INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE

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CHALLENGES AND POLICIES FOR GLOBAL WATER AND FOOD SECURITY

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CGIAR RESEARCH PROGRAM ON Water, Land and Ecosystems

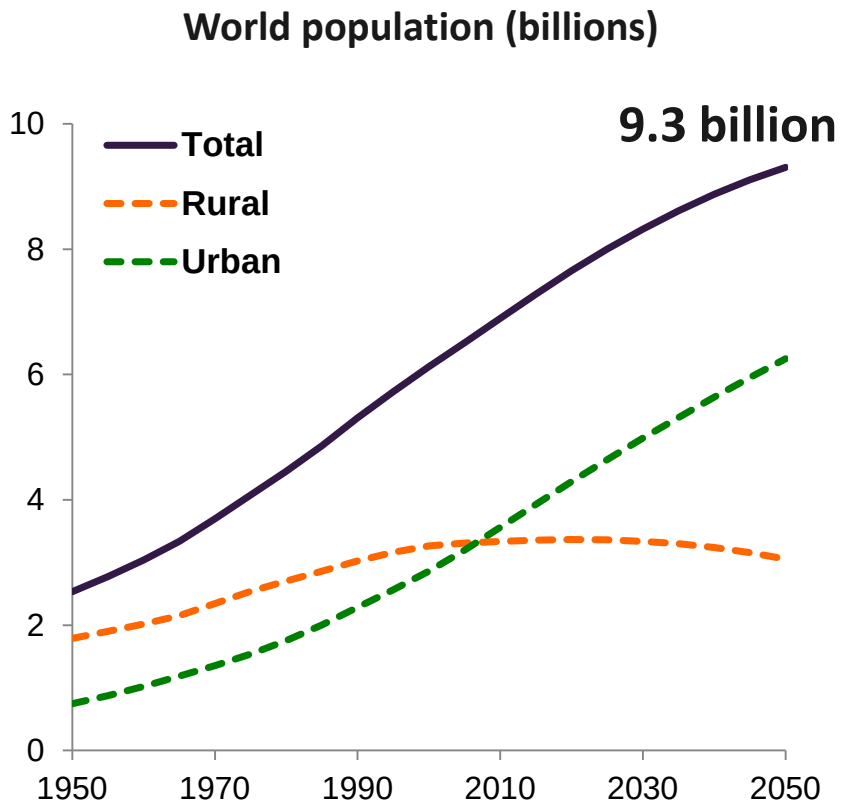
LED BY: IWMI International Water Management Institute

Outline

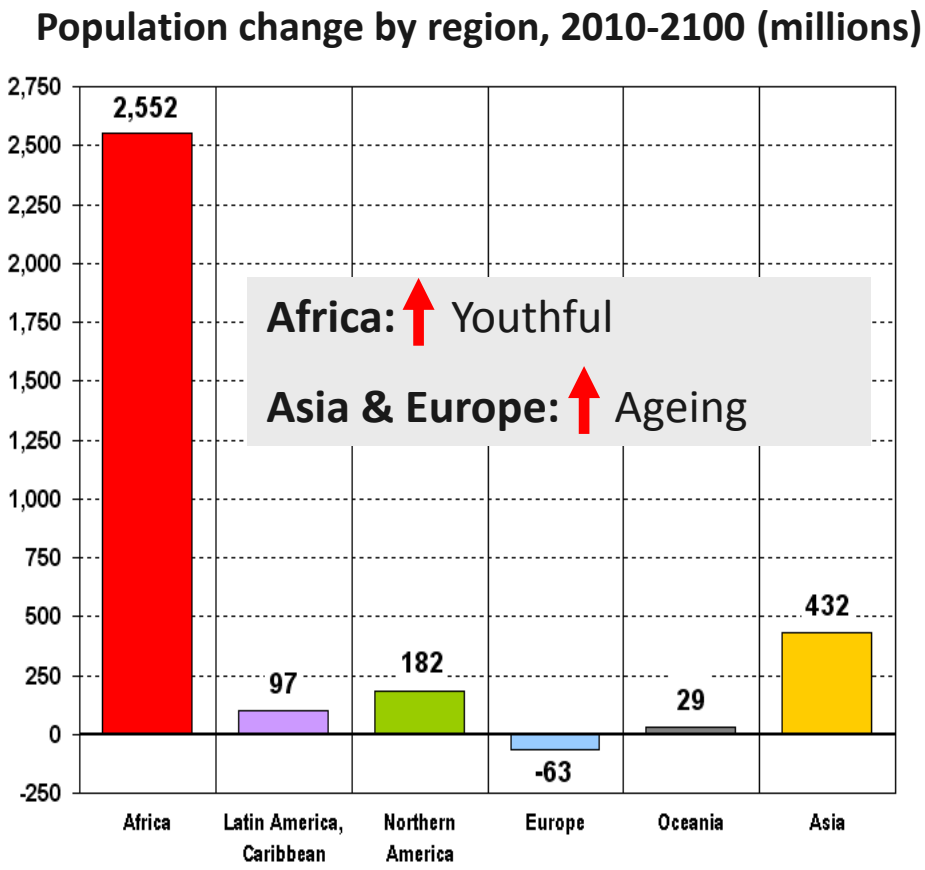
- Challenges for Water and Food Security
- Water and Economic Growth
- Scenario Modeling Methodology and Baseline Results
- Water Policies, Technologies, and Investments
- Alternative Scenario: Can improved water policies, technologies, and investments make a difference?
- Conclusions: Policies for Water and Food Security

Challenges for Water and Food Security

Increasing Population and Demographic Shifts



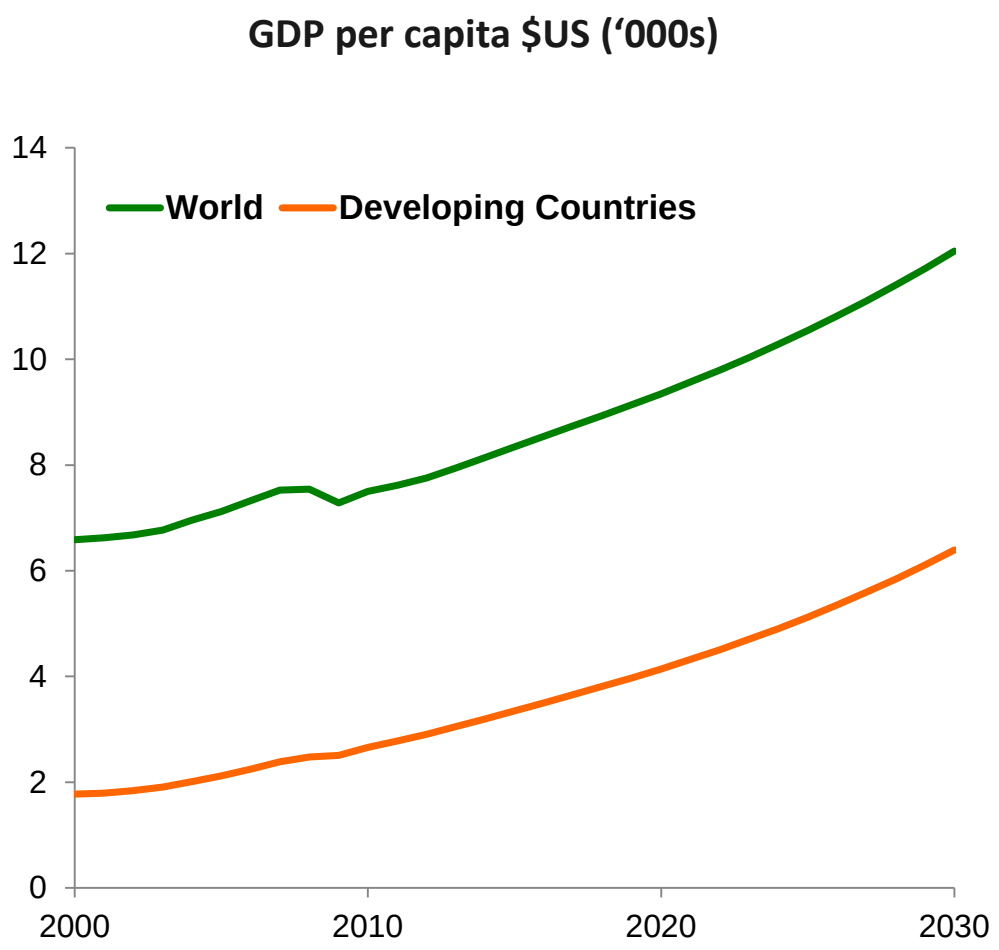
Source: Data from UN 2011



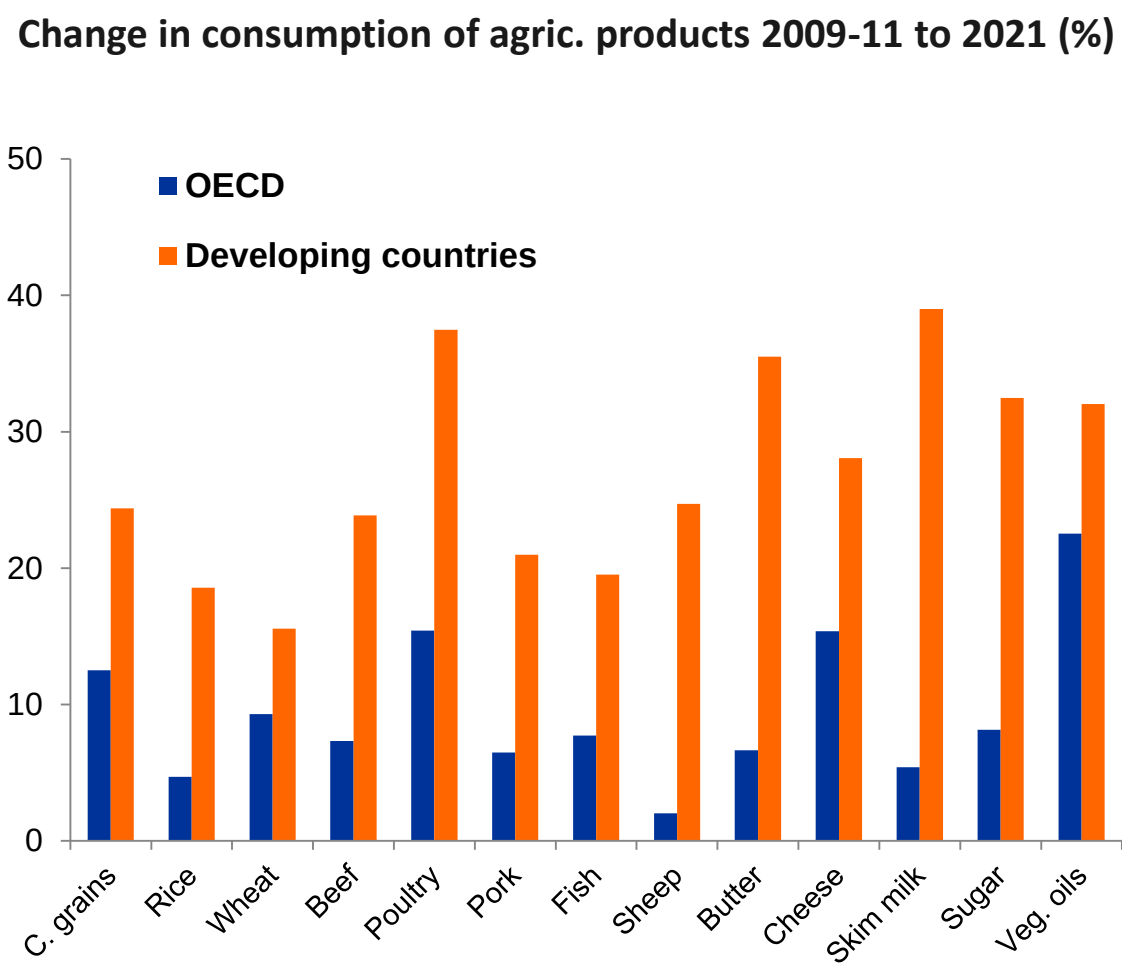
Source: UN 2011

Larger and more urban population will demand more and better food

Rising Incomes and Demand and Diet Changes



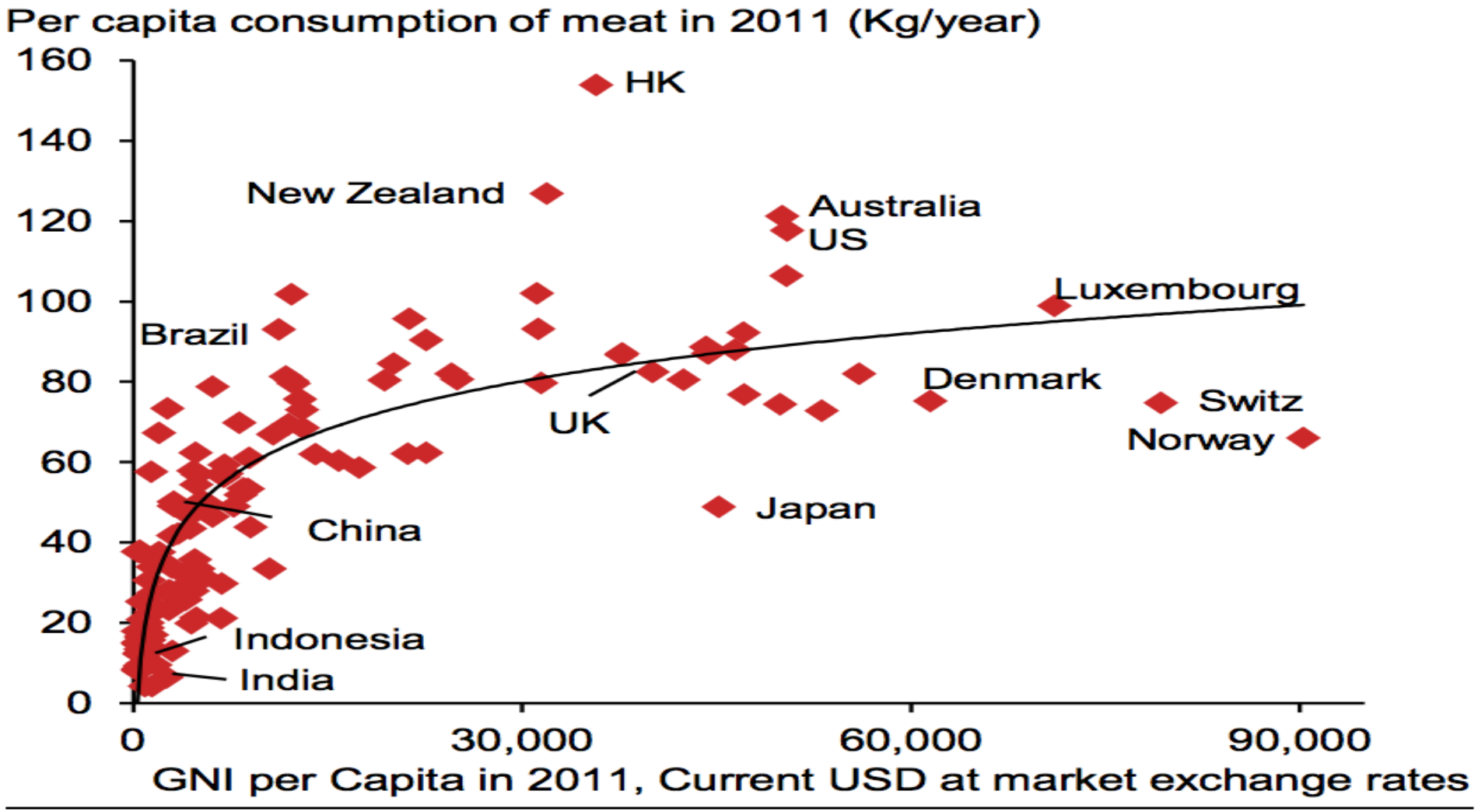
Source: ERS-USDA 2012



Source: OECD-FAO 2012

Income and Meat Consumption

Per Capita Meat Consumption by Country, 2011



Source: FAO, World Bank and Nomura Global Economics

Supply-side Drivers of Agricultural Growth and Food Security

- Supply drivers
  - Climate change and variability
  - Water and land scarcity
  - Competition with biofuels
  - Investment in agricultural research
  - Science and technology policy
    - Discovery, development, delivery
    - Intellectual property rights, regulatory systems, extension

http://www.tribuneindia.com/2004/20040721/har.jpg

http://fbae.org/2009/FBAE/website/images/btcotton_rice.jpg

Challenges for Water Policy

- Increasing costs of developing new water and delivering developed water
- Wasteful use of already developed supplies encouraged by subsidies and distorted incentives
- Depletion of groundwater, water pollution, declining water quality
- Climate change, extreme weather

Water and Economic Growth

Rainfall, Flood and Drought Impacts: Synthesis

VARIABLES	IMPACTS ON ECONOMIC GROWTH
Variability on precipitation	↓
Run-off	↑↑
Drought	↓
Flood - per capita GDP growth	↓

- Significant negative detrimental impact on different measures of economic growth in Sub-Saharan Africa
- Effects of hydro-climatic variables on economic growth - strongest in poor countries, countries with high human water stress, high dependence on agriculture

Source: Sadoff, C.W., J.W. Hall, D. Grey, J.C.J.H. Aerts, M. Ait-Kadi, C. Brown, A. Cox, S. Dadson, D. Garrick, J. Kelman, P. McCornick, C. Ringler, M.W. Rosegrant, D. Whittington, and D. Wiberg. 2015. Securing Water, Sustaining Growth: Report of the GWP/OECD Task Force on Water Security and Sustainable Growth, University of Oxford, UK, 180pp.

Impact of Water on Economic Growth

WORLD BANK CGE MODEL

- Economic consequences highly unequal with worst effects in driest regions
- Expected global damages - small relative to expected global GDP in 2050
- Global loss is misleading estimate because significant variations exist between regions
  - Western Europe and North America - negligible damages in most scenarios
  - Middle East, Sahel, and Central and East Asia - bulk of losses; magnitude of losses largely driven by level of water deficit: 10-14% losses in GDP relative to baseline

Source: World Bank 2016. High and Dry: Climate Change, Water, and the Economy. http://www.worldbank.org/en/topic/water/publication/high-and-dry-climate-change-water-and-the-economy

GTAP CGE Model

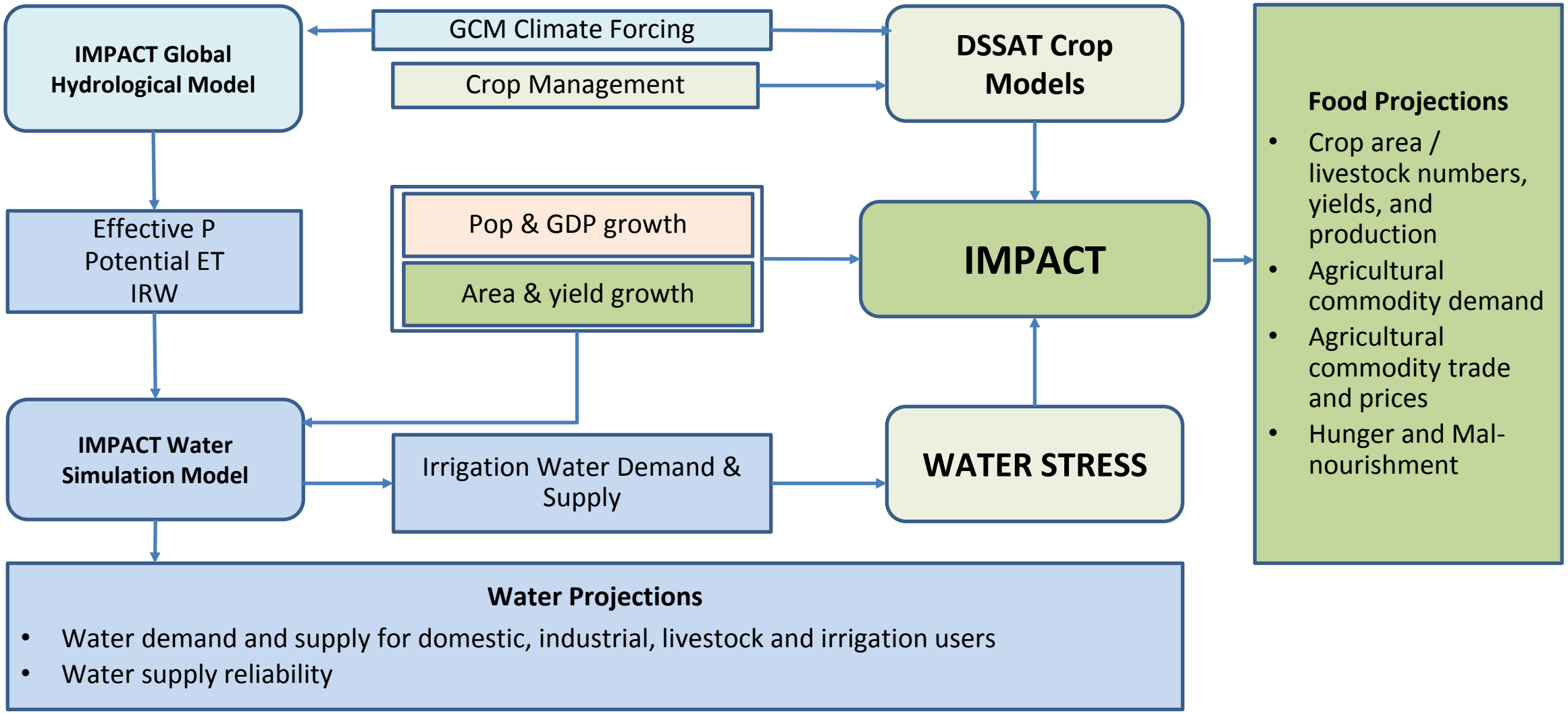
- Economic feedback effects and adjustments limit damage from water shortfalls
- Countries experiencing negative output shocks due to reduced irrigation availability may gain from higher commodity prices caused by shocks
- Regions can take advantage of trade to adjust composition of agricultural income and specialize in more beneficial commodities
- These adjustment effects, mediated by markets, reduce the initial effect of reduced water availability in farming

Source: Liu, J., T.W. Hertel, F. Taheripour, T. Zhu, and C. Ringler. 2014. International trade buffers the impact of future irrigation shortfalls. *Global Environmental Change* 29: 22–31 http://www.sciencedirect.com/science/article/pii/S095937801400137X

Scenario Modeling Methodology and Baseline Results

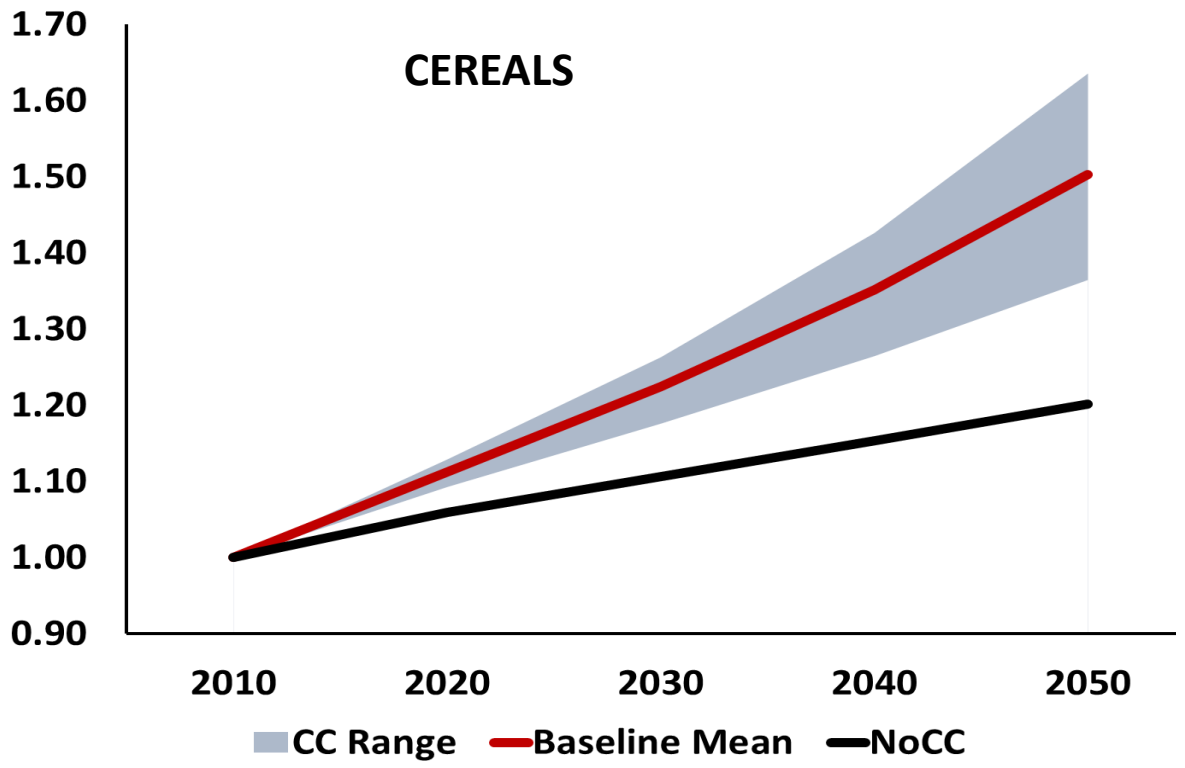
The IMPACT3 Modeling Suite

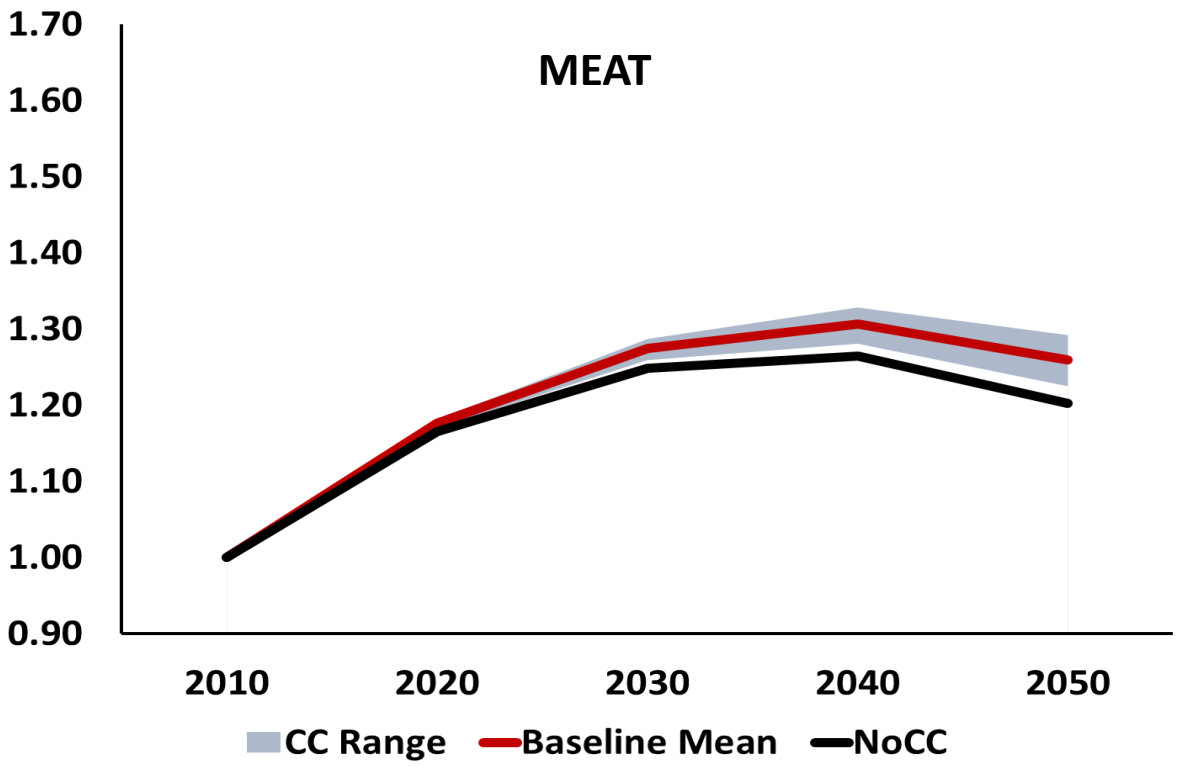
Linked system of hydrological, water use, crop simulation, and partial equilibrium economic models



Indexed Global Prices BAU

- Cereals - most severe global impacts of climate change on prices: 25% increase compared to NoCC in 2050; 50% higher than 2010
- Meat - relatively modest 5% impact (indirect) of CC

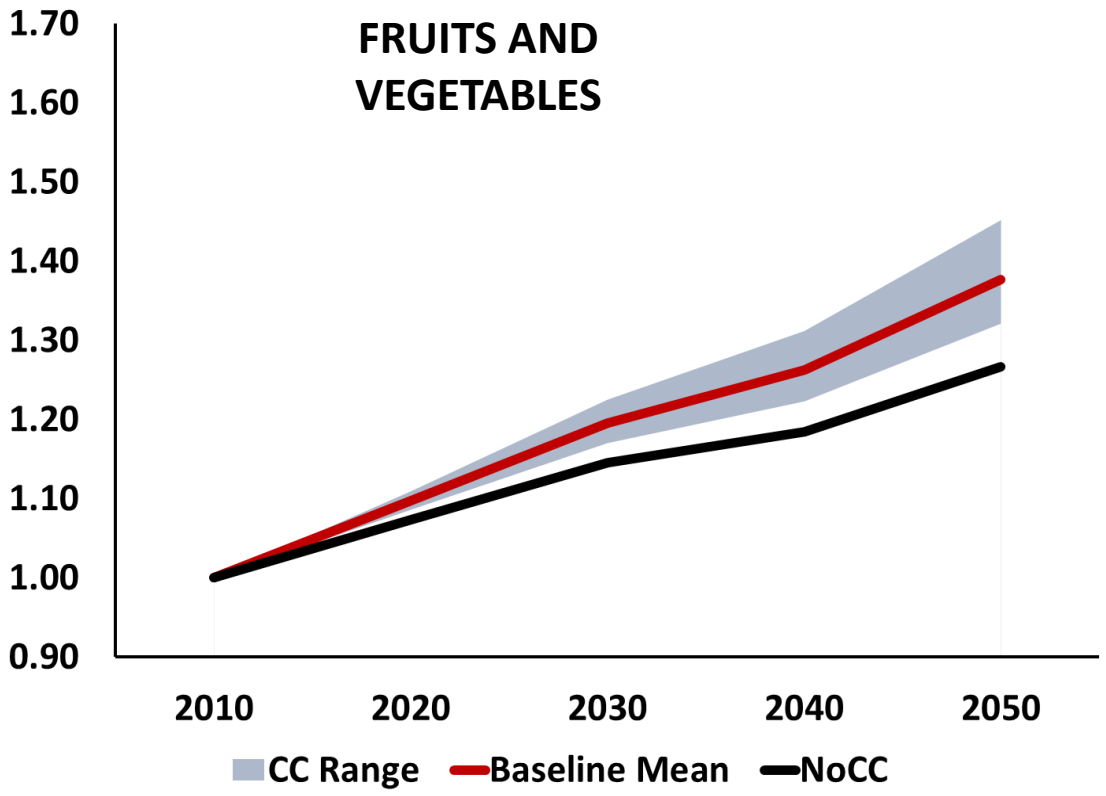


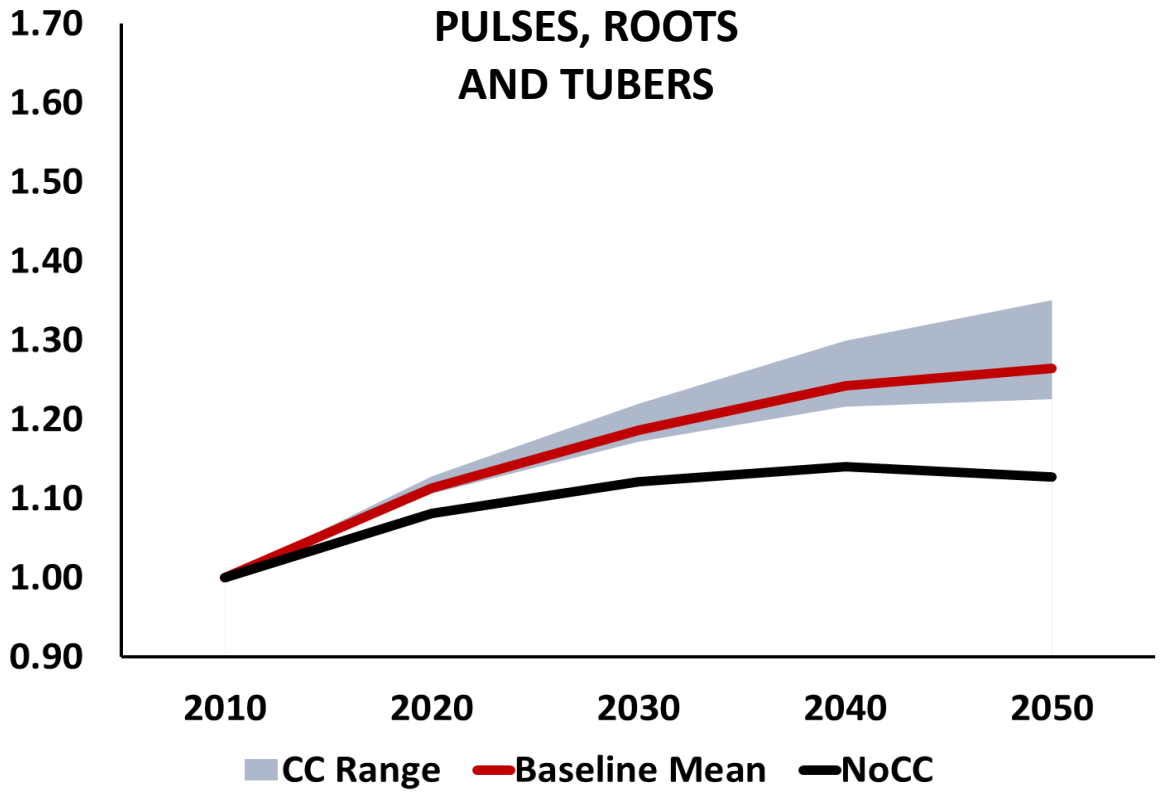


Source: IFPRI, IMPACT version 3.2, 8 September 2015

Indexed Global Prices BAU

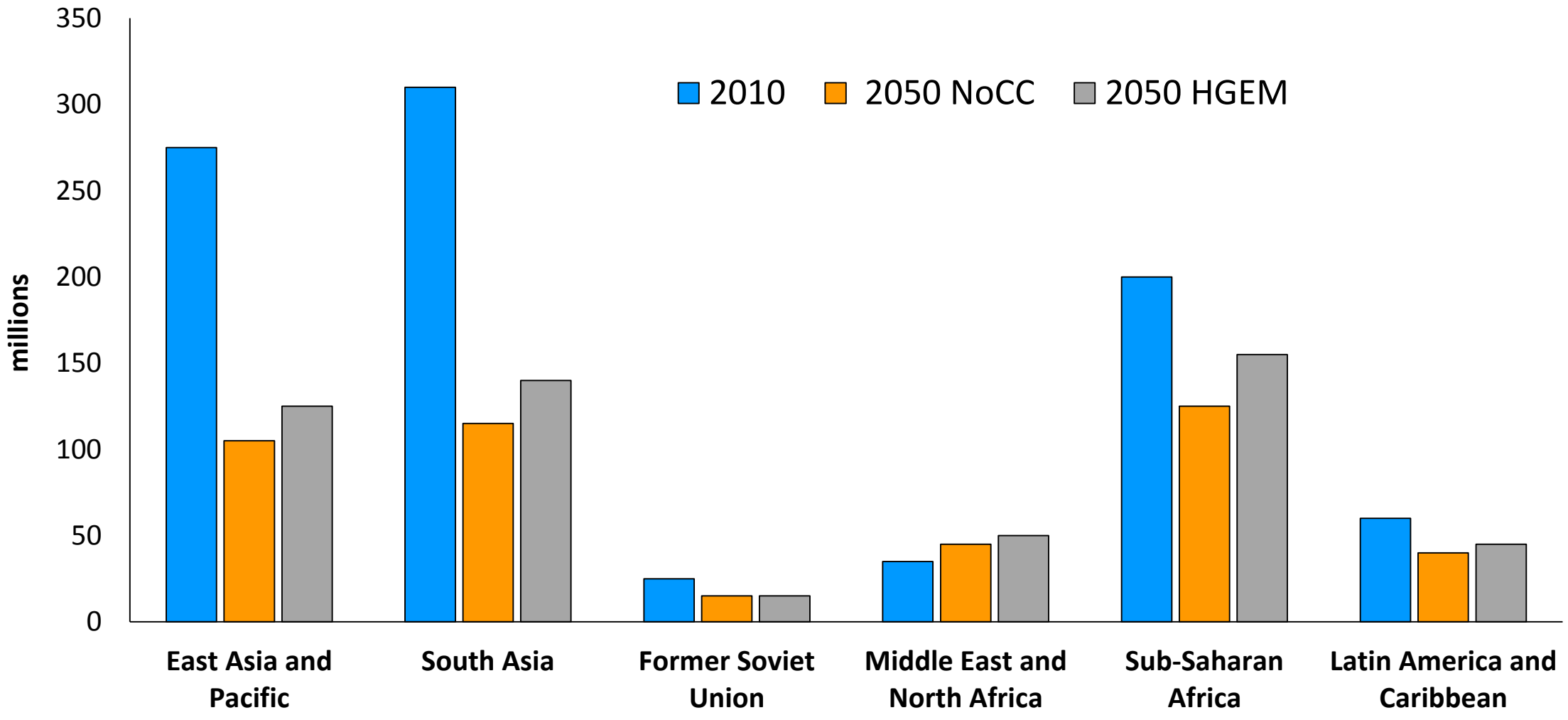
- Fruits and vegetables, pulses, and roots and tubers: 9% to 12% increase with CC in 2050 (about 30% above 2010 levels)





Source: IFPRI, IMPACT version 3.2, 8 September 2015

Population at risk of hunger (SSP2, RCP8.5)



Source: IFPRI, IMPACT version 3.2, 8 September 2015

Water Policies, Technologies, and Investments

Investment in Crop Breeding for Yield per Unit of Water and Land

- Plant breeding - improve plant biomass/unit of water through
  - More efficient transpiration
  - Efficiency of biomass growth per unit of transpiration
- Effective breeding for drought tolerance and other traits to get more yield per unit of water
  - Availability of diverse genes is essential
  - Tools of biotechnology should be employed
    - marker-assisted selection,
    - cell and tissue culture, and
    - gene editing, even if countries elect to forego transgenic breeding

Adoption of New Irrigation Technology and Farming Systems

- Farmers adopt advanced technology (drip and sprinkler irrigation, precision farming, conservation agriculture) for
  - Increased income from higher value crops
  - Convenience
  - Labor-saving
  - Lower pumping costs
- But real system-wide water savings are more difficult to achieve and often limited

Adoption of New Irrigation Technology and Farming Systems

- New technology: alternative water saving outcomes
  - Save water that would otherwise evaporate unproductively or flow to sinks, providing net system benefits
  - Divert water that would otherwise be used downstream by others - merely shifts benefits between farmers, rather than generating new benefits
  - Induce increased water use by increasing profitability of irrigation for individual farmers rather than saving water

Adoption of New Irrigation Technology and Farming Systems

- Achieving potential benefits is promoted by a water allocation system that recognizes these hydrological realities and interconnectedness of water in the river basin
- Well-specified tradable water rights provide incentives to optimize economic value of water

Establishment of Water Rights and Water Trading

- Conditions for effective water rights
  - Include perpetual right to proportion (share) of all allocations made in the river basin or system
  - Actual allocation made in any season
    - Expressed as share of actual allocation based on available water
    - Determined in transparent process and accounting for system evaporative losses and environmental outcomes, including water quality and flows to the sea

Source: Young, M. 2015. Unbundling Water Rights: A Blueprint for Development of Robust Water Allocation Systems in the Western United States. NI R 15-01. Durham, NC: Duke University. http://nicholasinstitute.duke.edu/publications

Constraints on Water Rights and Trading in Developing Countries

- High costs of measuring and monitoring water use, where infrastructure and institutions are weak
- Irrigation systems often large and service many small farmers - major constraint to implementing water rights and trading
- Long-standing practices and cultural and religious beliefs –
  - Water treated as free good, and
  - Entrenched interests benefit from existing system of subsidies and administered water allocations
- Development of well-specified water rights and trading likely to be medium- to long-term process

Capital Investment in Irrigation and Water

- New investments in irrigation and water supply - increasingly expensive and politically sensitive
- Substantial potential still exists for irrigation expansion in some regions of the world
- Africa - potential for 16 million hectares of profitable large-scale irrigation and at least 50 million hectares of small-scale irrigation

Capital Investment in Irrigation and Water

- Hard infrastructure investment - reduced role globally compared with past decades
- Large additional investments in water treatment and sewage disposal plants required
  - Global access to improved water and sanitation services = US$22.6 billion per year
  - Global access to regulated in-house piped water supply with quality monitoring and in-house sewerage connection with partial treatment of sewage = US$136.5 billion per year

Alternative Scenario: Can improved water policies, technologies, and investments make a difference?

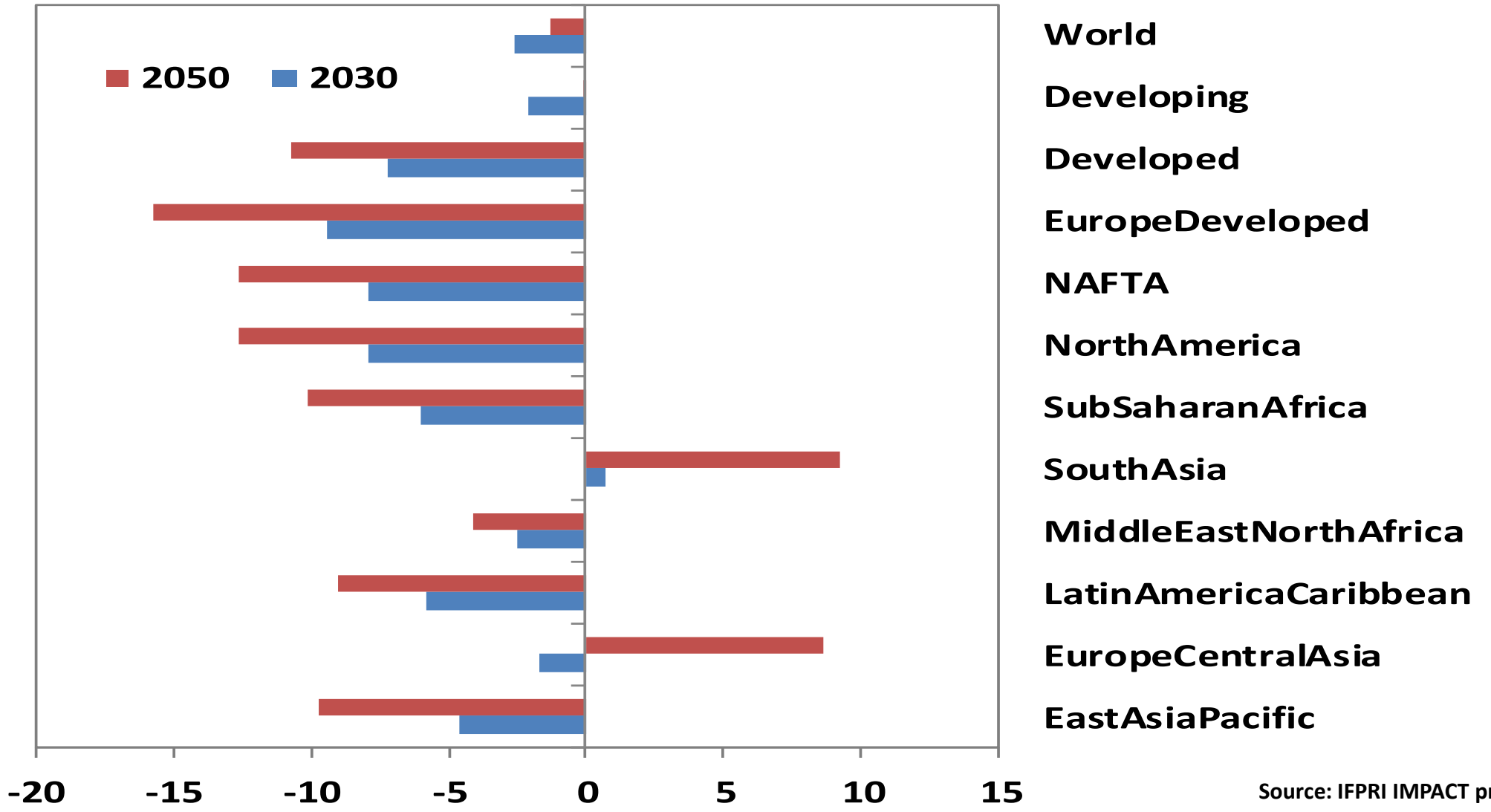
Alternative Scenario Description

- Underlying assumptions of water use efficiency gains
  - Efficiency measures in industry and residential water use and climate policies - lead to recycling and reduced demand for thermal cooling in power generation as fossil-fuel-powered plants are more rapidly replaced by renewable energy sources
  - For agriculture, basin water use efficiency gains are based on more efficient transpiration and reduced water losses
    - Drought resistant varieties and other advances in research and biotechnology
    - Reduced non-beneficial ET
    - Reduced losses to water sinks (e.g. due to water-conserving irrigation and crop management technologies and reduced evaporative losses during conveyance)

Alternative Scenario Description

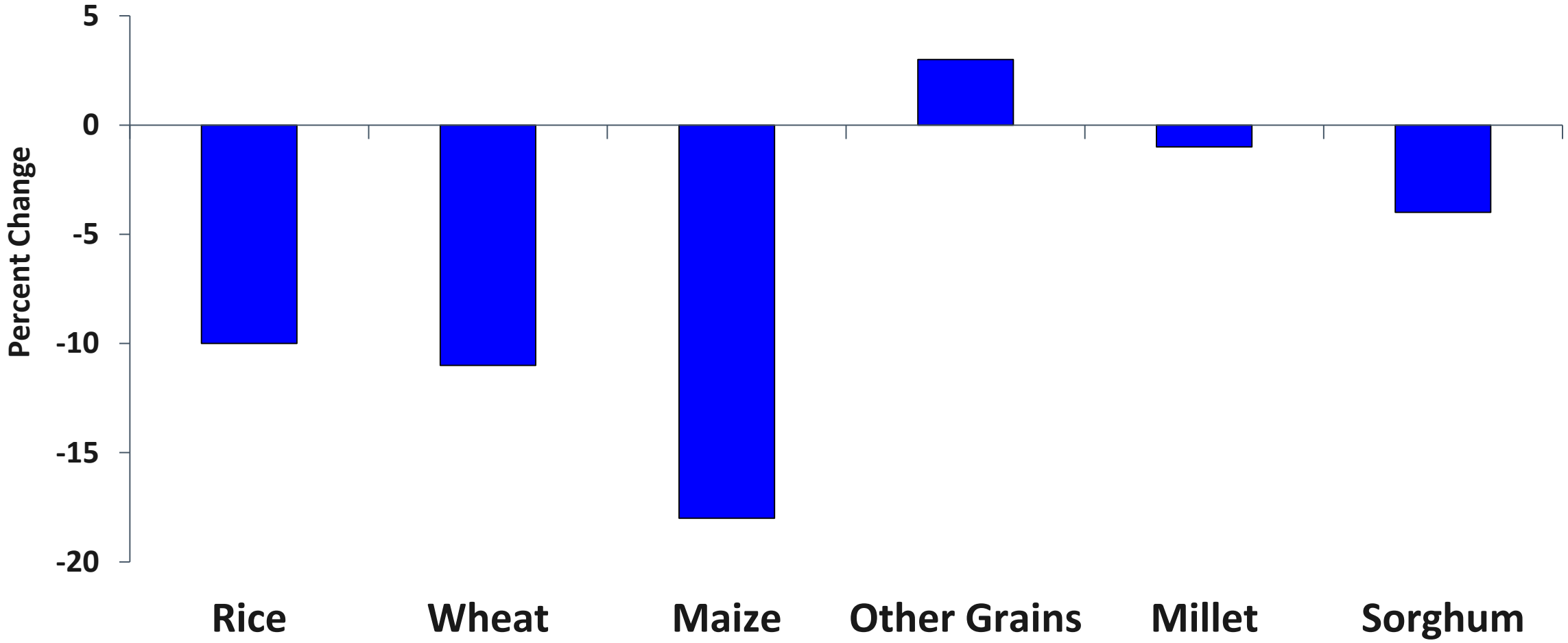
- Average global efficiency gains = 15% in 2050 compared to BAU
- Enhanced research and development increases annual productivity growth average across crops of 0.23 percentage points and 0.20 percentage points for livestock
- CGE model GTEM (Ahammad and Mi 2005) used iteratively with IMPACT to generate multiplier effects from agricultural and water sector productivity growth to GDP growth
- Globally, GDP growth increases
  - from 3.2% per year under BAU
  - to 3.6% per year under Alternative Scenario

Change in Irrigation Water Consumption Alternative Scenario Compared to BAU (%)



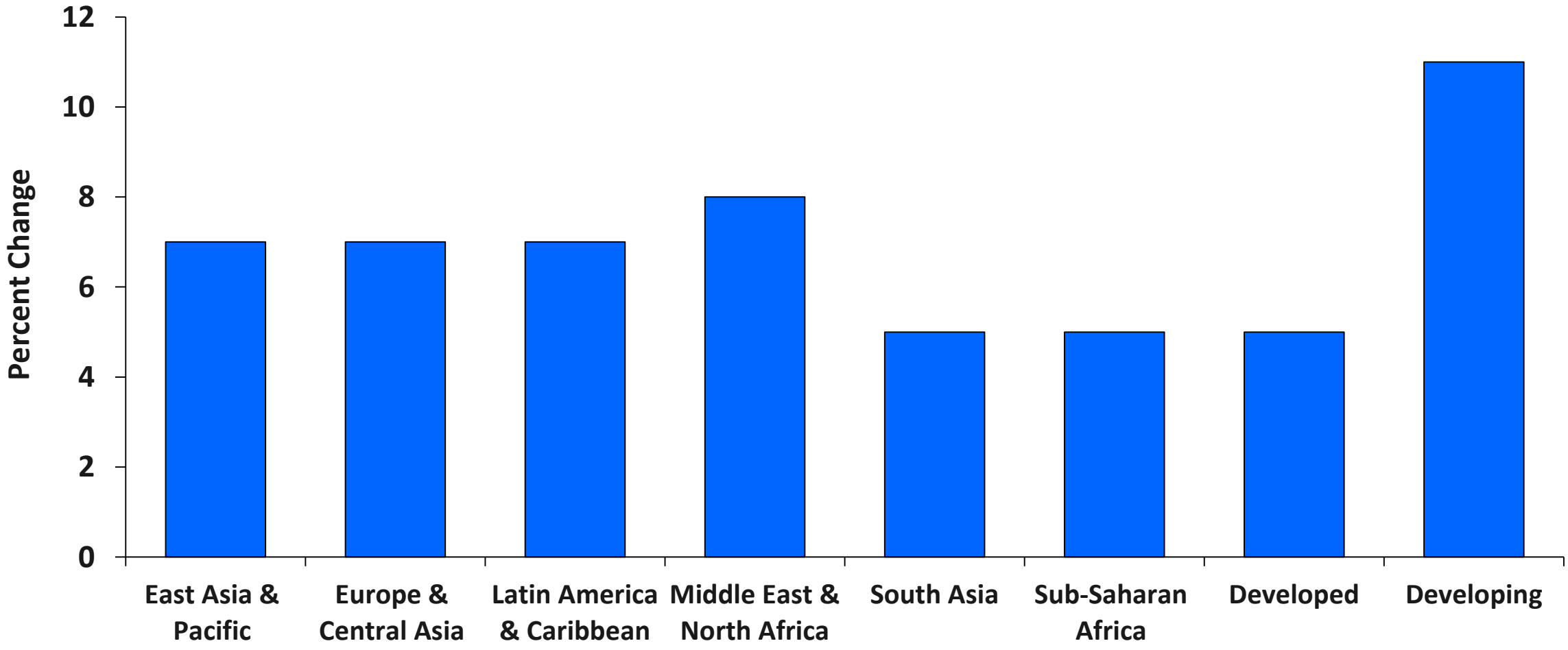
Source: IFPRI IMPACT projections 2012

Percent Change in World Prices of Cereals between BAU and Alternative Scenario, 2050



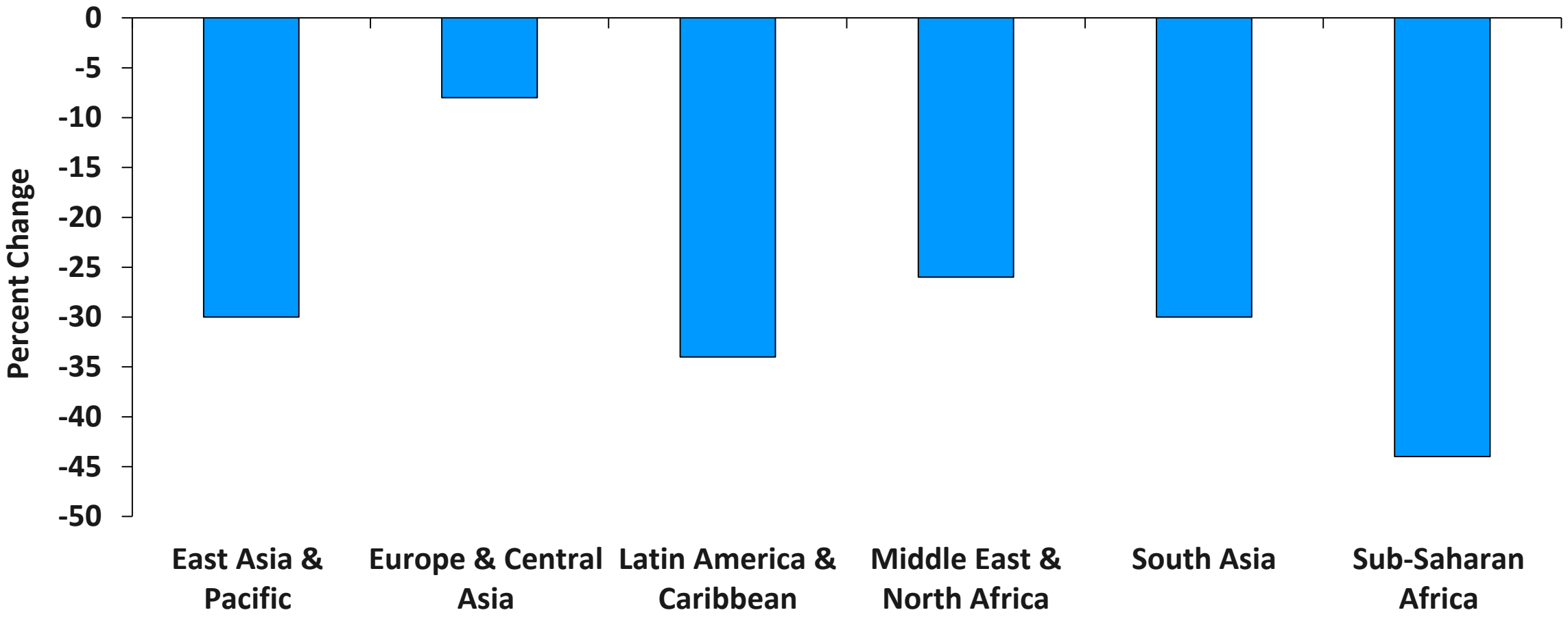
Source: Rosegrant, M.W., C. Ringler, T. Zhu, S. Tokgoz and P. Bhandary. 2012. Water and food in the bioeconomy. Challenges and opportunities for development. Selected paper prepared for presentation at the International Association of Agricultural Economists (IAAE) Triennial Conference, Foz do Iguaçu, Brazil, 18-24 August, 2012. Milwaukee, WI, USA; International Association of Agricultural Economists (IAAE). http://ageconsearch.umn.edu/bitstream/128295/2/RosegrantEtAl.pdf

Percent Change in Per Capita Cereal Consumption between BAU and Alternative Scenario, 2050



Source: Rosegrant et al. 2012

Percent Change in Population at Risk of Hunger Between BAU and Alternative Scenario, 2050



Source: Rosegrant et al. 2012

Conclusions

Conclusions

- Water scarcity increasing in much of the world, together with climate change and other factors
  - Relatively slow growth in agricultural productivity
  - Slow progress in reduction of hunger
- Plausible scenario for water and crop productivity growth significantly improves water and food security outcomes
  - Water rights and trading
  - New water technologies and farming systems
  - Investment in crop research to increase yield with respect to water and land
  - Increased investment in irrigation

Conclusions

- Water policy, institutional, and management reform and investments must be tailored to underlying conditions
  - Levels of development
  - Agroclimatic conditions
  - Relative water scarcity
  - Level of agricultural intensification
  - Degree of water competition
- Solutions are difficult and take time, political commitment, and money