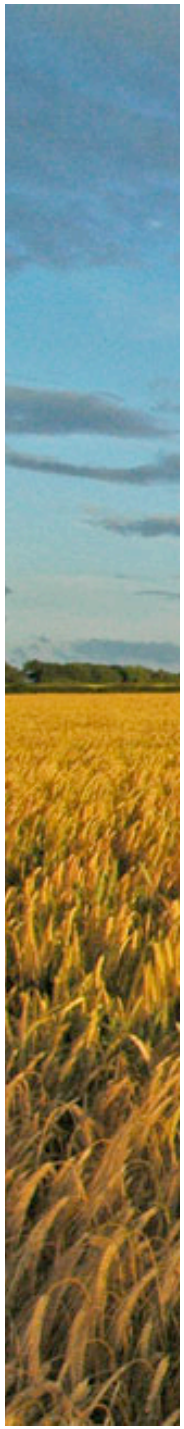


Source: USDA, Economic Research Service using data from Government of India, Ministry of Agriculture and Cooperation, Directorate of Economics and Statistics; and USDA.

Src: USDA/ERS, SSS-M-260-01, April 2010

Jatropha and Biodiesel in India

- Mix of private and public initiatives, large and small
- Supply chains vary by state; variation in access by poor
- 13.4 mil ha of available degraded land; yields uncertain



Conclusions: Biofuel Mandates

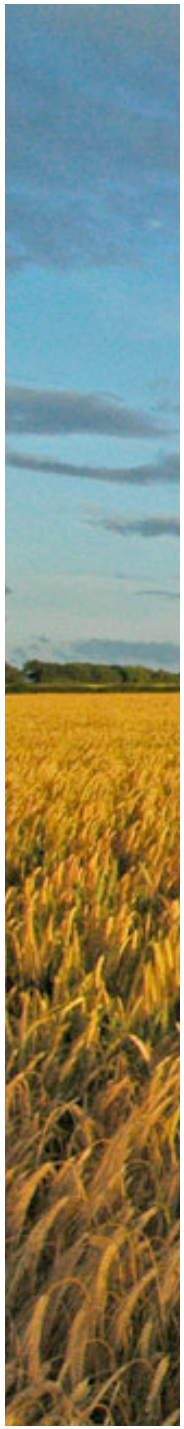
Global food price level and variability

- Own and cross price effects
- Land and water constraints

Implications for trade

- Inefficient trade pattern (U.S., Brazil)
- Export opportunities for SSA (duty-free access)

Role of co-products



Conclusions: Rural Development in SSA & India

Land acquisition ("land grabs")

- Estate vs. smallholder (outgrower)
- Land values and speculation

Water resources

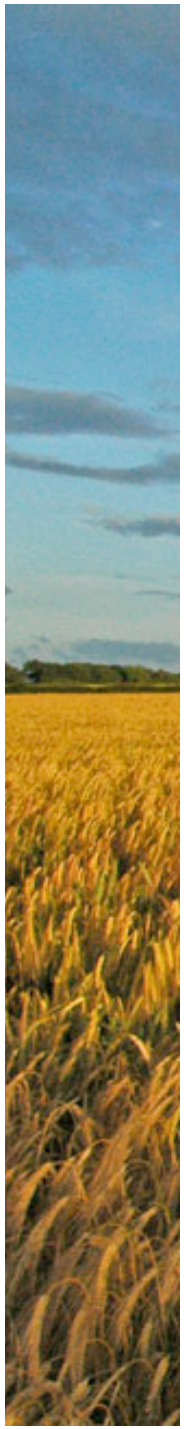
- Biofuels vs.food production

Macroeconomic implications

- Infrastructure development
- Policy (biofuel support, fiscal implications)

Governance and institutions

- National vs. state jurisdiction
- Multiple ministry oversight
- Institutions governing supply chains, extension, wage/income



Areas For Further Study

Land institutions in SSA countries

Macro- and micro-linkages in biofuels development

Food security implications

- Availability, access (income, price), stability
- Food gaps, role of women's labor

Thank you