Agriculture, food security and climate change—the global context

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Scaling in global, regional and farm models
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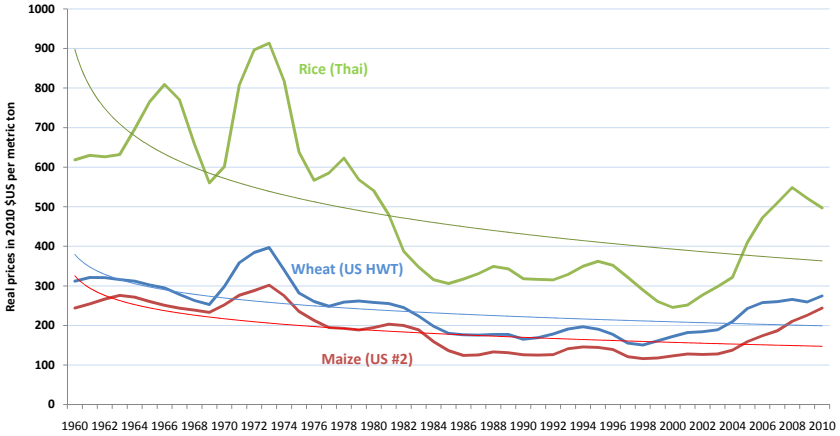
Key policy relevant questions

- Long-term evolution of agricultural and food prices, food security and nutrition
- Dual challenge—undernourishment and obesity
- Land expansion versus production intensification
- Impact of future climate change on prices, land use, trade, undernourishment
- Potential role of biofuels

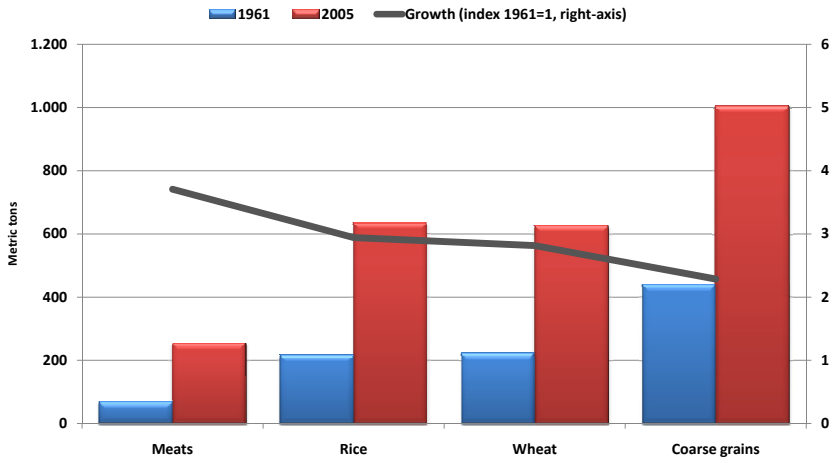
Long-term downward trend in real agricultural prices though-out the 20th century



Source: World Bank pink sheet (http://go.worldbank.org/4ROCCIEQ50, accessed 7-Jan-2014) and own calculations

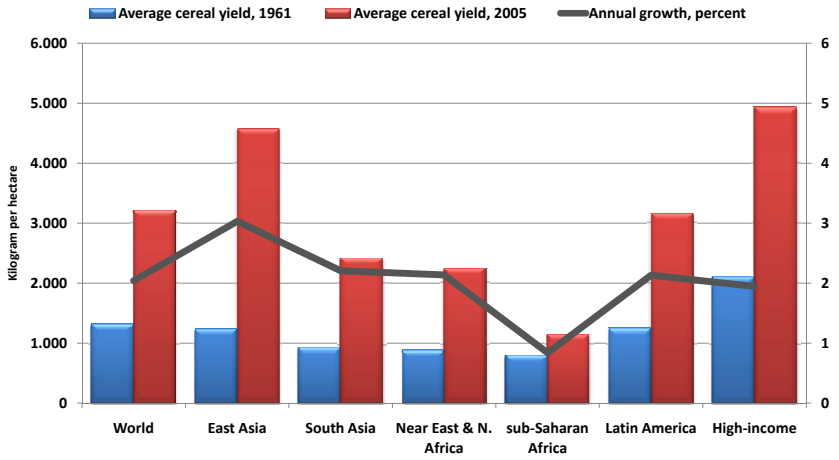
Note: 4-year leading moving average (last year available = 2013).

Large quantity changes for major commodities



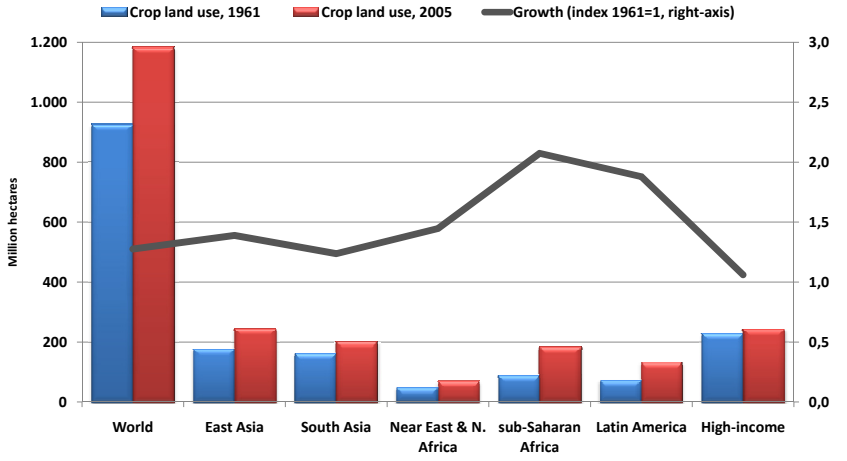
Source: FAO.

Yield improvements account for over 70 percent of production growth



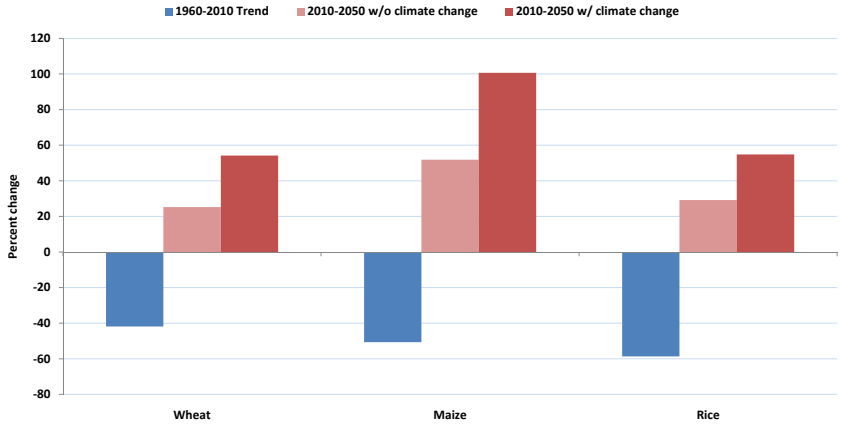
Source: FAO.

Global land expansion for crops of around 250 million hectares



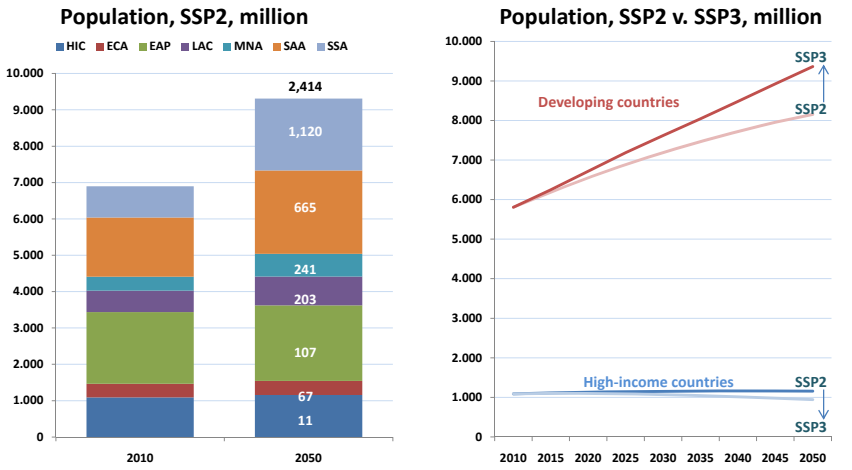
Source: FAO.

Radical change in the future?



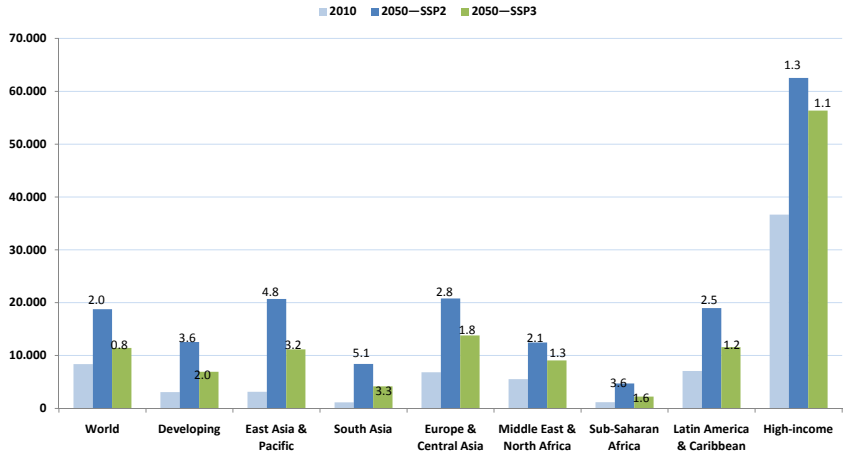
Source: World Bank pink sheet and own calculations for historical series, Nelson et al. (2010) for future price scenarios.

Slowing population growth, however…



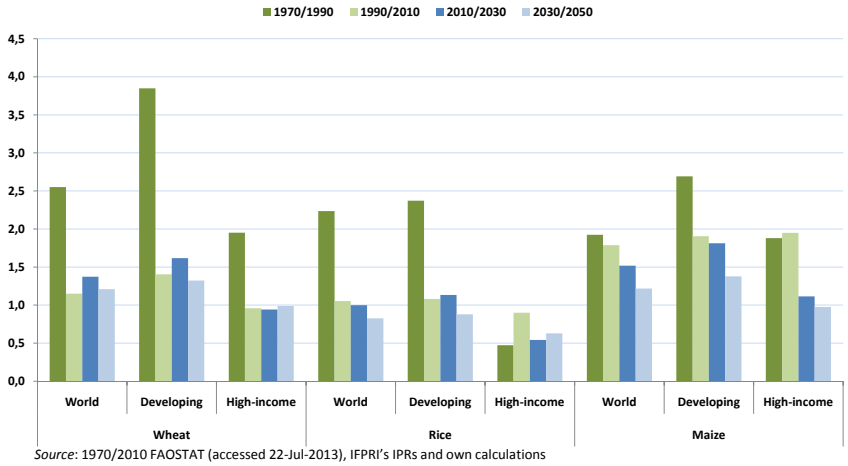
Note: 2010-2050 incremental change indicated in 2050 column. High-income (HIC), Europe & Central Asia (ECA), East Asia & Pacific (EAP), Latin America & Caribbean (LAC), Middle East & North Africa (MNA), South Asia (SAA), Sub-Saharan Africa (SSA).

GDP per capita under SSP2 and SSP3, $2007



Note: Growth rates, percent per annum, on top of columns.

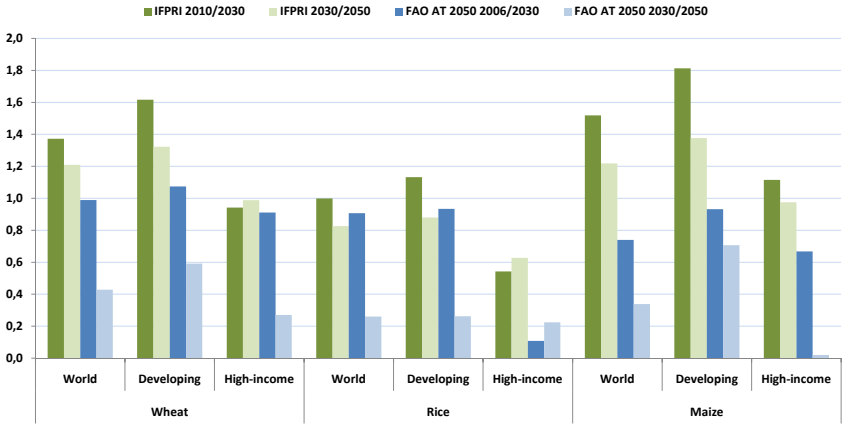
History vs. projected yield growth, percent per annum



Source: 1970/2010 FAOSTAT (accessed 22-Jul-2013), IFPRI's IPRs and own calculations

Note: Slight differences in regional aggregations between history and projections. Maize yield projections equivalent to coarse grain definition in GTAP.

IFPRI vs. FAO AT projections



Source: IFPRI's IPRs, Alexandratos and Bruinsma (2012) and own calculations

Note: Slight differences in regional aggregations between IFPRI and FAO projections. Maize yield projections equivalent to coarse grain definition in GTAP.

Agricultural Model Intercomparison and Improvement Project—AgMIP

- Wide range of model results
  - Crop and economic models
- Confusing policy advice

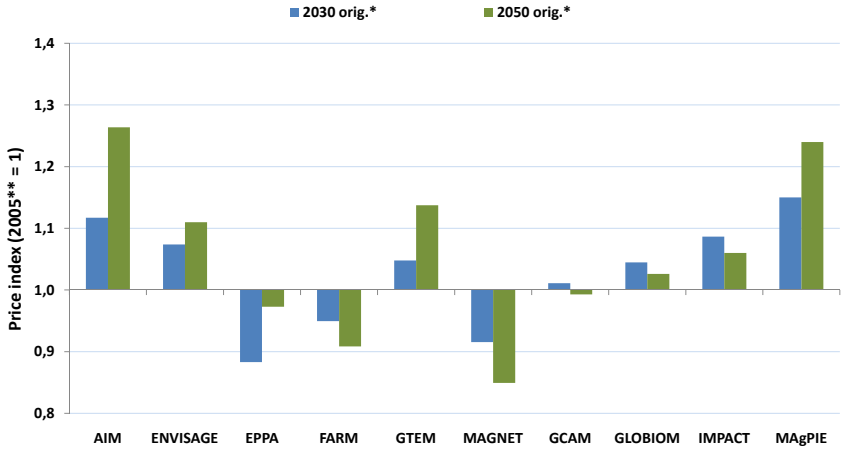
AgMIP and global economic models

- 6 General equilibrium
  - AIM (NIES, Japan), ENVISAGE (FAO, Italy), EPPA (MIT, USA), FARM (USDA, USA), GTEM (ABARES, Australia), MAGNET (LEI/Wageningen, Netherlands),
- 4 Partial equilibrium
  - GCAM (PNNL, USA), GLOBIOM (IIASA, Austria), IMPACT (IFPRI), MAgPIE (PIK, Germany)

Scenario design

- Harmonization of key exogenous drivers
  - Population and GDP (SSP2)
  - Exogenous yield growth (IFPRI)
- 3 Optics
  - Socio-economic (SSP2 vs. SSP3)
  - Climate change (2 crop models x 2 climate models)
  - Bio-energy

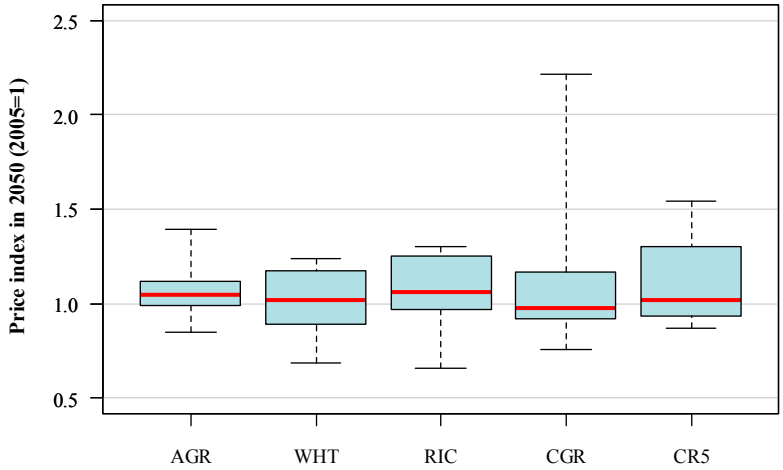
Still large differences in long-term price projections, though sharp narrowing after comparison exercise



* original: relative to model-standard numéraire; rebased: relative to the price index for global GDP
** trended 2005, i.e. hypothetical in the absence of short-term shocks

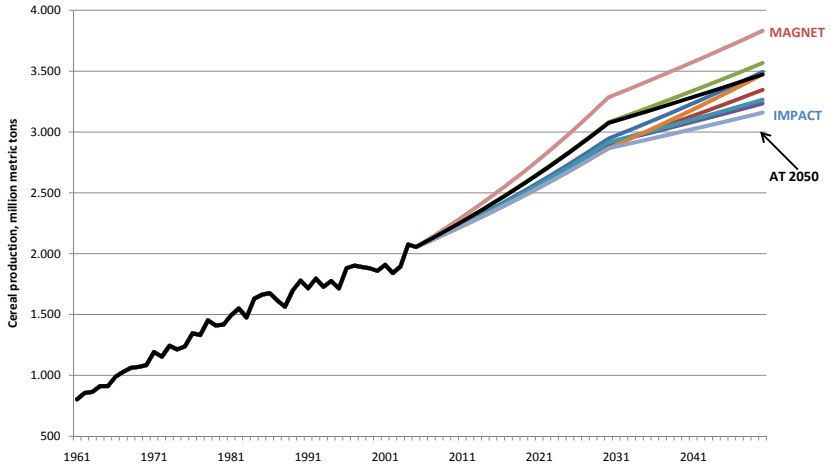
Source: von Lampe et al (2014).

Variation of world prices across commodities in 2050



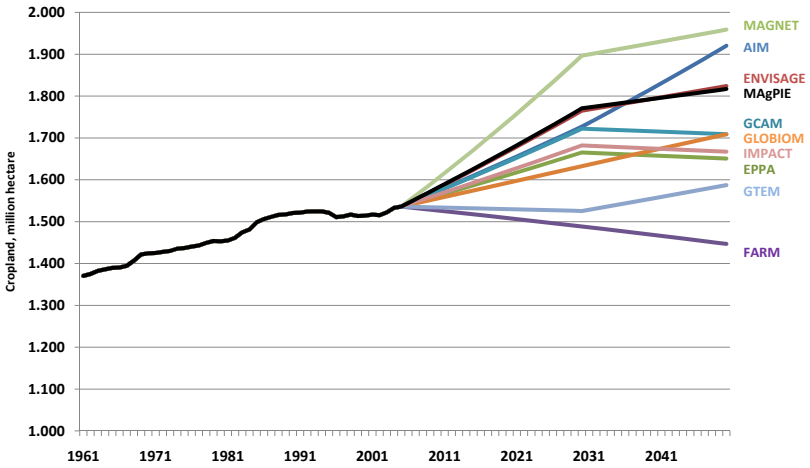
Note: All agriculture (AGR), wheat (WHT), rice (RIC), coarse grains (CGR), index for wheat, rice, coarse grains, oil seeds and sugar (CR5).
Source: AgMIP global economic runs, February 2013 and own calculations.

Cereal production—all above AT 2050 scenario



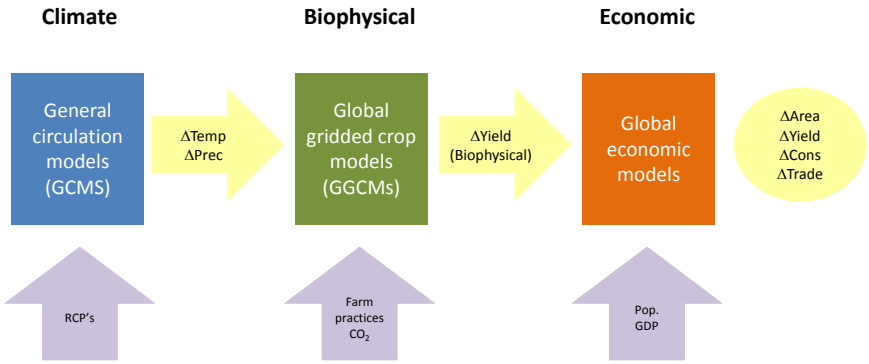
Source: 1961/2005 FAOSTAT (accessed 20-Feb-2014) and model simulations for 2005/2050.

Cropland projections vary significantly across models



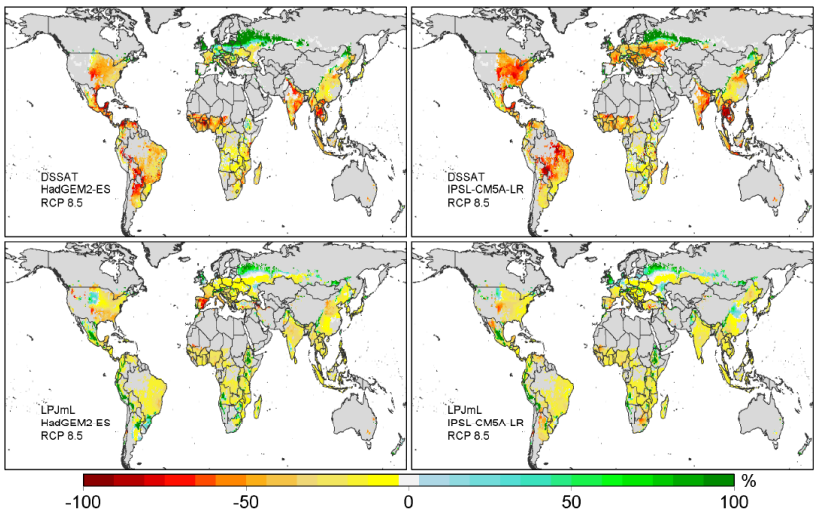
Source: 1961/2005 FAOSTAT (accessed 20-Feb-2014) and model simulations for 2005/2050.

The climate modeling chain: from biophysical to socioeconomic



Source: Nelson et al., PNAS (2013).

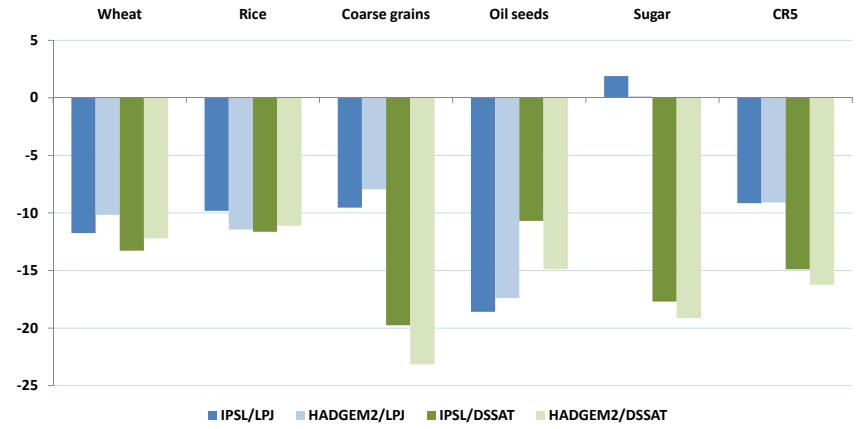
Four potential yield outcomes for maize in 2045 under RCP 8.5†



Source: Müller and Robertson (2014).

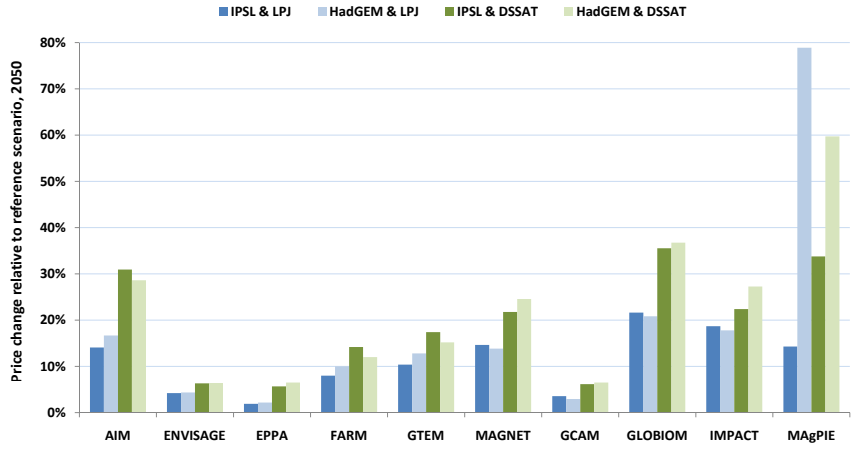
† Excludes CO_2 effects.

Simulated impacts for the four climate scenarios: global average for major crops in 2050 wrt reference



Source: Shocks from IFPRI as interpreted for use in the ENVISAGE model, Nelson, van der Mensbrugghe et al. (2014).

Climate induced changes in world average producer prices for five main crops (CR5) relative to reference in 2050



Source: von Lampe et al. (2014), based on model results as of February 15, 2013.
Note: All changes relative to the reference scenario for the same year.

Take away messages

- Fifty years of substantial progress, but
  - Significant pockets of poverty and under-nourishment
  - Areas of unsustainable farm practices
- In many aspects, next 50 years appear less daunting
  - Declining population growth and reaching food saturation thresholds,
  - Albeit with continued significant pockets of poverty (SSA and South Asia) and concerns with sustainability—soils, water, etc.
- However, new issues emerge:
  - Climate change
  - Bio-energy
- Quantitative analysis in the future will require more cooperation
  - Model comparison and validation
  - Model integration (climate, crop and economic)

Further reading

Alexandratos, N. & J. Bruinsma (2012), "World Agriculture Towards 2030/2050: The 2012 Revision,", FAO, Rome. http://www.fao.org/docrep/016/ap106e/ap106e.pdf

Special issue of Agricultural Economics (2014): http://onlinelibrary.wiley.com/doi/10.1111/agec.2014.45.issue-1/issuetoc

- **von Lampe, Willenbockel et al.**, "Why do global long-term scenarios for agriculture differ? An overview of the AgMIP Global Economic Model Intercomparison"
- **Robinson, van Meijl, Willenbockel et al.**, "Comparing supply-side specifications in models of global agriculture and the food system"
- **Valin, Sands, van der Mensbrugghe et al.**, "The future of food demand: understanding differences in global economic models"
- **Schmitz, van Meijl et al.**, "Land-use change trajectories up to 2050: insights from a global agro-economic model comparison"
- **Müller and Robertson**, "Projecting future crop productivity for global economic modeling"
- **Nelson, van der Mensbrugghe et al.**, "Agriculture and climate change in global scenarios: why don't the models agree"
- **Lotze-Campen, von Lampe, Kyle et al.**, "Impacts of increased bioenergy demand on global food markets: an AgMIP economic model intercomparison"

Proceedings of the National Academy of Sciences (PNAS) (2013): http://www.pnas.org/content/early/2013/12/12/1222465110.full.pdf+html

- **Nelson et al.**, "Climate change effects on agriculture: Economic responses to biophysical shocks"