



INTERNATIONAL FOOD  
POLICY RESEARCH INSTITUTE  
*sustainable solutions for ending hunger and poverty*

# Biofuels, Agriculture and Food Security: Key Connections & Challenges

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+ Others

Seminar & Discussion  
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# Objectives of Presentation

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- Describe the motivations and objectives of IFPRI's work on biofuels
- Discuss linkages between biofuels, food prices, poverty and food security – from various studies by IFPRI and other collaborators
- Discuss the cases of India and China in the context of the 'Biofuels & the Poor' project
- Discuss the challenges to modeling biofuels and its linkages to agriculture and the environment, within the context of ongoing efforts at IFPRI and potential for future collaboration

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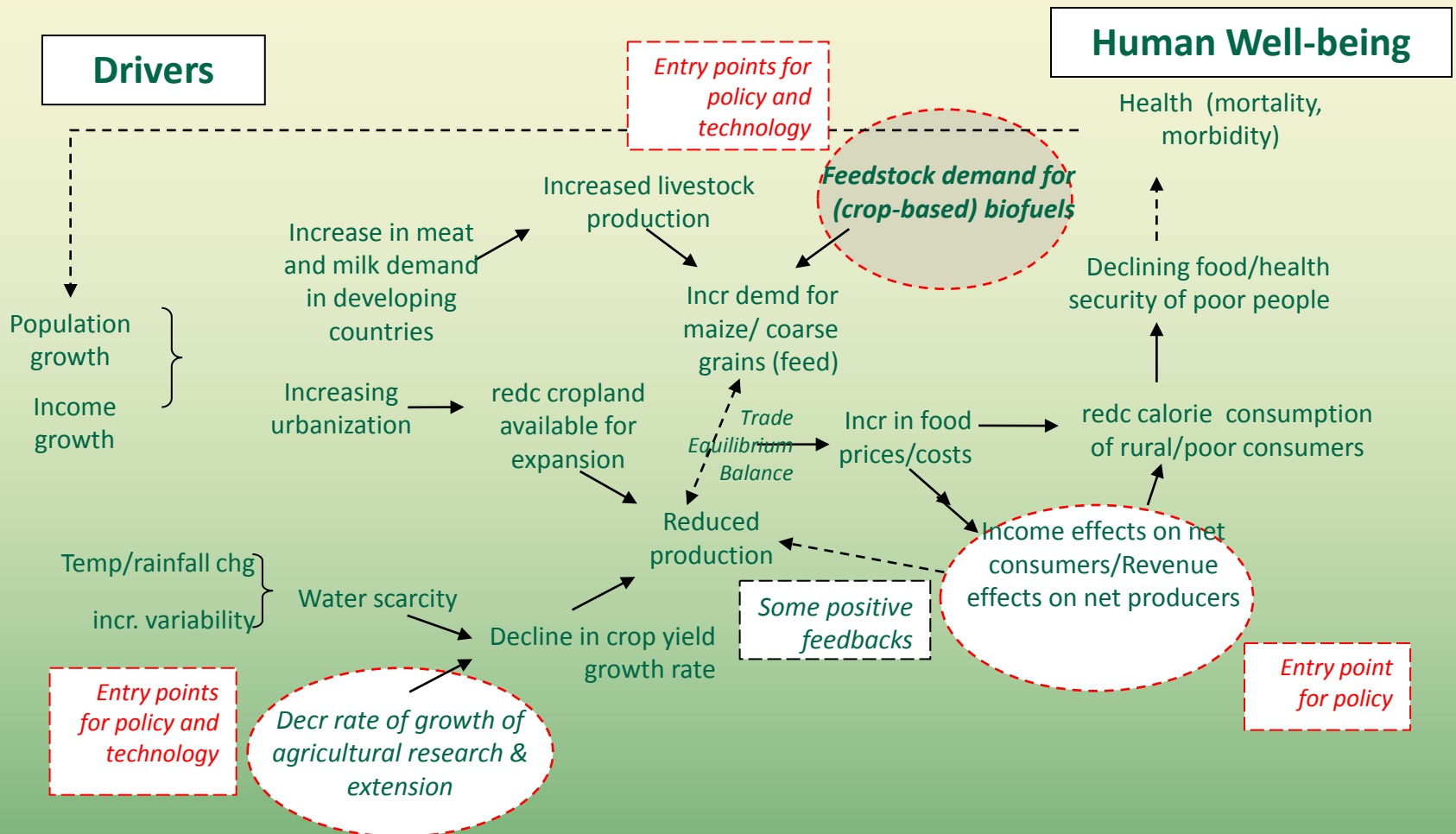
# **Where/why IFPRI started on biofuels-related work**

# Biofuels within the Context of Global Change

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- Many of the 'drivers' of change that we consider in our research work on future agricultural growth relate to socio-economic & environmental change
- The dynamics of food and energy markets are closely linked
- Demand-side pressures on food and feed supplies, from socio-economic growth are now joined with energy demand from agriculture (i.e. biofuels)
- Policy developments in the US and EU have been the main drivers behind worldwide growth in biofuels demand -- now there are concerns of sustainability

# Biofuels and other Drivers of Change



# IFPRI's contributions towards the debate

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- Bringing in the human well-being aspect that is often overlooked in the literature and public debate
- Putting the discussion on biofuels squarely within the discussion of agriculture and what's needed to feed the world to 2020, 2030 and beyond
- Discussing – both land and water use changes as well as overall eco-system health
- Identifying opportunities for biofuels investments to contribute to increased value-added and growth in agriculture – and where there might be some tradeoffs

# IFPRI's work has been evolving....

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- Started out in 2006 with analysis done (quickly) to support a series of 2020 briefs coming out on biofuels and agriculture (Hazell & Pachauri, eds.) – starting from scratch
- Then responding to requests for analysis on how biofuels might play a role in the food price issue
- Growing interest in the “land-grabbing” phenomenon
- Now more interest in the environmental sustainability aspects of biofuels, and what the ‘indirect’ land use change effects are of US and EU policy
- But the linkages with food security are still there....

# Moving from global to country-level

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- Our initial analysis has been at the global level (to address questions of biofuels and world food prices)
- More work going on at the country-level
  - ‘Biofuels and the Poor’ project has 3 case study countries – Senegal, India and Mozambique (all of which have IFPRI country/regional offices/programs)
  - IFPRI working with FAO – and also with ZALF (Germany) on Tanzania, which have both country- and village-level modeling/analysis
  - Working with collaborators looking at SADC region (Univ. College Cork, Michigan State Univ.)
  - Oxfam America have collaborated with us on Africa



# Potential pathways to have influence

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- Remain engaged with the wider research community on how biofuels affects food markets
- Engaged in discussion on the environmental dimensions of biofuels (in EU & US) – which can help contribute towards better policy design
- Potential for influence & impact at country-level
  - Our work in Senegal has the potential to have great influence and impact – their policy is in its infancy
  - India – no longer seem ‘sold’ on the idea of biodiesel from jatropha – but there are some inconvenient truths that need to be addressed in the local policy
  - Work on food security/poverty aspects still very weak

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# Biofuels and Food Prices

# Linkage between biofuels and prices

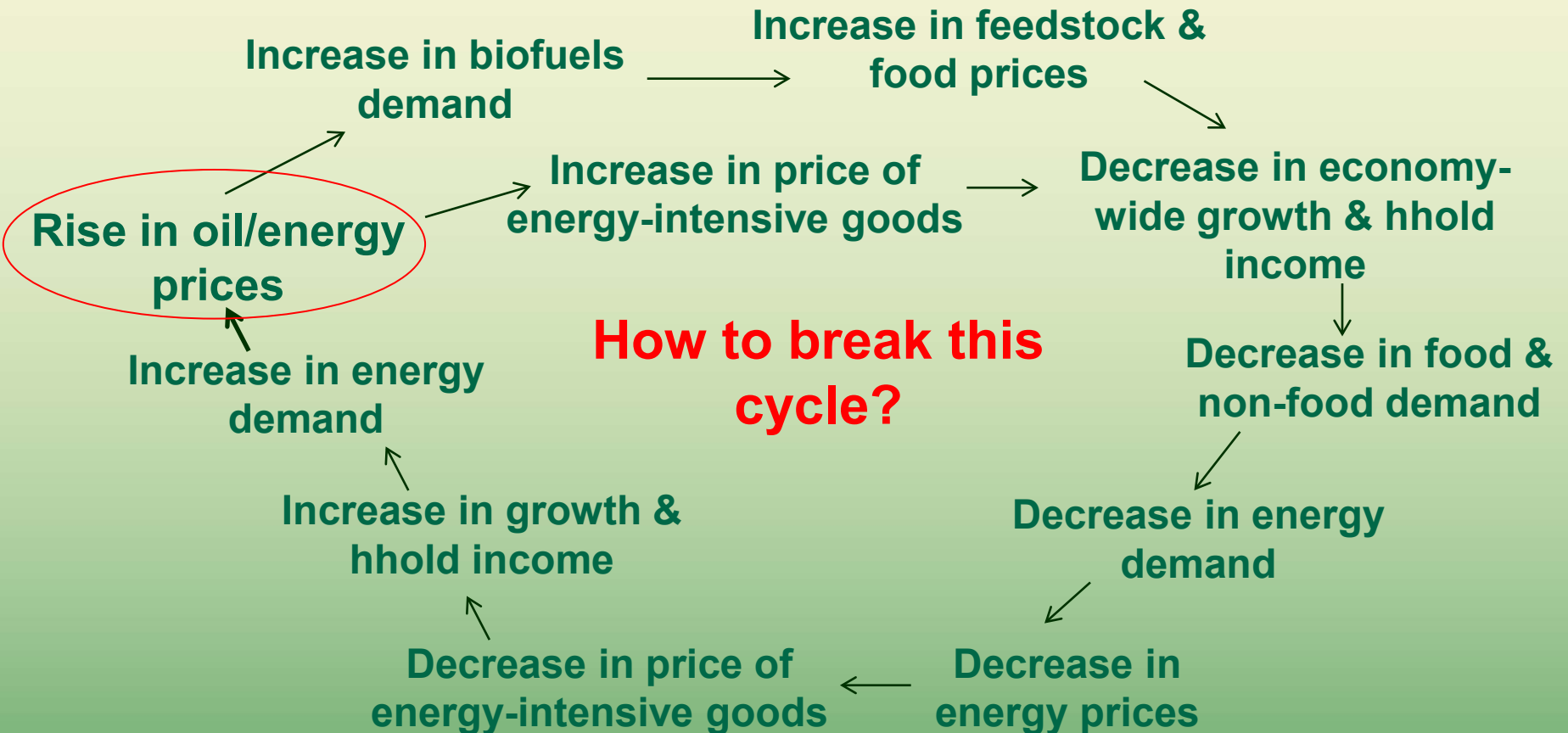
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There is a very relevant linkage between the price of oil and the dynamics in agricultural markets

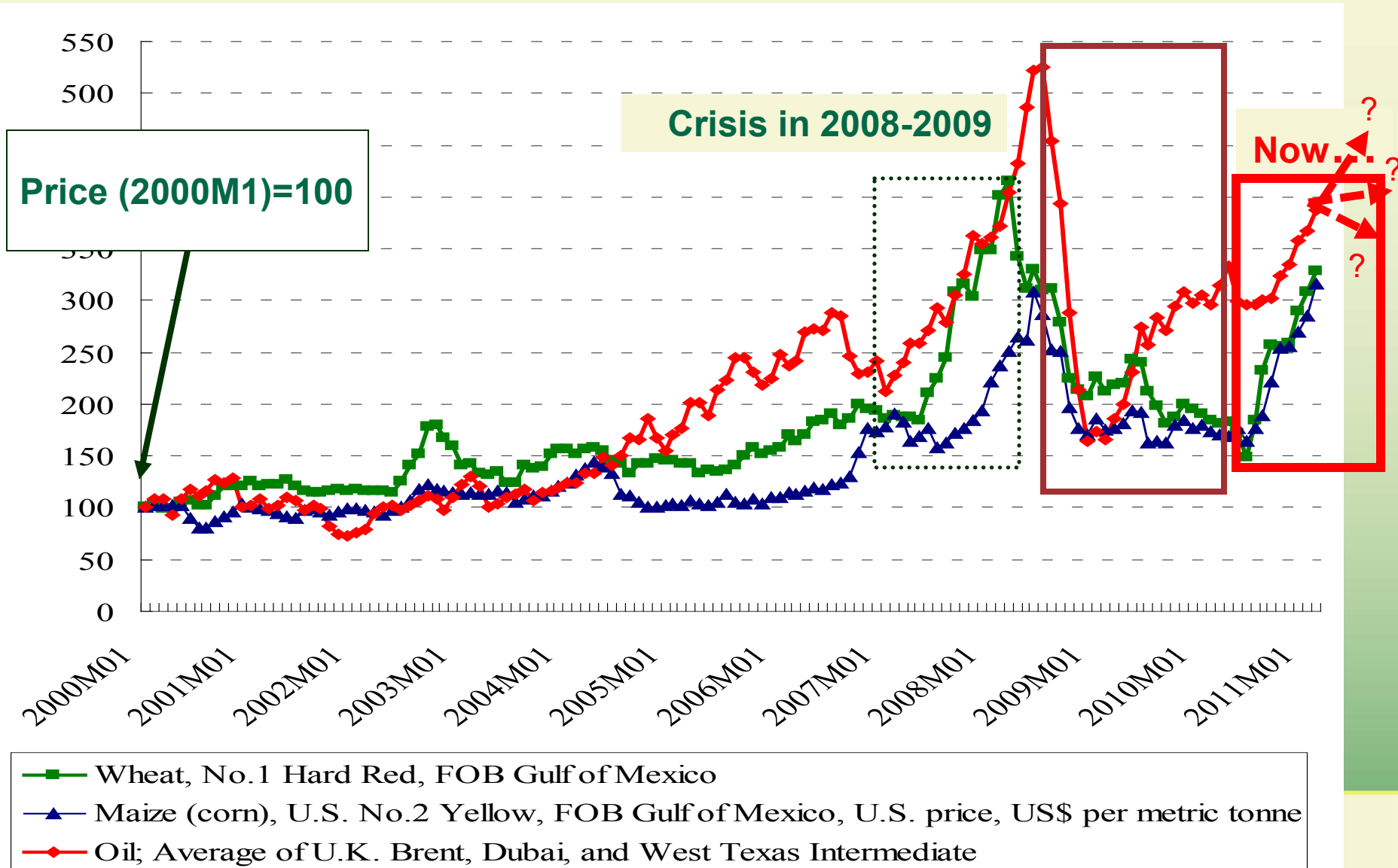
- The fast growth in US ethanol production before 2008 may have had less to do with tax credits than the high price of oil which made huge returns on investment (Babcock, 2011)
- The effects that high oil prices have on economy-wide growth and demand reinforce the ups-and-downs of food and fuel demand shifts – which could underlie future volatility
- Price rises can be positive for farmers – as long as they are gradual and sustained ( to allow supply response) – rather than short spikes, which really hurt consumers
- Although ag markets do have much less influence on energy markets than vice-versa – there are notable impacts – the high sugar prices has caused Brazil to produce less ethanol, which the US now exports

# Cycles of boom-and-bust

Oil & energy prices likely the biggest driver of future dynamics



# Prices of oil and grains are still moving together...and will continue to do so...



# Rising Food and Energy Prices

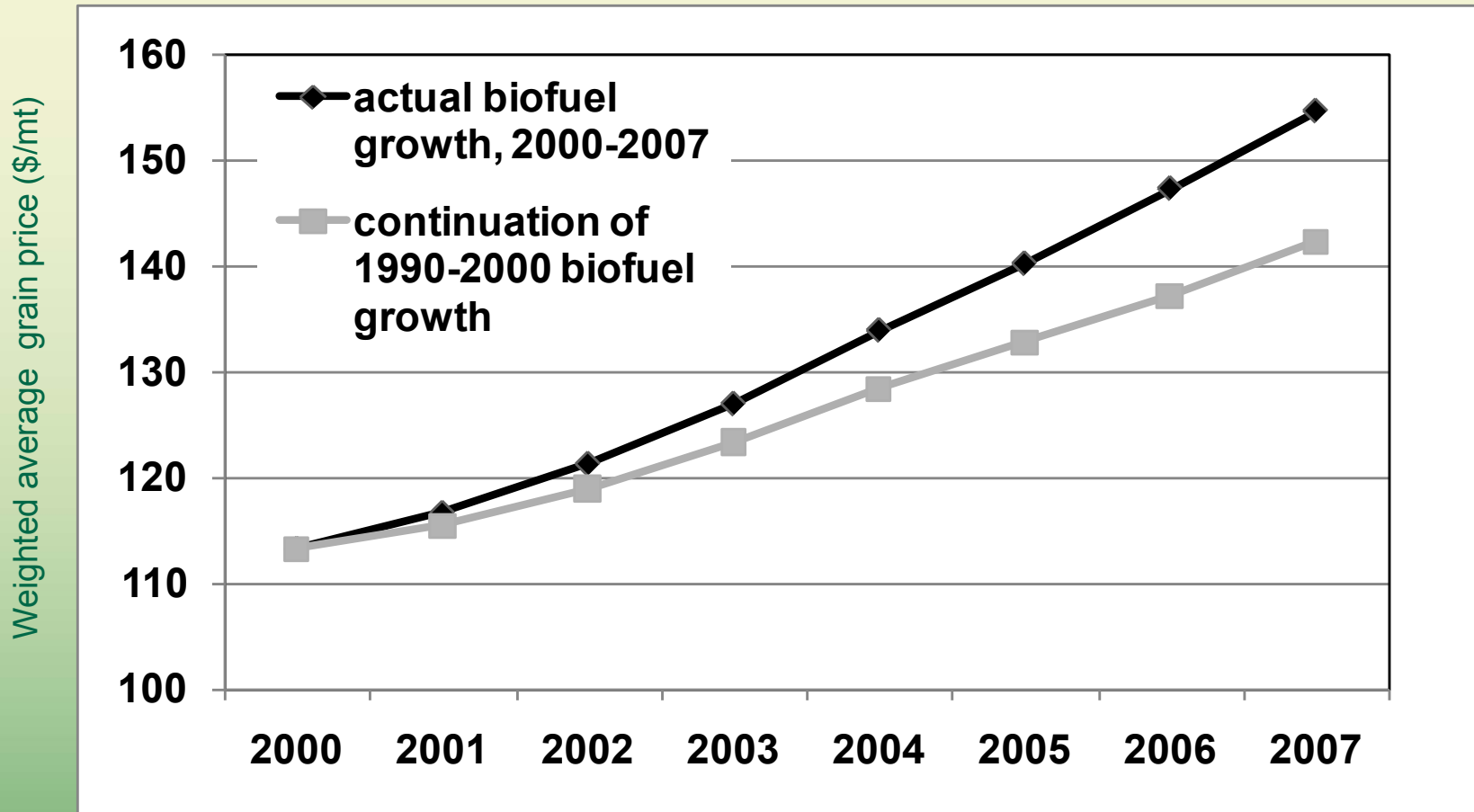
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Upward pressures on food and energy prices is still a concern in terms of what it means for global food security and the welfare of the vulnerable

- The 'drivers of change' are diverse – ranging from environmental to socio-economic changes
- The connection with biofuels (esp. US maize ethanol) is still there (....although the 2007-08 situation, differs from what has happened more recently)
- While higher food prices is still good news for producers, there are many poor net consumers whose well-being is threatened

# Biofuels counterfactual simulation for grain prices

30% difference in 2000-07 change in avg grain price



Source: IFPRI IMPACT projections ( Rosegrant, 2008)

# Our results compared to others

	OECD	IMPACT	FAPRI <sup>4</sup>	WEMAC
<b>World:</b>				
Maize: World price	14.6%	16.1%	---	52.6%
Maize: World production	2.9% <sup>1</sup>	4.7%	---	---
Sugar cane: World price (raw)	37.1% <sup>2</sup>	3.4%	---	---
Sugar cane: World production	7.4%	1.1%	---	---
Vegetable oil <sup>3</sup> : World price	15%	0.4%	---	---
Vegetable oil <sup>3</sup> : World production	2.6%	0.1%	---	---
<b>Maize:</b>				
Maize: US producer price	---	16.1%	16.2%	49.6%
Maize: US production	---	5.0%	5.8%	18.9%
Projection period	2008-2017	2000-2020	2011-2017	2006-2015

<sup>1</sup> World production of coarse grain, instead of maize, is reported.

<sup>2</sup> World price of sugar, instead of sugar cane is reported.

<sup>3</sup> Vegetable oil, a composite reported for OECD (soybean, rapeseed, sunflower and palm oil) ; the oil item reported for IMPACT includes all oil products (oilseed oil, palm oil, etc.).



# Various reasons for the difference

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- We've tried to look at the key factors that we believe to be driving a significant share of the differences among the studies
  - **Partial-equilibrium model analysis**
    - Scenario design
    - Key assumptions and modeling approaches
  - **General-equilibrium model analysis**
    - Key model assumptions and parameters
  - **PE versus GE**
    - Fundamental differences in model structure
- Other studies have done similar work to explain LUC results (EC studies, AgMIP, etc.)

# Key Messages from the “Biofuels & the Poor” Project

- Biofuels *will* cause large impacts in the global market
  - Scenario: policy intervention, low oil price, low substitution
  - Price: US maize (↑14%), US Soybean (↑18%), Brazil Sugar (↑33%), EU Rapeseed (↑31%)
  - Production: US maize (↑15%), US Soybean (↑24%), Brazil Sugar (↑129%), EU Rapeseed (↑120%)
- Effects from biofuels will reach beyond the US, EU and Brazil
  - For example, under the policy intervention plus H-H scenario, the East Africa, West Africa, South African, India, and the Rest of South Asia regions will all export more of maize and wheat.
  - East Africa and India will reduce their export of rice and beef & mutton, while the Rest of South Asia region will boost its export of the two commodities by 48.5% and 10.6%, respectively.

# What role does biofuels have to play in the current situation with food prices?

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This time round, biofuels is more of a background factor than a driving cause of price increases – it conditions the response of markets to new shocks

- Evidence shows that the growth of biofuels production capacity in US has been stagnant since 2008 (the quick growth prior to 2008 has leveled...)
- Analysis of groups like FAPRI show that the US ethanol sector operates on a break-even basis – the early entrants got the big gains (& later ones lost....)
- The fact that it continues to consume such a sizeable share of corn prodn means that it matters

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# **The impact of OECD biofuels growth on the rest of the world**

# The impacts of OECD biofuels growth

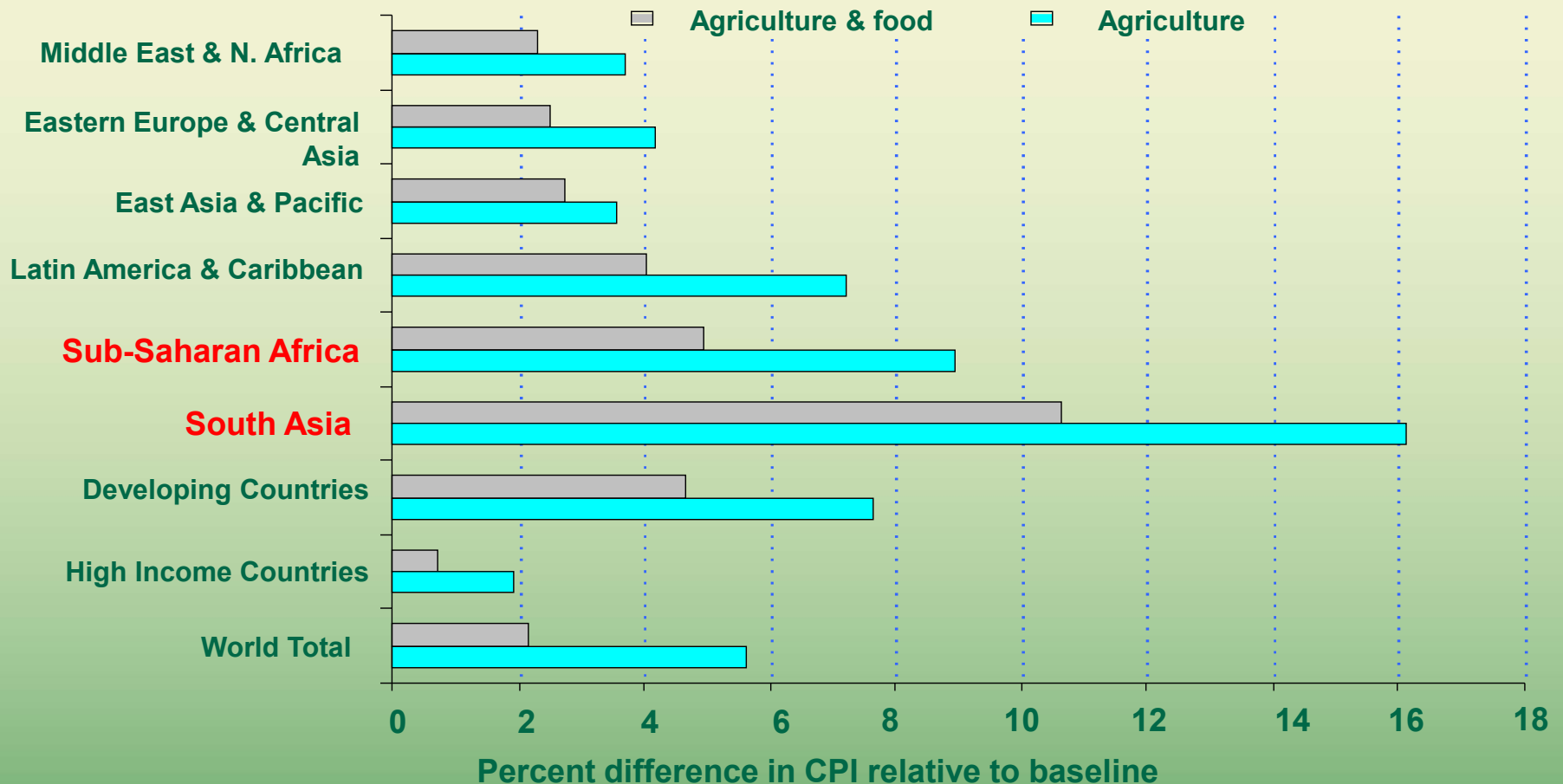
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The biggest biofuel-related impacts that India is likely to face, in the near-term are those coming from the rest-of-the-World (esp. US, EU and Brazil)

- These impacts will be transmitted through world markets in terms of decreased exports of biofuel feedstocks and higher world market prices
- These are part of the “impact pathways” that we’ve tried to describe in the ‘Biofuels & the Poor’ project
- We can quantitatively describe them through the results of global and country-level mkt equil models

# Impacts of biofuels growth on CPI & real income

From World Bank CGE analysis (de Hoyos & Medvedev, 2009)



# Impacts of biofuels growth on CPI & real income

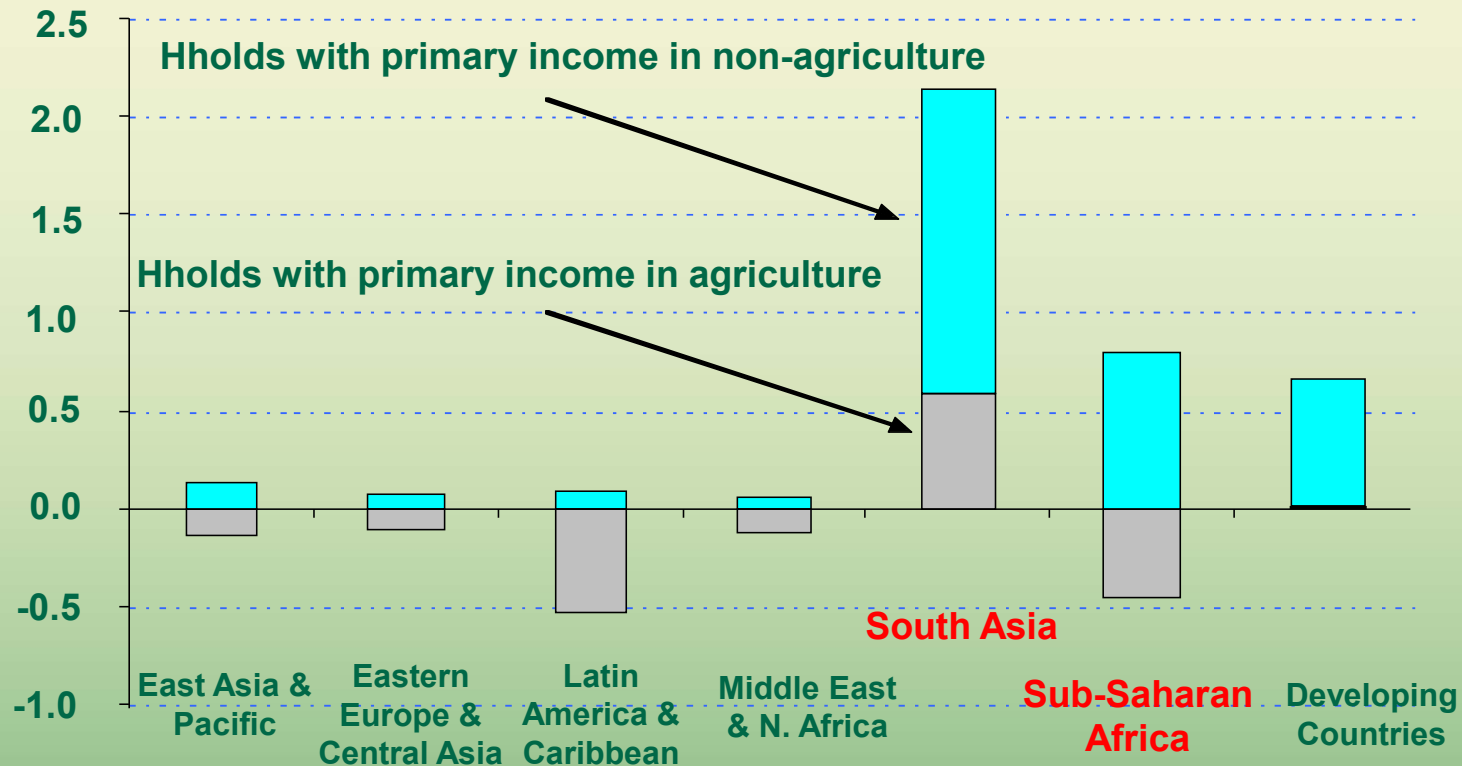
From World Bank CGE analysis (de Hoyos & Medvedev, 2009)

(percent change in 2010 relative to non-biofuels scenario)								
	Consumer price Index				real income			
	Agric.	processed foods	Agric. & food	All goods & services	% change		\$2004 million	
					hholds	national	hholds	national
India	19.8	5.2	13.5	5.7	-3.9	-5.5	-21,512	-54,105
Rest of South Asia	2.6	1.2	1.9	0.6	-0.5	-0.7	-1,026	-1,821

**Compared to other regions, South Asia & SS Africa suffer the biggest welfare losses in their analysis**

# Decomposition of biofuels poverty impacts

## Lower poverty impacts in So Asia for agricultural households

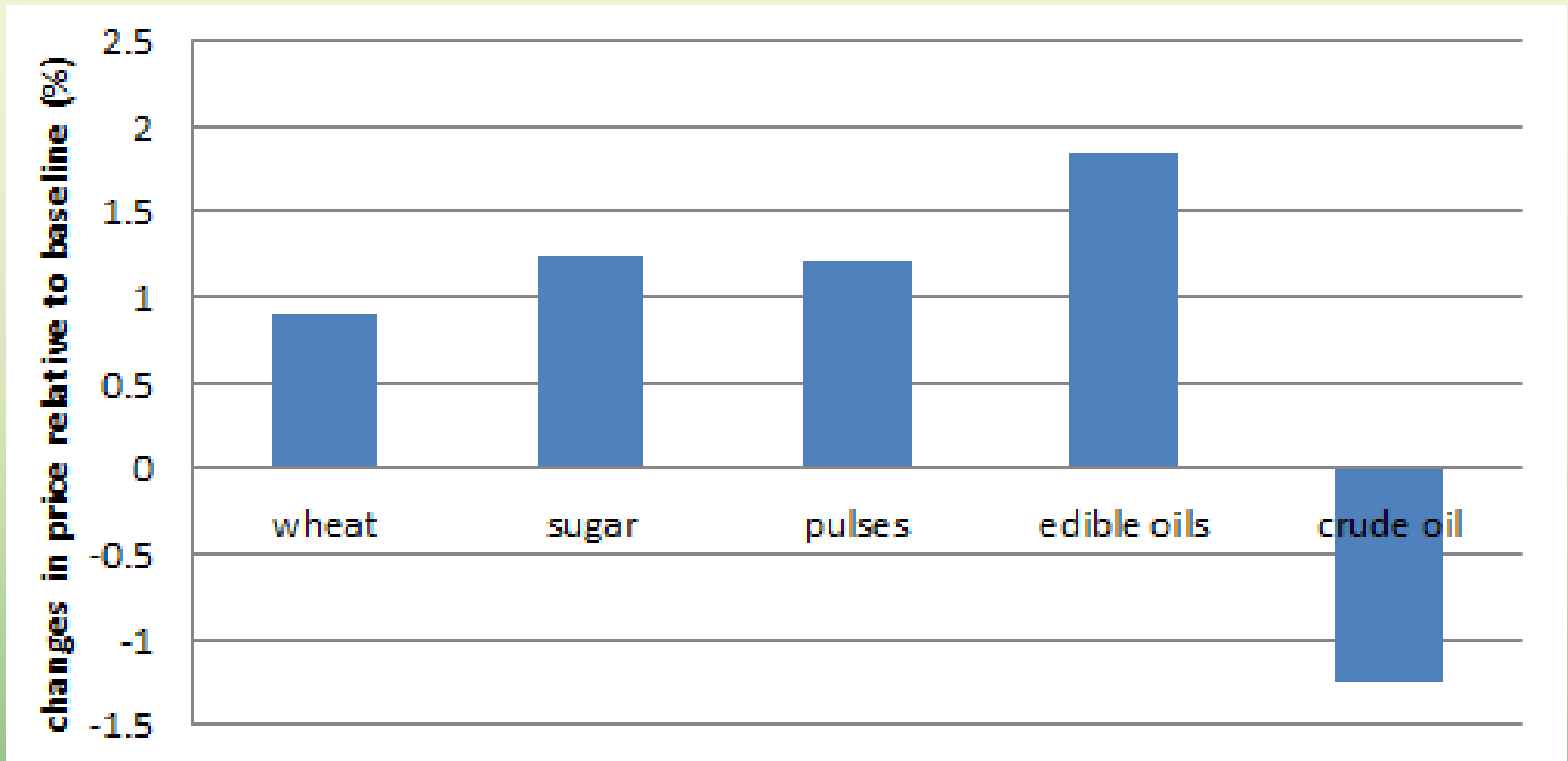


From World Bank CGE analysis (de Hoyos & Medvedev, 2009)



# From our own global analysis

These are world price changes of key Indian imports



From GTAP model analysis (Yang et al., 2011)

# Transmission to country-level

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Taking these scenarios from the global analysis done by our collaborators, with the global GTAP model – we impose them on the country-level model for India

- Since this is a partial equilibrium model, we don't get the full change to real income that comes from CGE-type models
- We are able to see how prices in various markets are affected
- Based on that, we can see which types of households get affected, in terms of farm revenue

# Multimarket modeling analysis for India

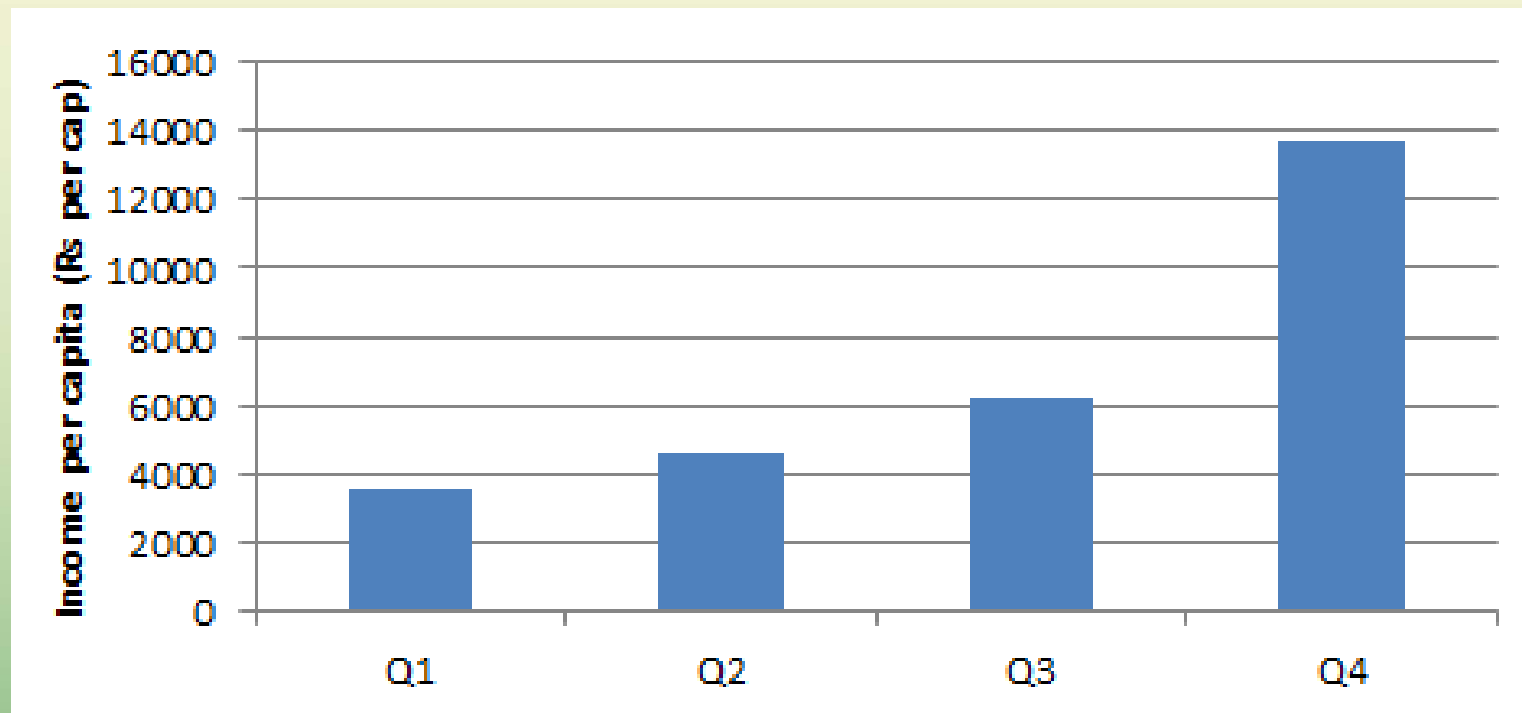
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In order to look at the price dynamics that come from interactions between food and energy markets, we built a special-purpose model for India

- Drawing from a long tradition of multi-market model analysis
- Parameterized the model with the best estimates of demand and supply response possible
- Had to simplify some relationships to better clarify the linkages and understand what is happening
- Gradually add back more detail as needed

# Distribution of per capita income in model

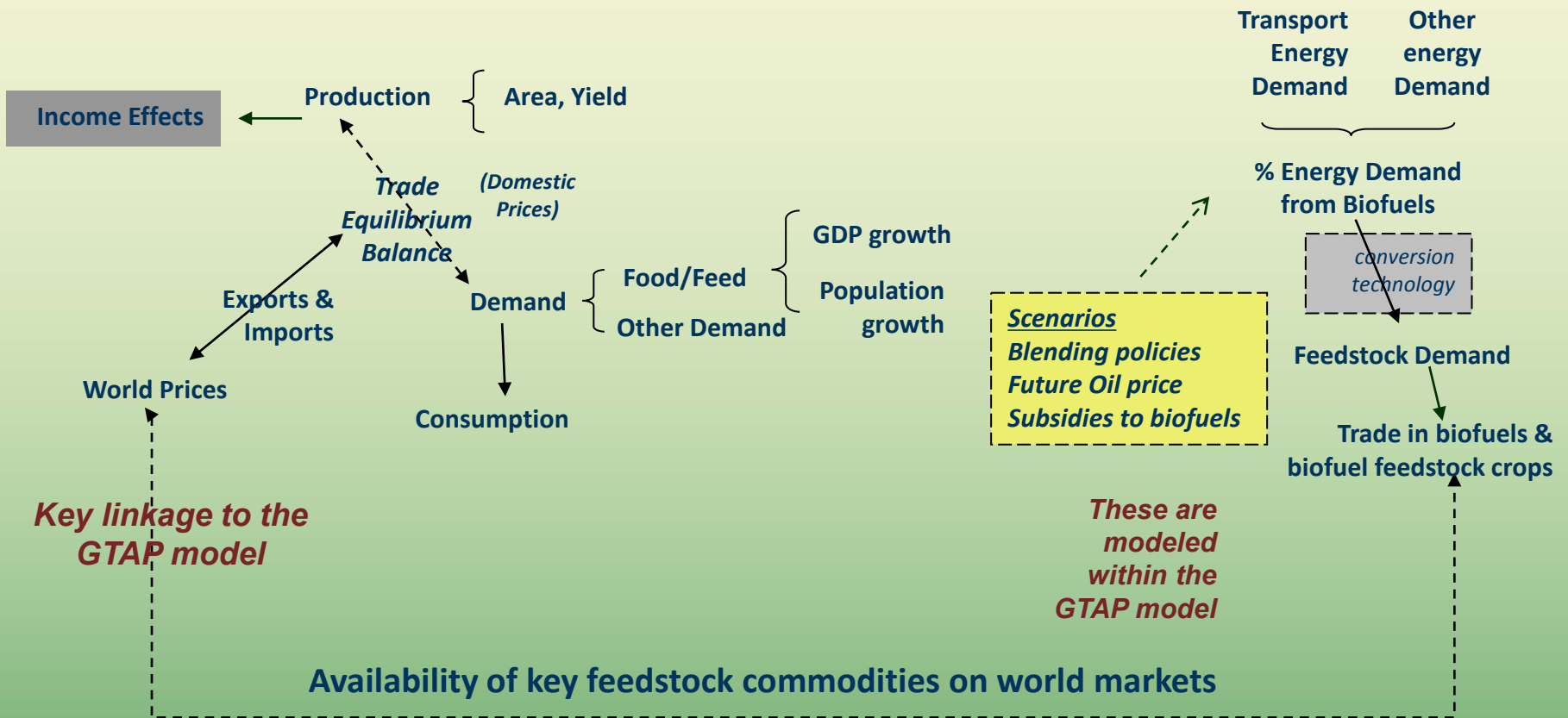
No clear urban-rural split – although likely more  
urbans in higher quartiles



# Simple schematic of model interactions

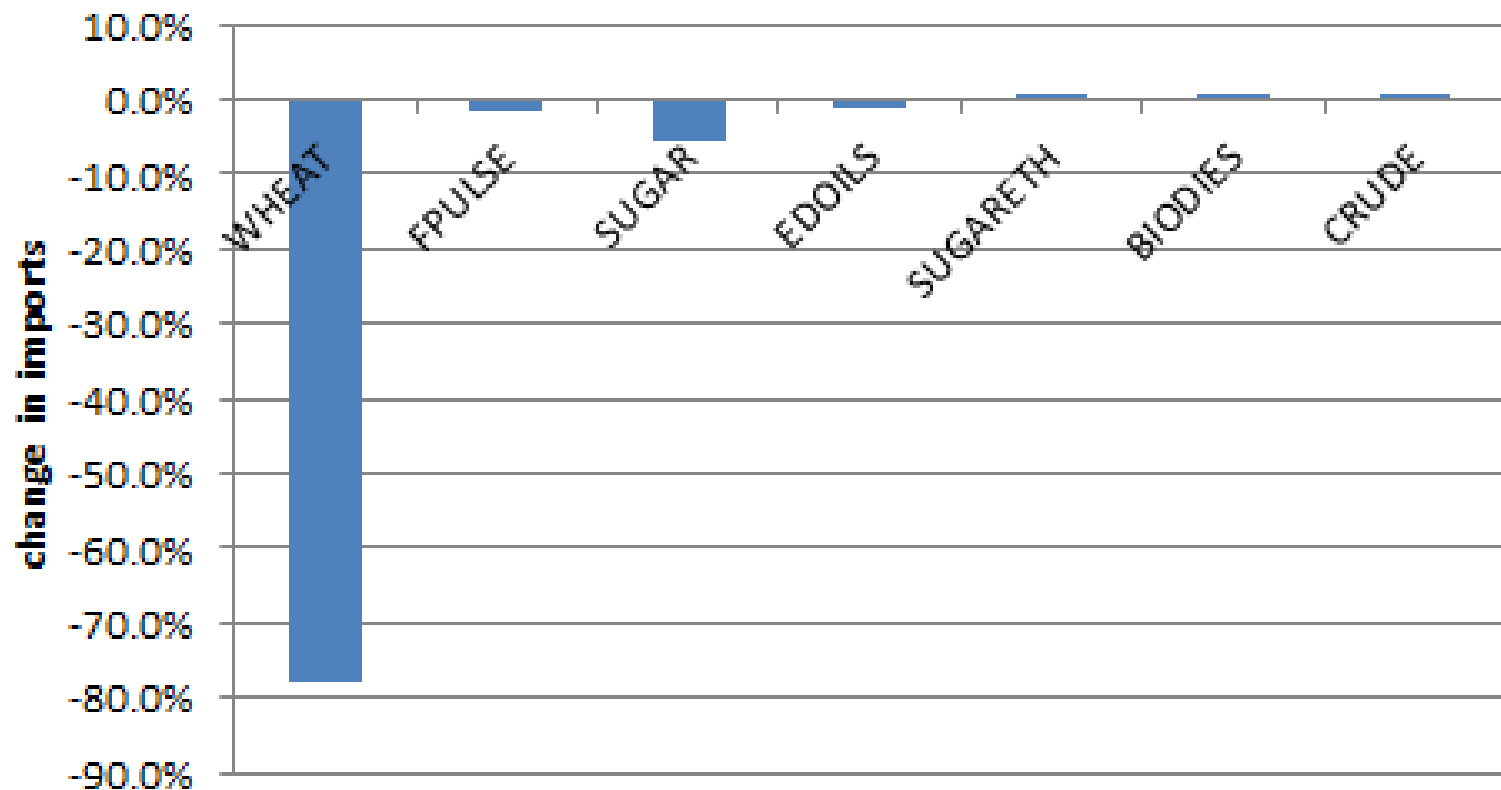
Modeled at country-level by PE multi-market model

Modeled at global-level by GTAP CGE model

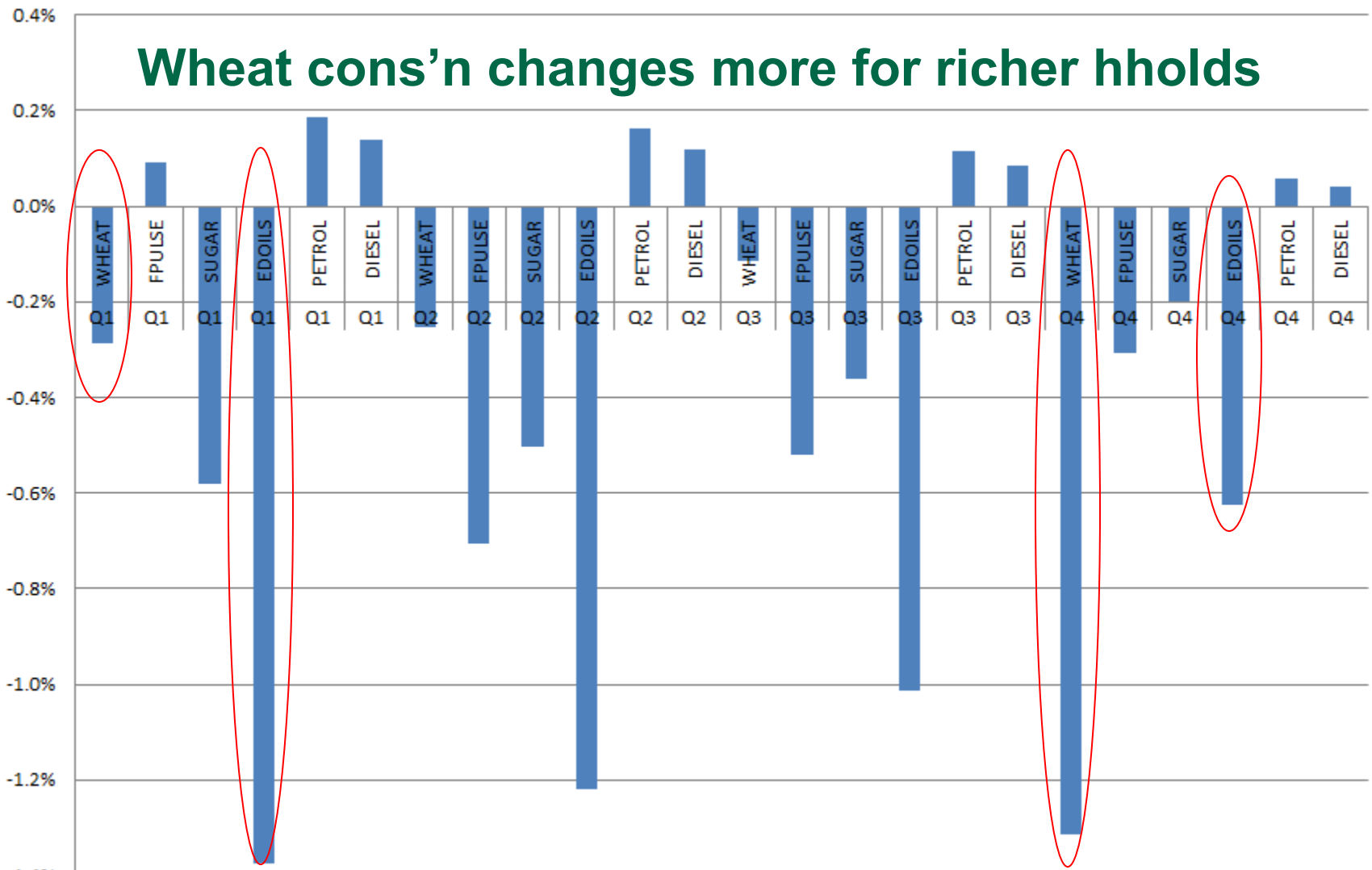


# Changes in imports due to shocks

Wheat sees the biggest % decline in imports  
Fuel product imports increase very slightly



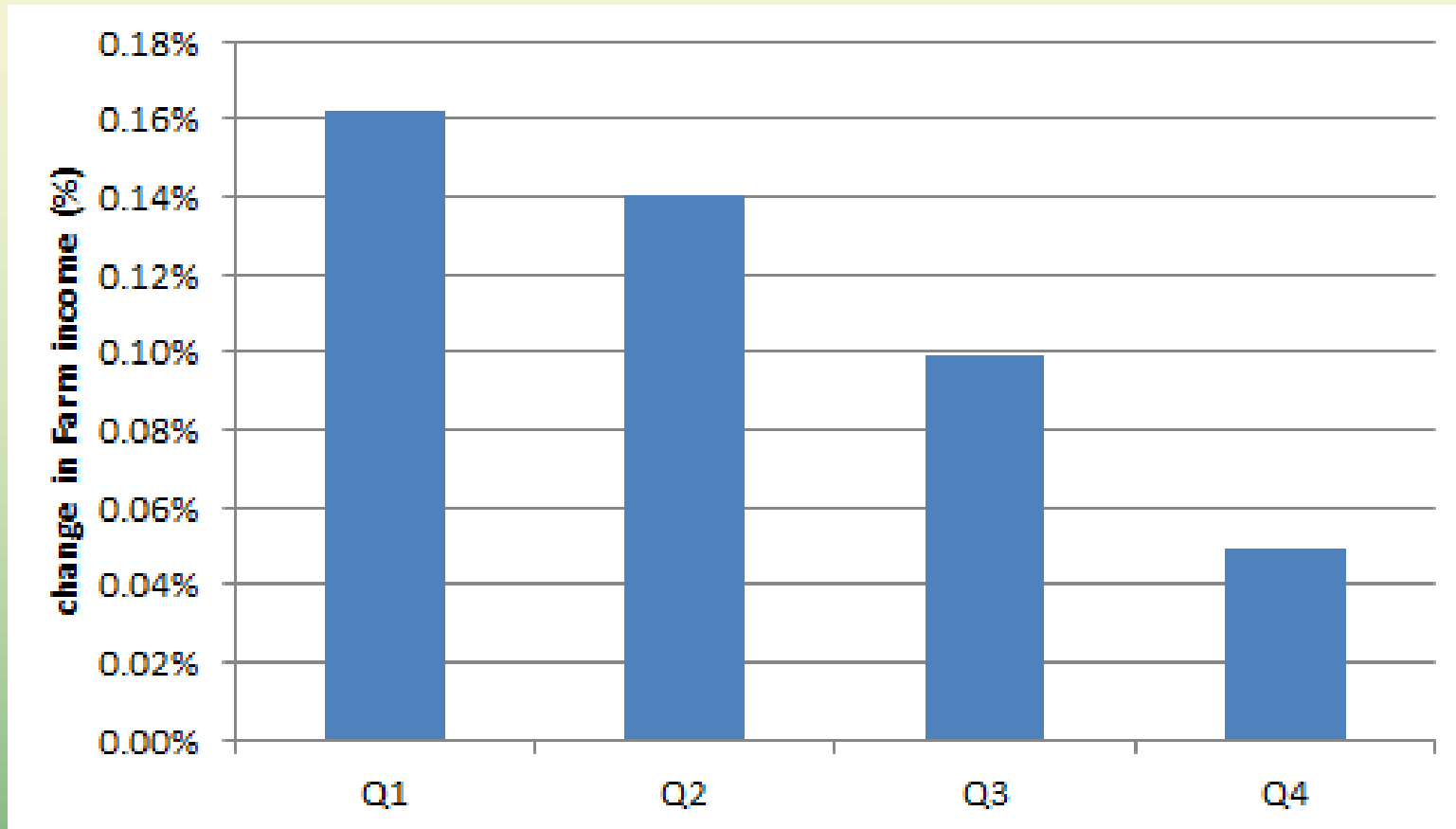
# Demand shocks on key imported goods



Oils & sugar cons'n impacted more for poorer hholds

# Changes in farm income due to shocks

## Poorer households benefit more from price increases





# Implications for Indian households

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We see consumption impacts differ across strata, as well as changes in farm income

- Since the richer households consume more wheat, their consumption goes down more
- Increases in oil & sugar prices (& import decreases) affect poorer households more
- We have not fully integrated livestock into this model, so there may be impacts from higher coarse grain prices that we are not seeing
- The food consumption of these coarse grains is low (unlike the case in SS Africa, f. ex.)

# Summary of biofuel impacts on India

Since the growth in the own-production of India will likely be slower than policy-makers hope – most biofuels impacts are likely to come from the outside

- The continued growth of OECD production of 1<sup>st</sup> generation biofuels from sugar, oils and maize will have impacts on India – especially sugar and oils
- The decrease in maize exports from US may provide an opportunity for Indian maize exports and benefit producers – although effect on livestock will be mixed
- Didn't show a very clear division between rural and urban in country analysis – but we know urbans tend to lose (since they're net consumers of everything)

# The outlook for biofuels in India

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In contrast to the other case study countries considered in the 'Biofuels & the Poor' project, India clearly has an existing value chain for biofuels

- There are some policy actions that are needed to close some gaps, however.
- In terms of ethanol, the stability of the supply is the main issue – even without blending with petrol, there is a market for it (both internally & for export)
- In terms of biodiesel – jatropha is not yet ready to take off at large-scale & there are not many feasible alternatives (may need a re-think at the policy-level)

# The impact of biofuels on India

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Regardless of India's internal policies, biofuels growth elsewhere will continue to have an impact on hholds

- This is unavoidable since India is a net importer of many of the feedstocks that are being used elsewhere (esp. oils, sugar)
- In future, many of these shocks will come at the same time – since higher oil prices will lead to greater profitability (and demand for) biofuels elsewhere – which will push up feedstock prices
- Like elsewhere, the linkage of energy to food markets will bring about new cyclical dynamics

# Looking at the case of China

Another large and fast-growing country, like India – but where domestic biofuels growth has grown more strongly

- Unlike India, China pushed biofuels growth aggressively from the most productive feedstocks (initially not worrying much about the food-fuel competition)
- In 2007 China decided to halt the growth of ethanol from grain-based feedstocks out of concerns from food prices
- In the ‘Biofuels and the Poor’ project – we did a similar *ex ante* impact analysis of biofuels linking the results of a GTAP-based model to a detailed country-level, multi-market model for China (CAPSIM)

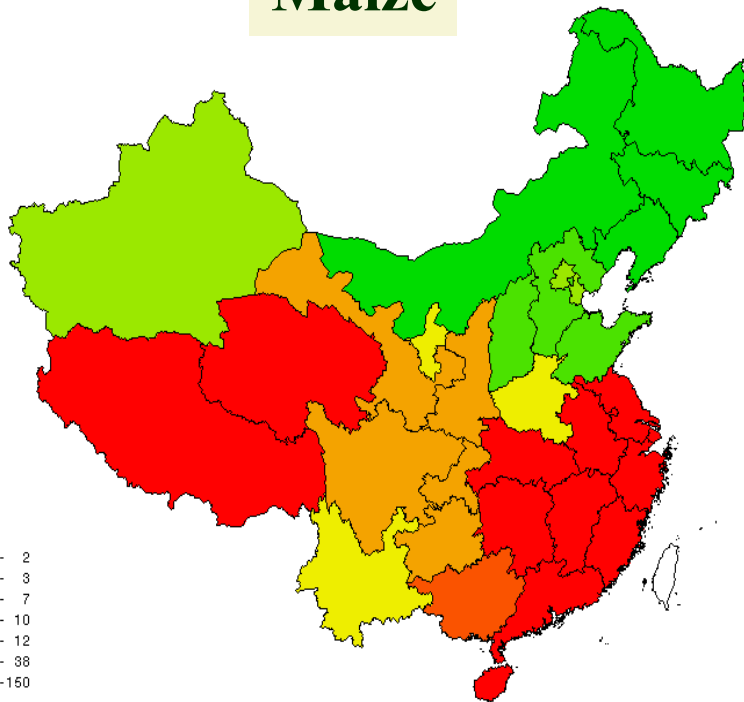
# Impacts on output, net export and domestic price under aggressive scenario (relative to baseline, 2020)

	Output		Net export	Price
	(1000 tons)	(%)	(1000 tons)	(%)
Wheat	-844	-0.8	1002	10.6
Maize	15179	8.8	21775	20.2
Soybean	1765	13.3	13708	27.6
Cotton	266	3.0	266	10.7
Veg.Oils	394	6.0	1820	15.7
Sugar	102	0.9	391	7.1
Pork	-2063	-3.2	-26	5.6
Beef	-160	-1.9	3	4.4

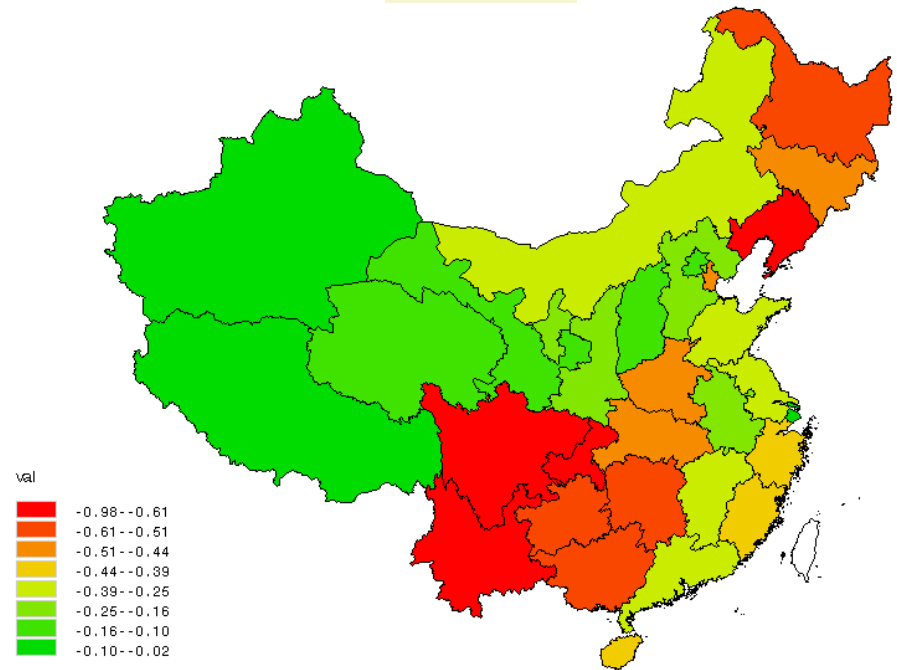
# Impacts of biofuel development on provincial maize and pork production (relative to baseline, 2020)

(kg/capita)

## Maize

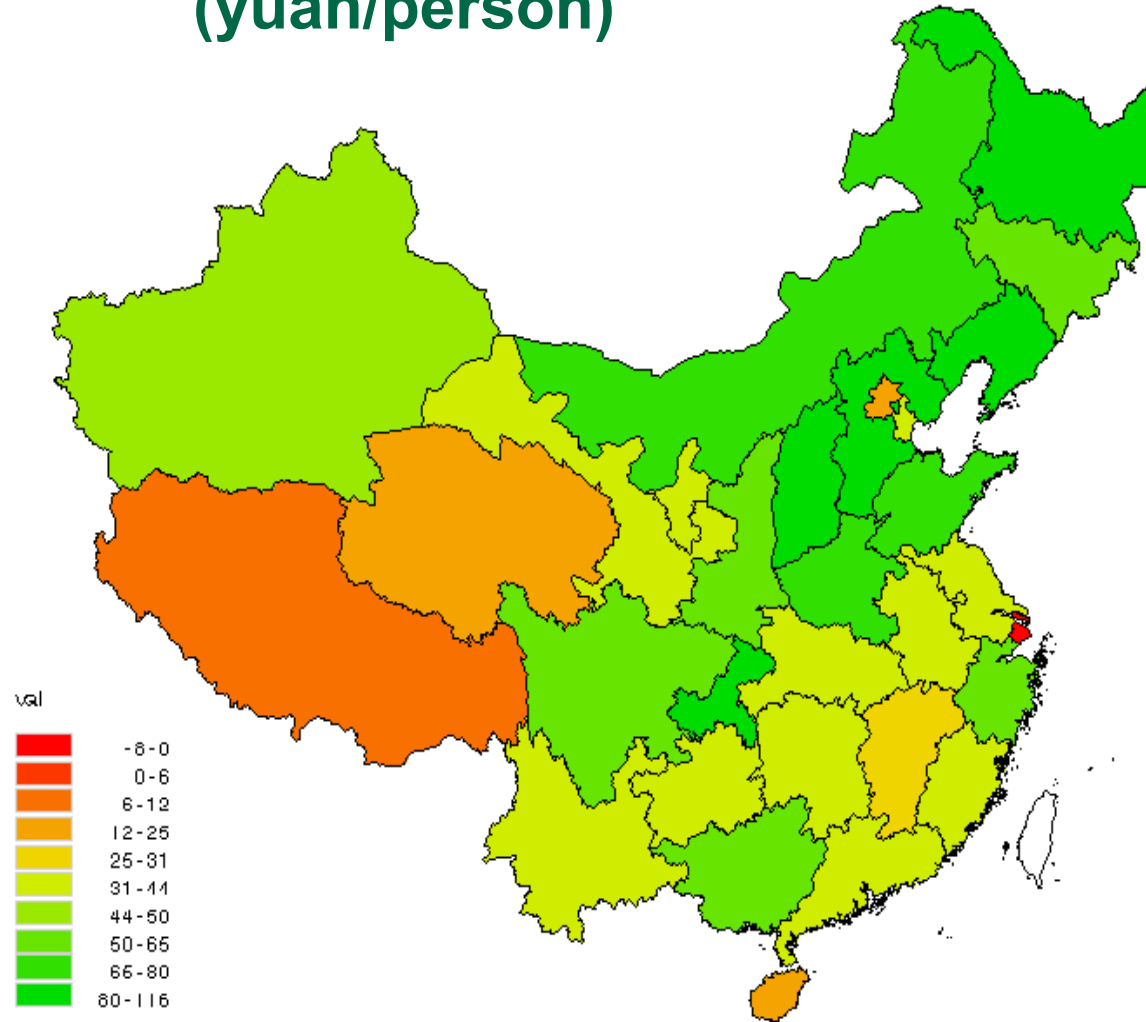


## Pork



# Impacts on agricultural income of poorest farmers (relative to baseline, 2020)

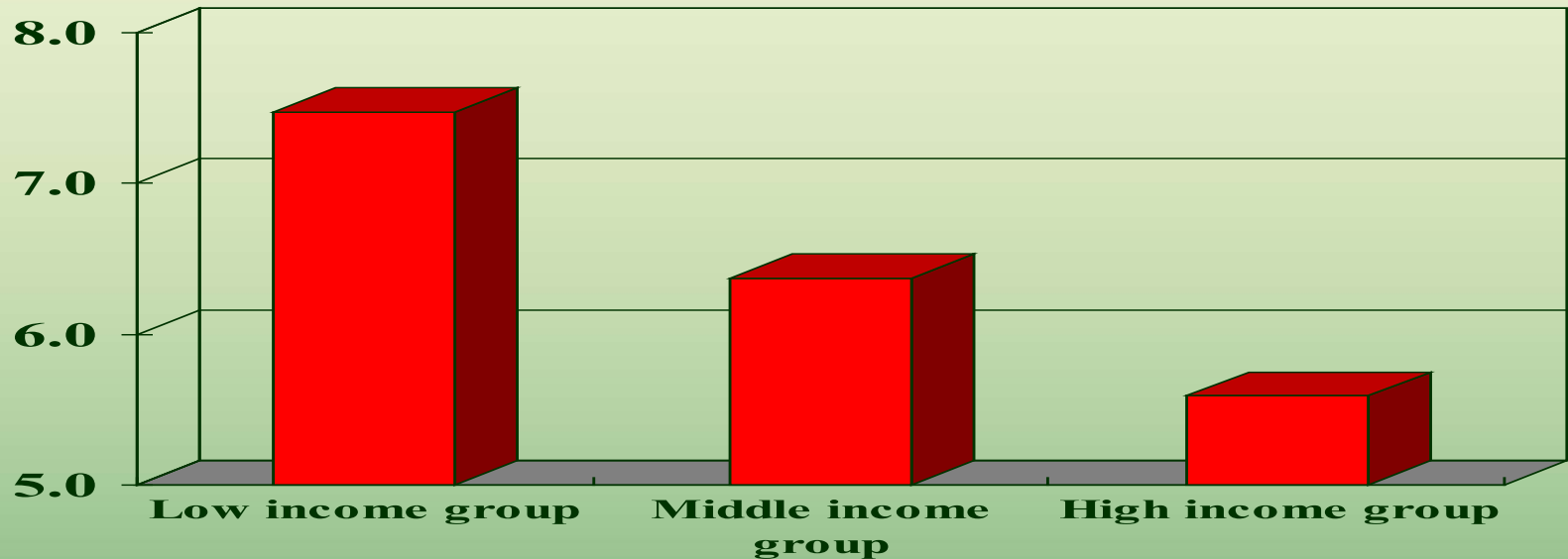
(yuan/person)





# Impacts on farmer's agricultural income growth by income groups

(annual avg growth, %)



# Key messages from analysis

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- Biofuels have big impact on China's agricultural economy
    - And those effects are largely positive
    - Encourages the expansion of key feedstock crops
    - Livestock feed prices do rise though....
    - Growth in biofuels gives a boost to farmer incomes (esp. poor farmers)
    - They all gain relative to the baseline case
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# Challenges in modeling Biofuel impacts and policies

# Some of the key components to be added to the current modeling framework

In the coming years there are a number of high-priority areas which we aim to improve in order to better capture the effect of biofuels on agriculture and the environment

- Improving the representation of US biofuel policy mechanisms – market for RINs & mandate hierarchy
- Addressing the bilateral nature of biofuels trade
  - The CBI countries and tariff policies
  - The two-way trade of ethanol b/w US & Brazil
- Linking to a better energy-transport model framework
- Better representation of by-products (DDGS)
- Better modeling of land use change (crops & livestock)

# Hierarchical nature of mandates and the market for RINs

The nature of the US biofuel sector and the approach to policy implementation present unique challenges to modeling (compared w/ other ag goods)

- The fact that certain biofuels (biodiesel, cellulosic & sugar-based ethanol ) can be used to meet the advanced mandate but are not substitutable for others
- How to address the uncertainty over future policies? Will EPA allow corn ethanol to satisfy the advanced mandate or will Brazilian ethanol have to fill the gap?
- The RIN market is a domestic tradeable – which requires a more detailed modeling of the sector than what we currently have w/in IMPACT (or even MIRAGE)

# Bilateral trade in biofuels

At present, we treat biofuels trade as we do that of other agricultural products in IMPACT – total net trade that is pooled at the global level

- So we can't distinguish b/w the ethanol that comes via the CBI countries into the US vs other sources
- Short of breaking biofuels into heterogeneous types (high- vs low-carbon), bilateral trade flows could also help to distinguish sources of biofuels that are relevant for policy (the US advanced mandate, the EU FQD)
- Since the biofuel market is smaller than many of the ag markets we deal with – will be relatively simpler to handle
- Will eventually extend itself to the rest of the model

# Linkages to a better framework for modeling energy and transportation demand

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Another important area in which we need to move beyond the simple reduced form approach we have initially adopted when expanding the model for biofuels

- The penetration of FFVs into domestic market is not explicit in our modeling (esp. relevant for Brazil)
- May make better sense to link to a more detailed model than to build more complexity into the current model
  - Start with 'soft' linkages (not allowing for full feedback)
  - Then start to incorporate reduced-form functions derived from the more detailed model
- BEPAM model is a good example of how to do this

# Better capturing the feed market effects of biofuel by-products (and production)

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This is something that all models try to do, when capturing the effect of biofuels on grain markets and the livestock sector – although in various ways

- CGE models might represent this as a reduction in cost for livestock activities (reflecting avoided grain costs)
- More properly – this should be treated as a separate and tradeable commodity that can substitute with grain feeds
  - Although only up to certain proportion
  - Is only relevant for ‘industrial’ style livestock systems
- Currently we are engaging in a detailed disaggregation of our livestock sector into feed regimes (extensive vs. intensive) which will be better for handling DDGS effects



# Improving the modeling of land use change in agriculture

This is key to capturing the environmental impacts of agricultural expansion – whether from biofuels or not

- Land use change has to incorporate livestock interactions which is key to capturing land-forest dynamics in Brazil (a point of contention in iLUC debate)
- Clearly linked to the improvement of livestock mentioned
- Currently colleagues at IFPRI are working on a comprehensive model of land use change
  - Taking an econometric choice-based approach
  - The challenge is in linking it in a tractable way
- Have also tried simpler ‘rule-based’ approach

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# **Conclusions: Biofuels and Policy**

# What is the real objective of a national biofuels program?

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There are a number of (legitimate) reasons why countries want to push their own national program for biofuels – but not all of them may be compatible

- A support program for the producers of feedstock (corn, oilseed & other producers) – provides a ‘floor’ for the price (which is driven by oil prices)
- A way of reducing imports of fossil fuel so as to
  - Promote ‘energy independence/security’
  - Avoid costly import bills which strain budgets
- A way of reducing the carbon intensity of fuels

# Multiple use of biofuel feedstocks is key

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- This flexibility between food or fuel uses, is what has made Brazil's sector unique and highly productive
  - The lack of by-products or alternative food uses is the big drawback of jatropha (among others) – less options for the farmer in case biofuel demand falls (w/oil prices)
- EcoEnergy in Tanzania has adopted a food-first approach, where they focus on producing as much sugar as they can (since they know demand is going up) – whatever ethanol they can make is extra \$\$\$
  - Edible oil crops could offer the same opportunity if one focuses on increasing productivity (which lowers costs) – which palm oil has achieved

# How can biofuels work in less-developed regions?

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- Biofuels operations work best when:
    - Feedstock production can be of high productivity – which lowers costs and competes less with other land uses
    - There is dual/multiple uses of products (esp 1<sup>st</sup> gen)
    - There is a well-functioning value chain with opportunities for vertical integration
  - Those countries who don't meet these conditions should re-consider their priorities & assess tradeoffs
  - If biofuel ventures can't be justified from an agribusiness perspective -- then they probably won't work in the long-term
  - Energy problems in LDCs go beyond transport fuels – a more comprehensive (even regionally-based) strategy might be better to address urban/rural needs
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# Important methodological challenges to modeling biofuel policy impacts

There's a great need for *ex ante* assessment of the economic & environmental impacts of biofuels – but there are challenges in doing so

- The land use dimensions are key to understanding the environmental impacts of crop & livestock expansion
- The policy regimes that govern the biofuel sectors in OECD countries are complex & subject to uncertainty
  - Closely linked to transport & energy policy which many ag models don't handle well
  - Mandates & future blending targets are uncertain
- Great need for collaboration b/w energy & ag specialists

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# Thank You

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# Extra slides



# The IMPACT Model

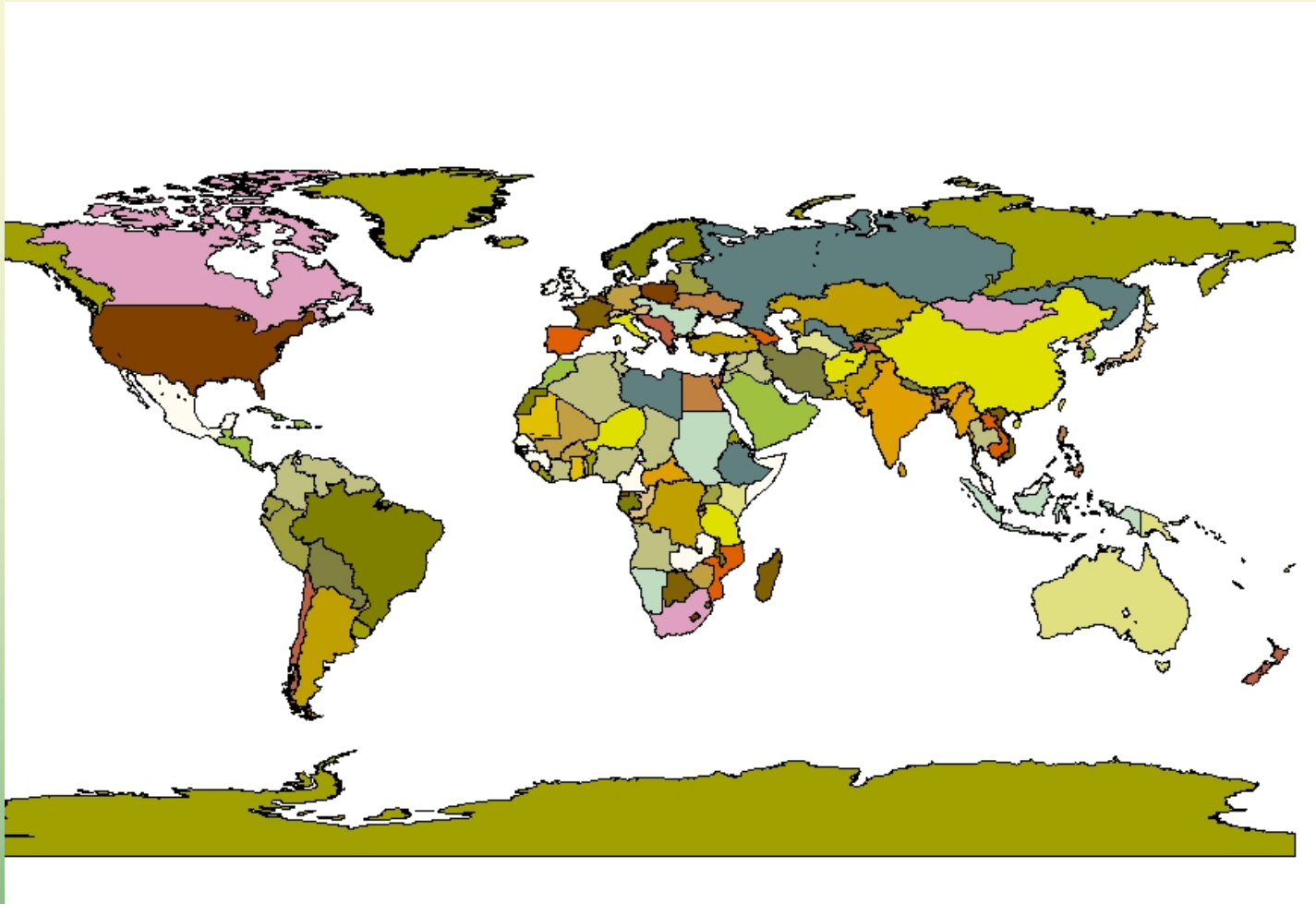
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- IMPACT – “International Model for Policy Analysis of Agricultural Commodities and Trade”
  - Representation of a global competitive agricultural market for crops and livestock
  - Global
    - 115 countries
    - 281 food production units
    - 32 agricultural commodities
-

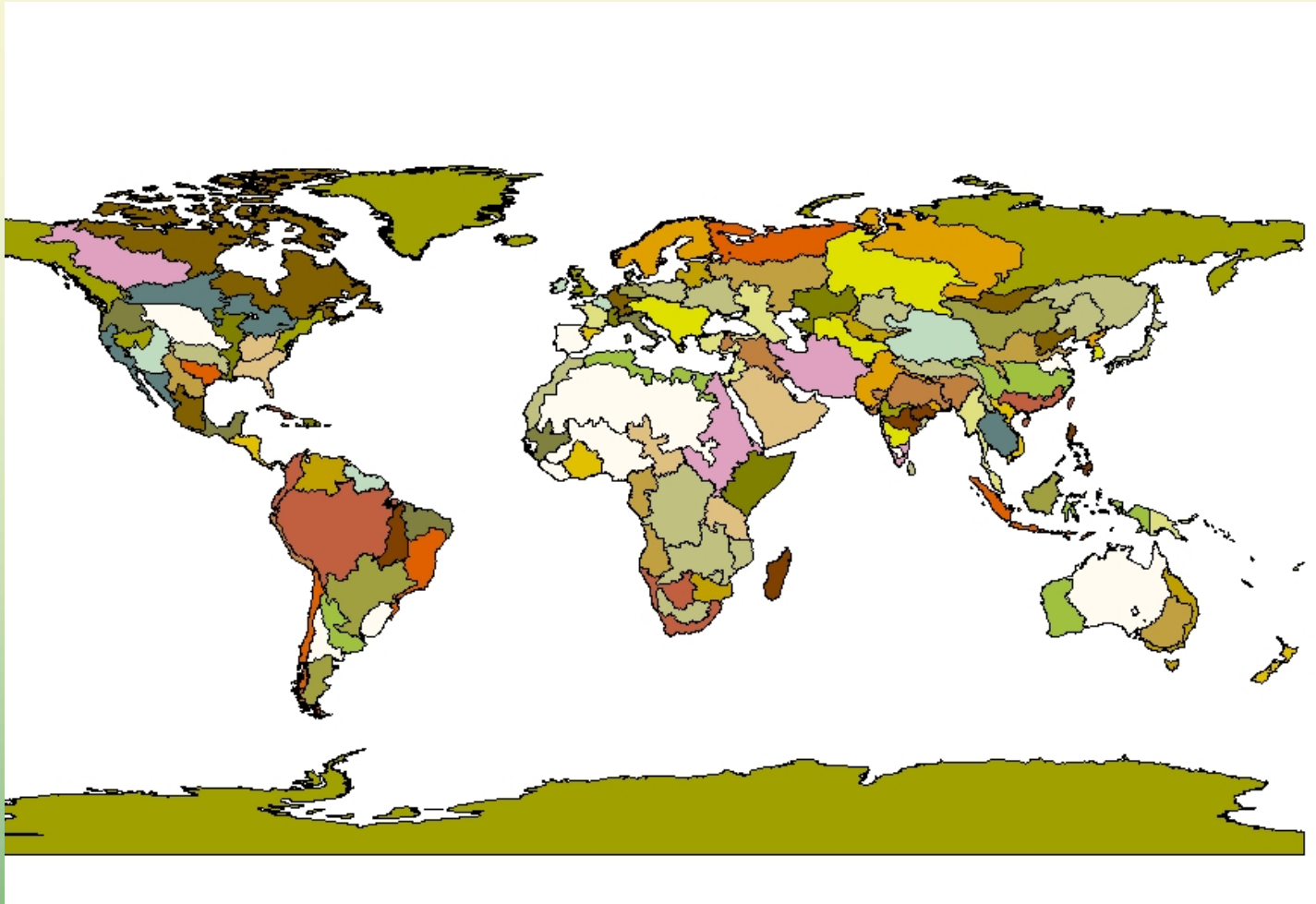
# 32 IMPACT Commodities

- Cereals
  - Wheat, Rice, Maize, Other Coarse Grains + Millet, Sorghum
- Roots & Tubers
  - Potatoes, Sweet Potatoes & Yams, Cassava & Other Roots and Tubers
- Dryland legumes
  - Chickpea, Pigeonpea, Groundnut
- Livestock products
  - Beef, Pork, Sheep & Goat, Poultry, Eggs, Milk
- Fish
  - Eight capture and aquaculture fish commodities plus fish meals and fish oils
- High-Value
  - Vegetables, (Sub)-Tropical Fruits, Temperate Fruits, Sugar Cane, Sugar Beets and Sweeteners
- Other
  - Soybeans, Meals, Oils
- Non-food
  - Cotton, Biofuel products (ethanol, biodiesel)

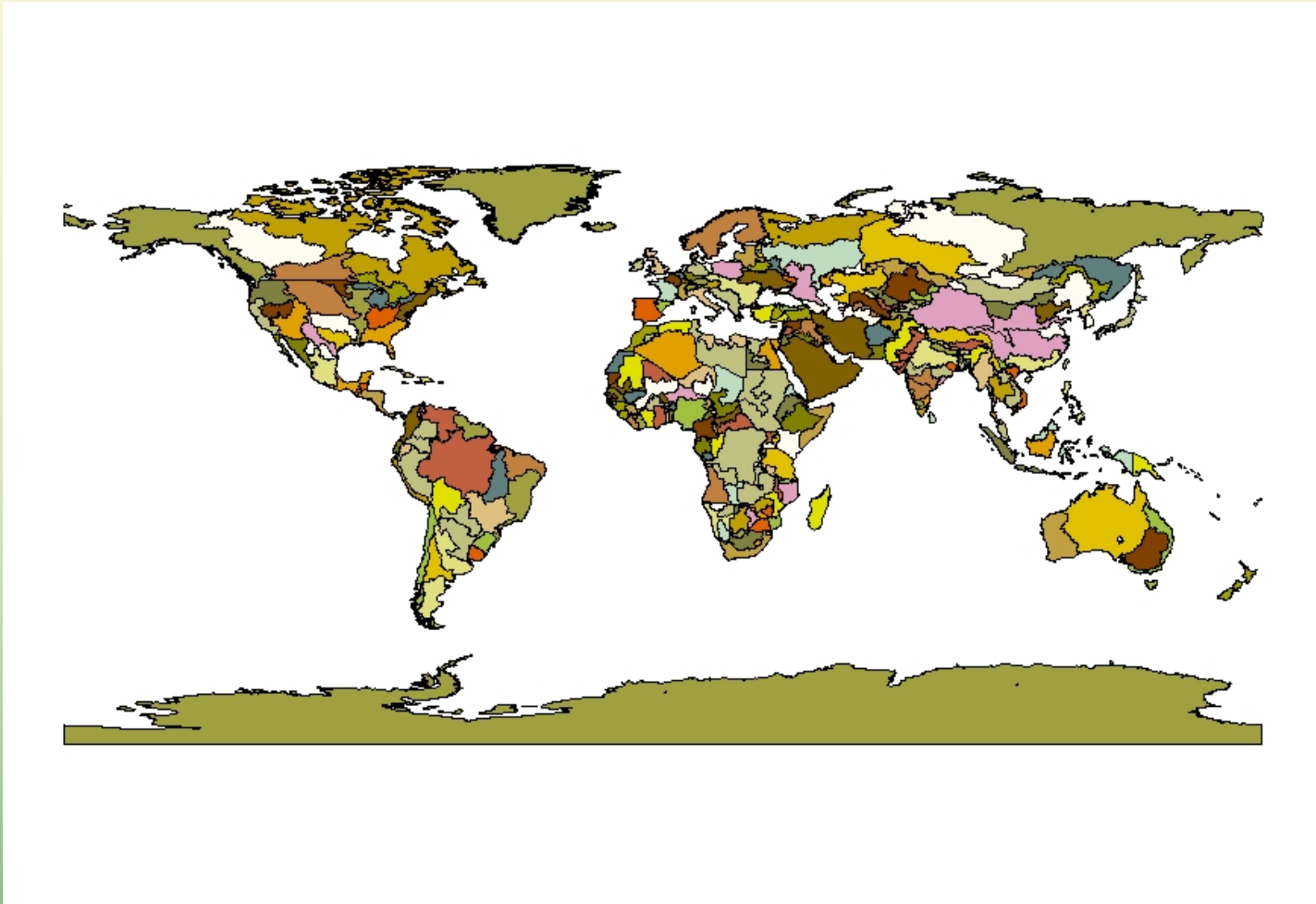
# Global Economic Regions (115)



# Global Basins (126)



# Global Food Production Units (281 FPU)



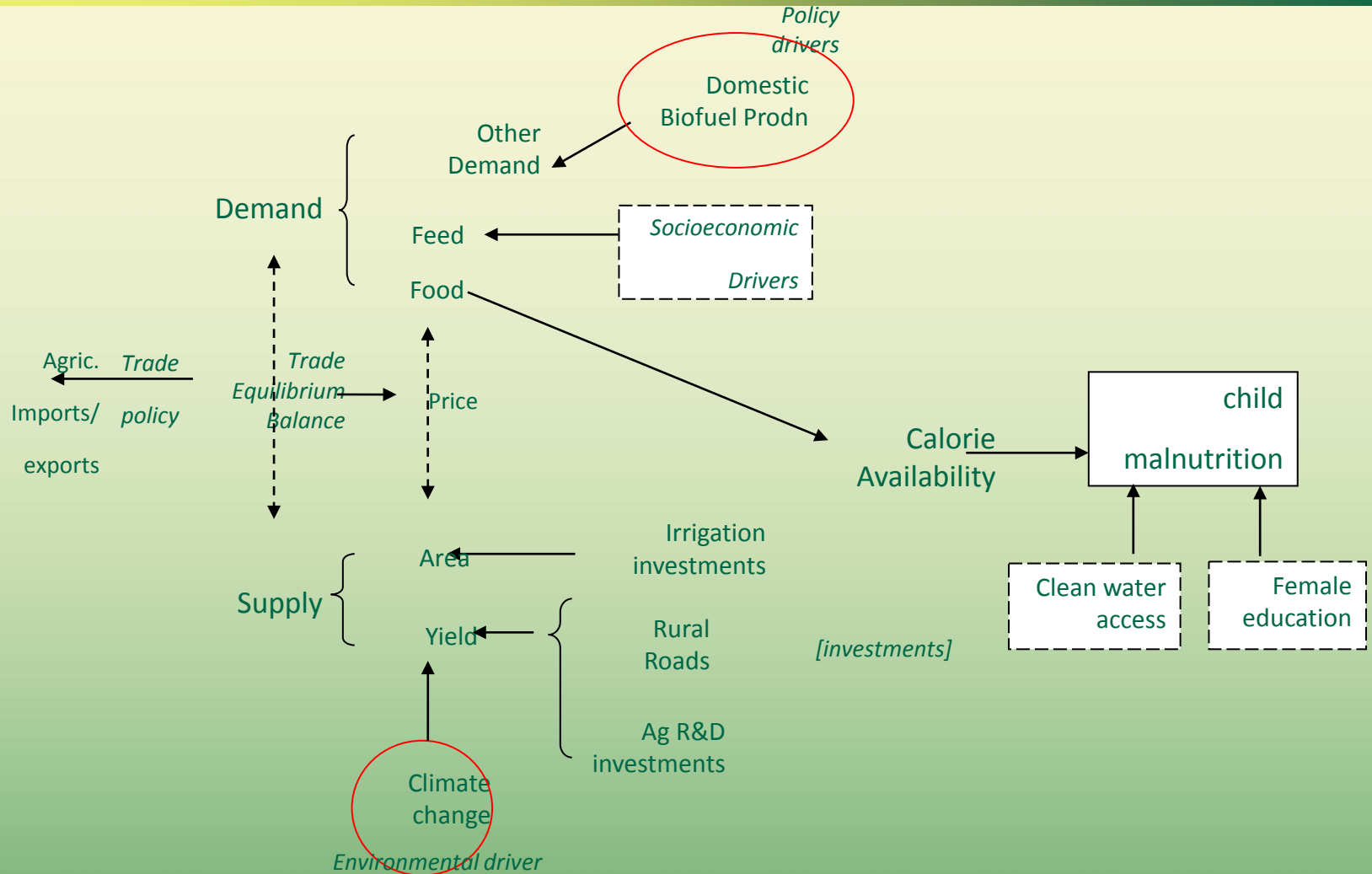
*Higher river basin spatial resolution planned for better  
water availability modeling*

# IMPACT Basics

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- Global, partial-equilibrium, multi-commodity agricultural sector model
  - Links country-level supply and demand through global market interaction and prices
  - Country-level markets are linked to the rest of the world through trade
  - World food prices are determined annually at levels that clear international commodity markets
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# Key linkages in modeling drivers & outcomes



# IMPACT Outputs

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- Supply
  - Demand (food, feed, and other demand)
  - Net trade
  - World prices
  - Per capita demand
  - Number and percent of malnourished children
  - Calorie consumption per capita
  - Plus
    - Water use, (at some point: *soil carbon, total biomass*)
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# The Key Uses of IMPACT

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- Much of the past work of IMPACT has centered around providing a forward-looking perspective on what's needed to meet future food needs, and the implications for key CGIAR mandate commodities
  - Because it was designed to look at the long term, that aren't covered by others (USDA, FAPRI, OECD), the results are better used for projections and not prediction – which implies that you're more interested in deviations from a baseline, under alternative scenarios, rather than point estimates
  - Can be useful for determining which crop improvements have the biggest effect on food availability and levels of malnutrition
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# Typical IMPACT-driven scenarios

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- Looking at the implications of socio-economic growth (income, population) on food/feed demand and other indicators mentioned above
  - Looking at the implications of higher factor prices (fertilizer, labor) on crop yield – and production
  - Fairly simple trade liberalization or protection scenarios (with phased changes over time)
  - Looking at implications of improved socio-economic conditions ( access to clean water, girls secondary schooling, rural roads ) on child malnutrition
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