Emissions pricing of food commodities: climate change mitigation potential and global health impacts

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FUTURE OF Food *The Oxford Martin Programme on the Future of Food*

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Background

Rise in food-related GHG emissions could seriously impede efforts to limit global warming:

- Food system responsible for $>$ 25% of all GHG emissions, most of which related to livestock (Vermeulen et al, 2012; Steinfeld et al, 2006; Tubiello et al, 2014).
- Food-related emissions projected to increase by up to 80% by mid-century due to population growth and dietary changes (Popp et al, 2010; Hedenus et al, 2014; Tilman and Clark, 2014; Bajzelj et al, 2014; Springmann et al, 2014).
- In 2050, food-related GHG emissions could take up half of emissions budget allowed to keep global warming below 2°C, and exceed it by 2070 (Hedenus et al, 2014; Springmann et al, 2016).

$\Rightarrow$ Reducing food-related GHG emissions will be critical for climate change mitigation.

Difficulties of regulating emissions from food and agriculture:

- Ag emissions are variable (non-point) and hard (and costly) to monitor at source (Lassey, 2007; Bouwman et al, 2002; Snyder et al, 2009).
- Most Ag emissions are intrinsic to the system (methane from ruminants, nitrous oxide from fertilizers) → difficult to address without affecting output and food availability (Smith et al, 2007, 2008).
- Potential impacts on food security (Golub et al, 2013; Havlik et al, 2014).

→ Food and agriculture largely spared from climate policies.

Background

This study:

- *Global analysis of emissions and health impacts of levying GHG taxes on food commodities (at point of purchase).*

Addresses difficulties:

- Demand-side policies (in theory) preferable when monitoring costs high, high substitutability, and limited mitigation options apart from output reduction (Schmutzler and Goulder, 1997; Wirsenius et al, 2010).
- Health impacts depend on both food availability and food composition, e.g., dietary changes away from emissions-intensive animal-based foods associated with better health (Tilman and Clark, 2014; Springmann et al, 2016).

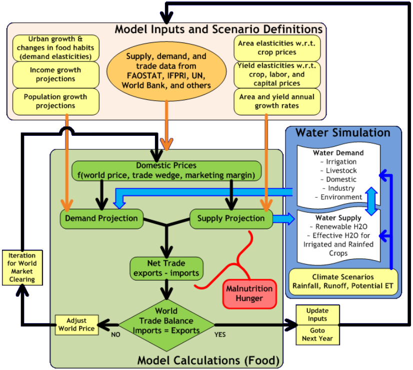
Research approach

Methods: coupled modelling framework

- Agricultural analysis:
  - Use of IMPACT model to project future food consumption
- Environmental analysis:
  - Commodity and region-specific GHG emissions factors from FAO and Tilman and Clark (2014)
- Economic analysis:
  - Social cost of carbon estimates from model comparison of integrated assessment models (for US Gov)
  - Consumer responses to price changes with international data on prices and elasticities (IMPACT),
- Health analysis:
  - Use of global comparative risk assessment framework developed at Oxford

IMPACT description

International Model for Policy Analysis of Agricultural Commodities and Trade (**IMPACT**):

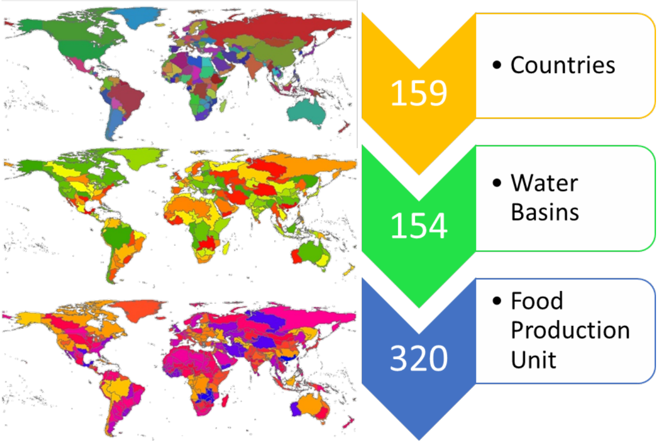


Partial equilibrium approach:

- World food prices are determined annually at levels that clear international commodity markets
- Food production depends on crop and input prices, productivity growth, area expansion, irrigation and water availability
- Food demand depends on commodity prices, income, and population growth

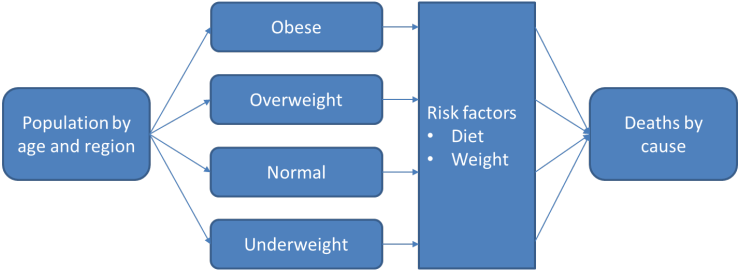
IMPACT description

High spatial resolution:



Global health model

Comparative risk framework:



- 6 risk factors: fruits&veg and red meat (2/3 of dietary risks), weight classes (5 of following 10 risk factors)
- 5 causes of death: CHD, stroke, T2DM, and cancer (60% of NCD deaths), aggregate of other causes
- Changes in mortality by calculating population attributable fractions (PAFs) to risk exposures

Scenario assumptions:

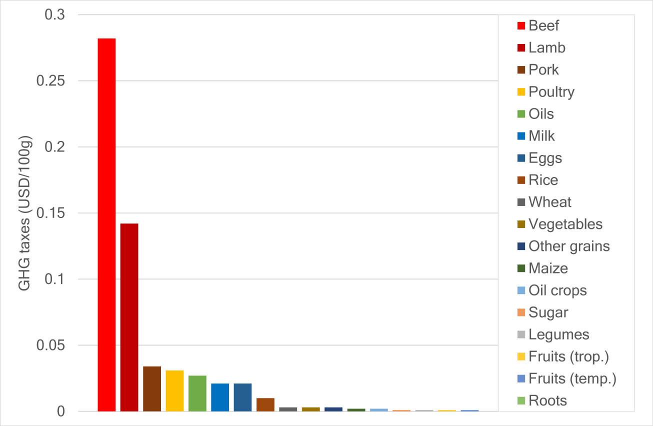
- GHG taxes on food commodities at point of purchase;
- Taxes are implemented independently in each country as coordinated implementation unlikely (focus on demand response, no international feedbacks);
- Emissions and health impacts for the year 2020 (when new global climate agreement is to be implemented);
- Health impacts for adults (aged 20 or older), but sensitivity analysis of health impacts on children.
- GHG price of 52 USD/tCO_2-eq associated with discounting future climate damages with a discount rate of 3%.

Research approach

Model scenarios:

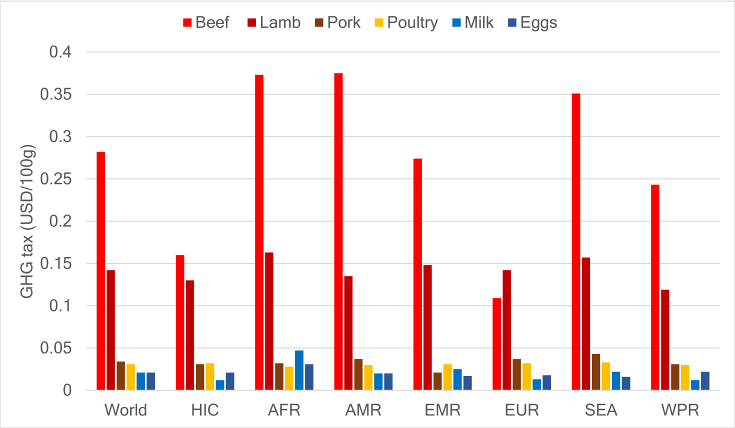
- *TAX*: GHG taxes on all food commodities
- *TAXadj*: Tax exemptions for health-critical food groups in dev countries (fruits&veg and staples)
- *TAXani*: GHG taxes only on animal products (meat, dairy, eggs)
- *TAXrem*: GHG taxes only on red meat (beef, lamb, pork)
- *TAXbef*: GHG taxes only on beef
- Income-compensated variants ($_r$)
- Variants in which three quarters of tax revenues are used to subsidize fruits&veg ($_s$)

Results: GHG taxes on all food commodities



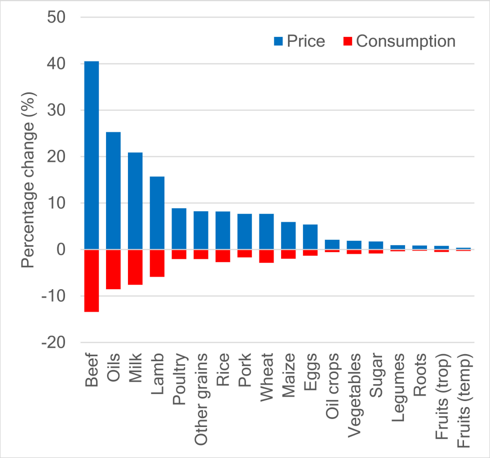
- GHG taxes highest for animal-sourced foods.

Results: GHG taxes on all food commodities



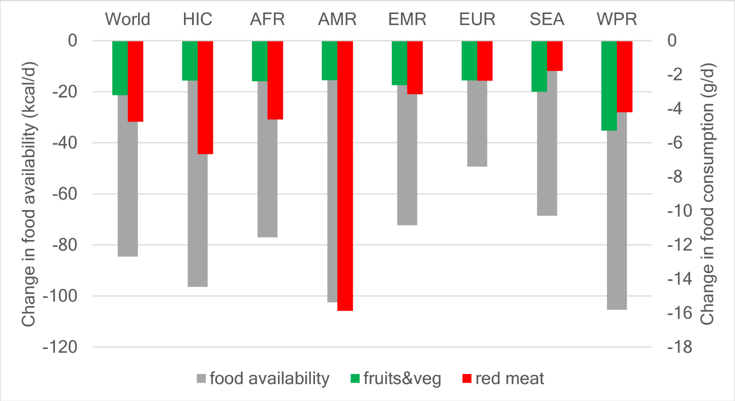
- Regional differences due to different production systems (e.g. grass-fed beef in AMR vs intensive grain-fed beef in USA vs mixed beef and dairy systems in EUR).

Results: GHG taxes on all food commodities



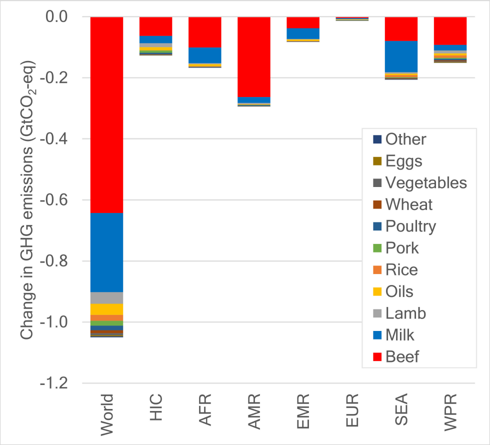
- High price and consumption changes for ruminant-based foods and vegetable oils (det by GHG taxes and baseline prices).

Results: GHG taxes on all food commodities



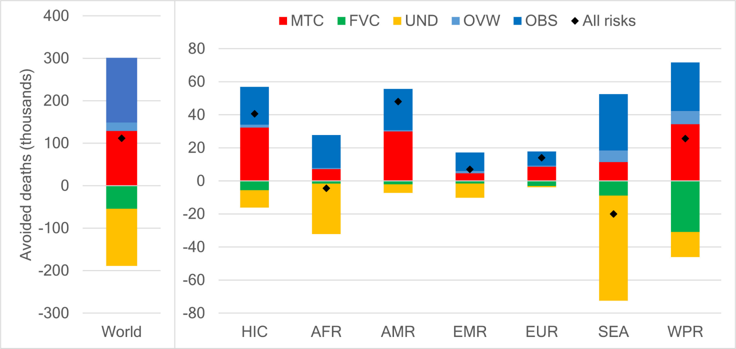
- High meat impacts in AMR due to high emissions intensities;
- low meat impacts in HIC, EUR, and EMR due to low emissions intensities (HIC, EUR) and high prices (EUR, EMR).

Results: GHG taxes on all food commodities



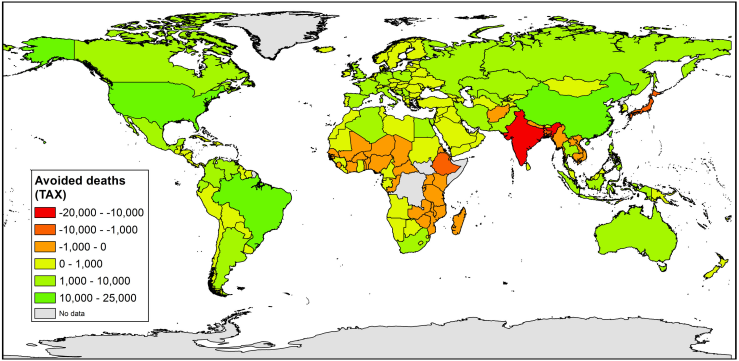
- High emissions reductions ($\approx$ 1 $GtCO_2$); two thirds from less red meat, a quarter from less milk; three quarters from MICs.

Results: GHG taxes on all food commodities



- Health benefits due to ↓red meat, ↓overweight, ↓obesity;
- Health losses due to ↓fruit&veg, ↑underweight.
- Global benefits, but net losses in AFR and SEA.

Results: GHG taxes on all food commodities



- Net losses in 35 countries;
- Greatest losses in India, Bangladesh, Ethopia;
- Greatest benefits in China, Brazil, USA, Mexico, Russia.

Alternative model scenarios

Model scenarios:

- *TAX*: GHG taxes on all food commodities
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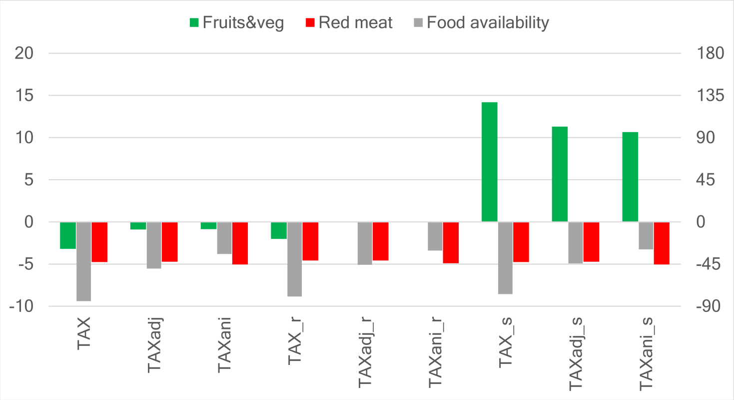
- Income-compensated variants ($_r$)
- Variants in which half of tax revenues are used to subsidize fruits&veg ($_s$)

⇒ **15** different tax scenarios

Results: alternative tax scenarios

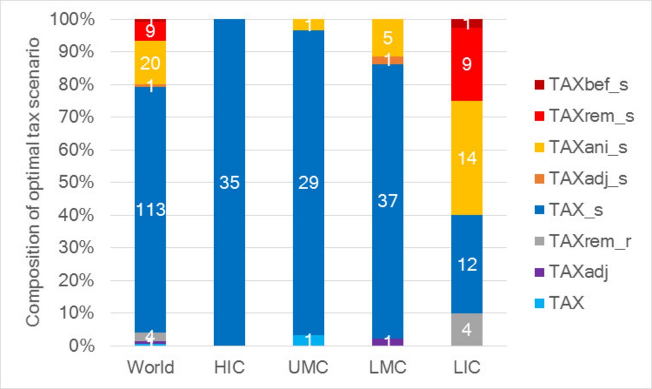


- TAX→TAXani: ↑ fruits&veg, ↑food availability;
- (TAX,TAXadj,TAXani)→(TAX_r,$TAXadj_r$,$TAXani_r$) →TAX_s,$TAXadj_s$,$TAXani_s$): ↑fruits&veg.

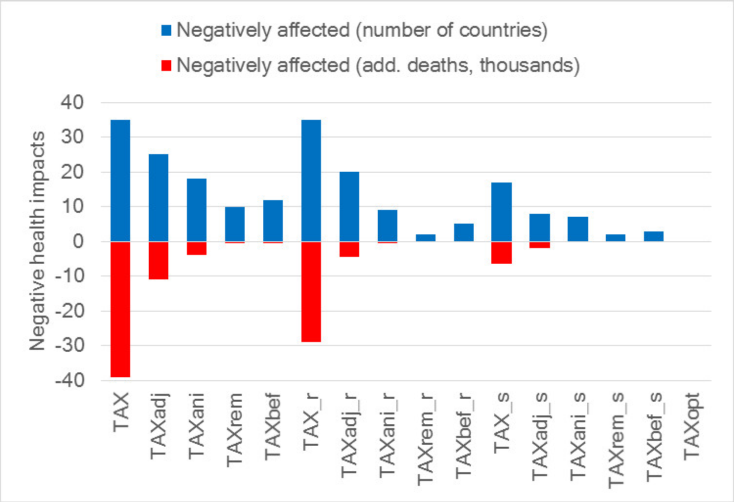
Results: alternative tax scenarios

Find health-maximising tax scenario for each region:

- Optimization across all 15 tax scenarios:

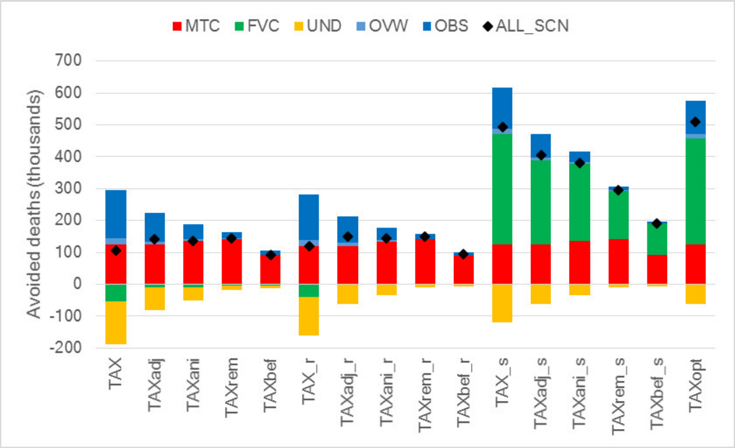


Results: optimal tax scenario



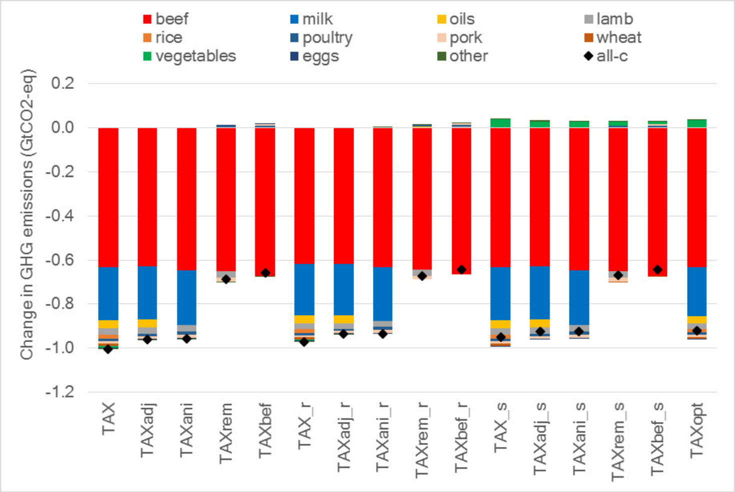
- No negative net health impacts in TAXopt scenario.

Results: optimal tax scenario



- Global health benefits increases fivefold in TAXopt.

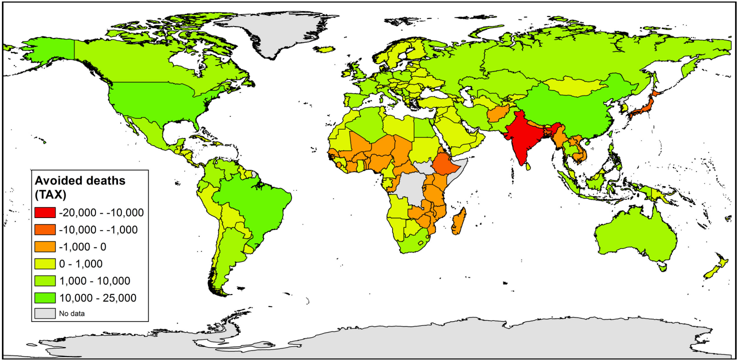
Results: optimal tax scenario



- Mitigation potential similar in TAXopt as in TAX.

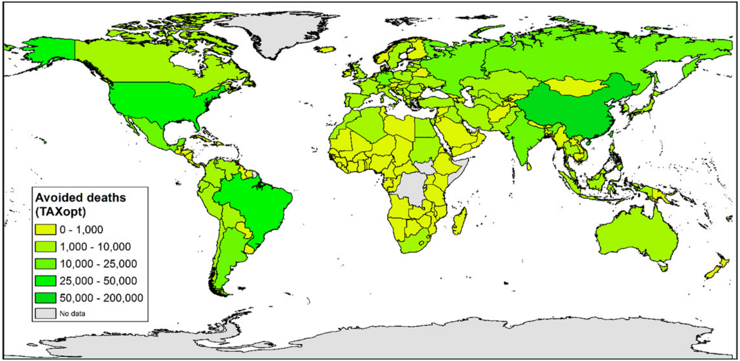
Results: optimal tax scenario

From naive tax scenario...



Results: optimal tax scenario

To health-sensitive taxing schemes:



Sensitivity analysis

Direction of results not affected by:

- Potential impacts on undernourishment and stunting amongst children:
  - 3% change in TAX, <0.4% change in TAXopt
- Greater number of years lost early in life (YLS), disability associated with ill-health (DALY):
  - negative impacts in up to 8 very low-income countries
- Different GHG prices (14, 52, 78, 156 USD/tCO_2-eq):
  - 150,000-1,300,000 avoided deaths; 0.3-1.9 GtCO_2-eq emissions reduced.

Discussion

We find:

- GHG taxes on food commodities could, if appropriately designed, be a health-promoting climate change policy in HICs and most LMICs;
- Increased food prices and reductions in food availability not necessarily negative:
  - $\downarrow$obesity $>$ $\uparrow$underweight
  - benefits from $\downarrow$red meat $>$ losses from other food groups.
- Special policy attention needed in LICs and other vulnerable countries (and populations) to avoid health losses:
  - excluding fruits&veg and other critical food groups from taxation;
  - compensating income losses;
  - using tax revenues for health promotion, e.g. subsidies for fruits&veg.

Discussion

Results in context:

- GHG mitigation potential ($\approx$ 1 $GtCO_2$):
  - More than current GHG emissions of global aviation;
  - 10% of emissions gap for 2020;
  - $>$ supply-side measures, such as rice, livestock, and manure management (each below 250 $MtCO_2$-eq; Smith et al, 2014);
  - Similar to global mitigation target for agriculture in 2030 (Wollenberg et al, 2016).
- Health benefits ($\approx$ 100,000-500,000 avoided deaths)
  - Comparable to health benefits of reduced air pollution from coal-fired power plants (West et al, 2013);
  - Small when compared to potential health benefits of global dietary change towards more plant-based diets ($\approx$ 5-8 million avoided deaths in 2050; Springmann et al, 2016)

  $\rightarrow$ Additional policy measures needed for more health benefits from dietary change.

Discussion

Caveats:

- Health analysis based on food groups:
  - strong epidemiological evidence
  - no account of changes in nutritional quality of diets (fatty acid composition, sodium content, micronutrients).
- Comparative static framework:
  - no account of time lags between introduction of GHG taxes and changes in food consumption and health outcomes.
- Comparative regional analysis:
  - coordinated implementation seems unlikely at present;
  - no account of feedbacks between countries;
  - no account of supply side.

Contact

Thank you for your attention.

Comments and suggestions:

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Co-authors:

- *University of Oxford*: Peter Scarborough, Mike Rayner, Charles Godfray
- *International Food Policy Research Institute:* Daniel Mason-D'Croz, Sherman Robinson, Keith Wiebe

Panel discussion

Jerry Nelson:

- Biological research on effects of higher CO_2 and temperature on micronutrient availability, especially vitamins;
- Restructure ag research priorities to increase availability of micro nutrients (e.g. fruits and veggies rather than staples).

Keith Wiebe:

- Need improved modeling of fruits, vegetables, and animal-source foods - in terms of livelihoods, nutrition, and the environment;
- Need improved modeling of the impacts of climate variability and extreme events.

Marco Springmann:

- Increase detail of economic analysis of dietary and food-system changes;
- Align resolution of health and agricultural analysis, and introduce more food groups into analysis.