United States Department of Agriculture

Climate and Biomass Impacts on Global Land Use

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22nd AIM International Workshop
Tsukuba, Japan
9-10 December 2016

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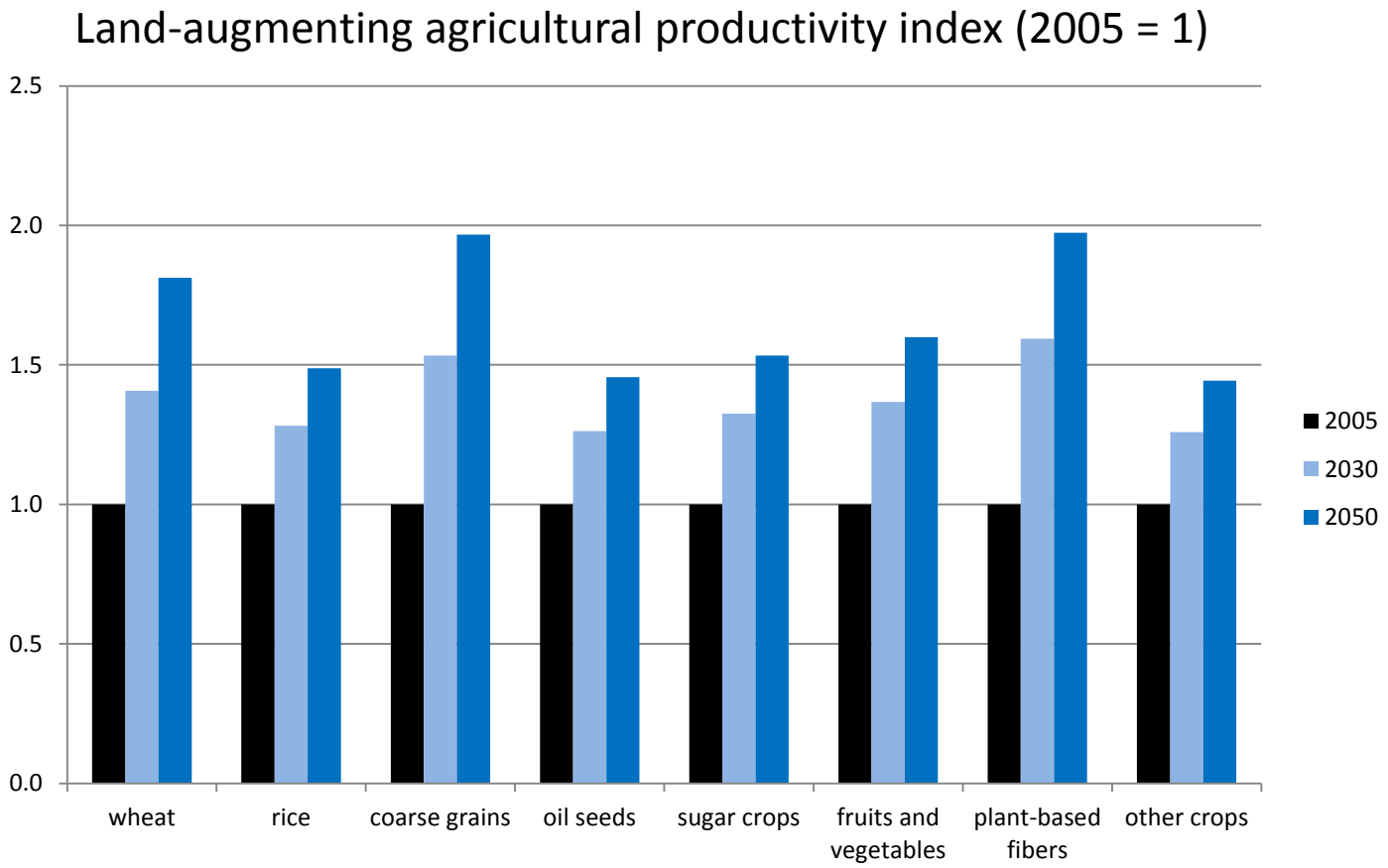
Overview

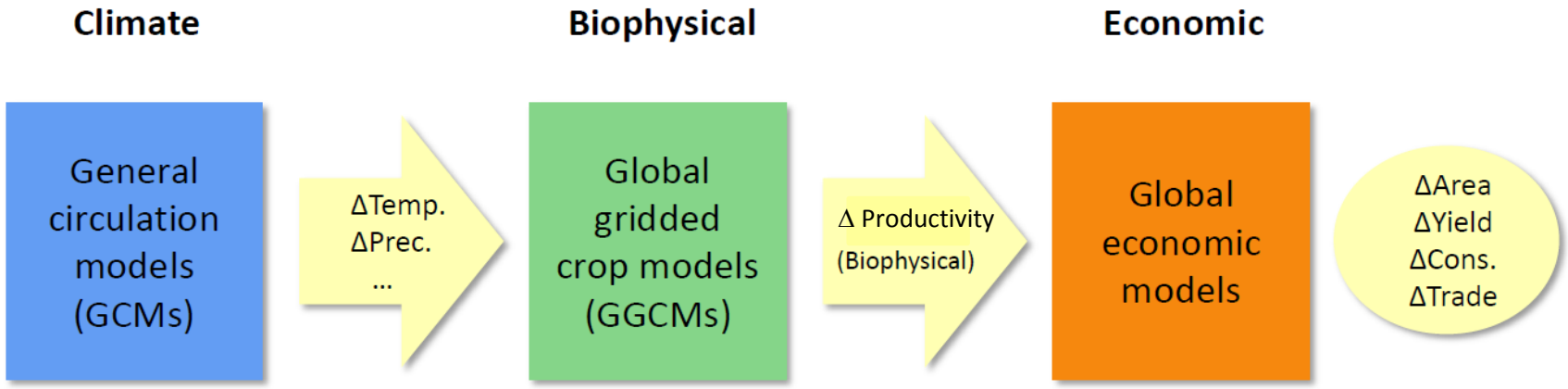
- Motivation
  - What is the relative impact on global land use between climate change and bioenergy scenarios?
- Reference scenario
  - Agricultural productivity growth to 2050 from IFPRI by world region and crop
- Adaptation to climate change
  - SSP 2 and RCP 6.0
  - SSP 2 and RCP 8.5
  - Three GCMs and one crop model (LPJmL)
- Biomass supply
  - EMF-33 scenarios with bioenergy targets
- Outstanding issues

Agricultural Productivity Growth

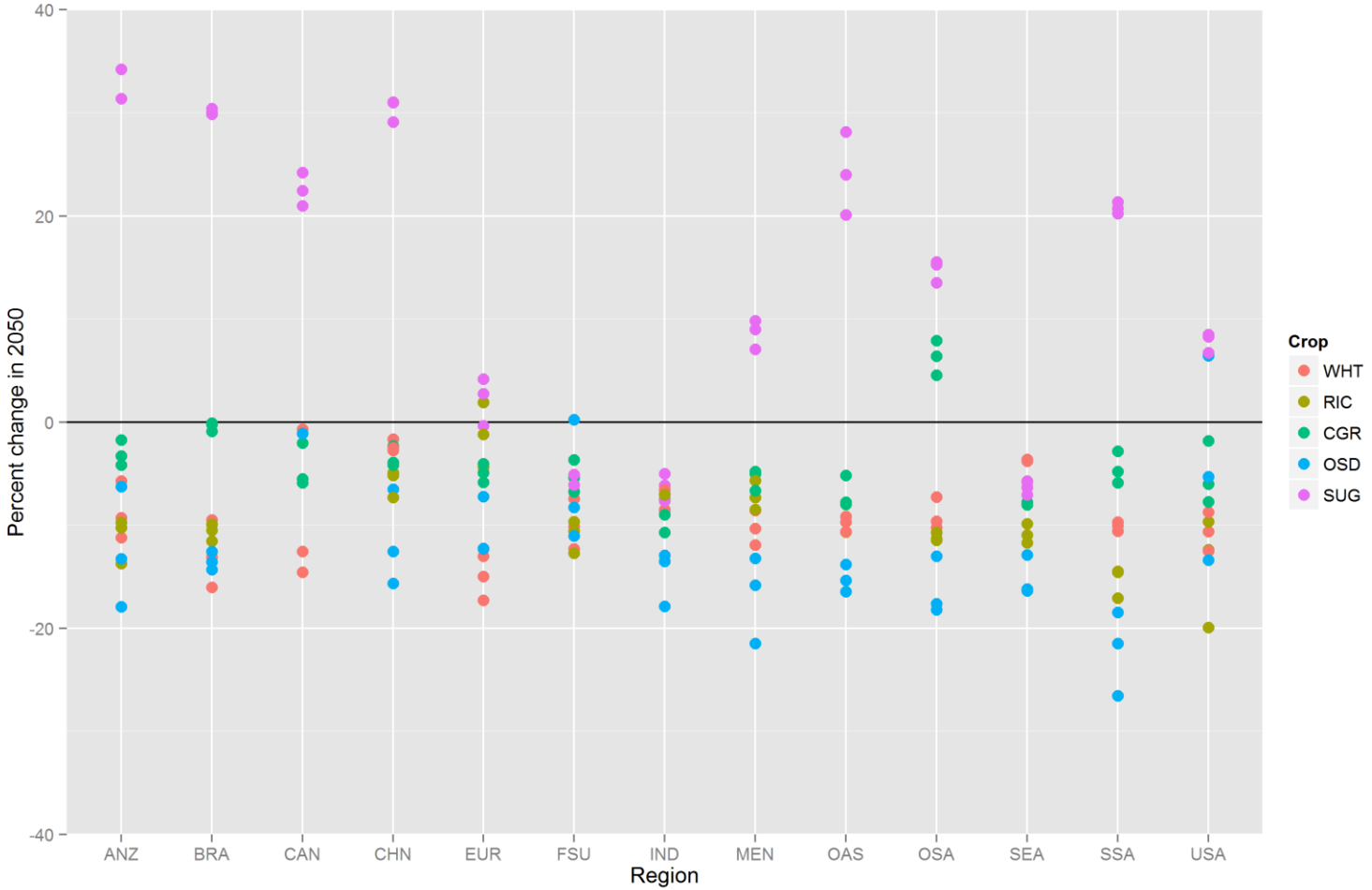


Source: IMPACT model maintained by the International Food Policy Research Institute. IMPACT values are based on expert opinion about potential biological yield gains for crops in individual countries based on historical yield gains and expectations about future private and public sector research and extension efforts.

The climate modeling chain: From biophysical to socioeconomic



Exogenous impacts of climate change on crop yields under SSP 2 and RCP 6.0 (percent change relative to SSP 2 baseline in 2050 without climate change)

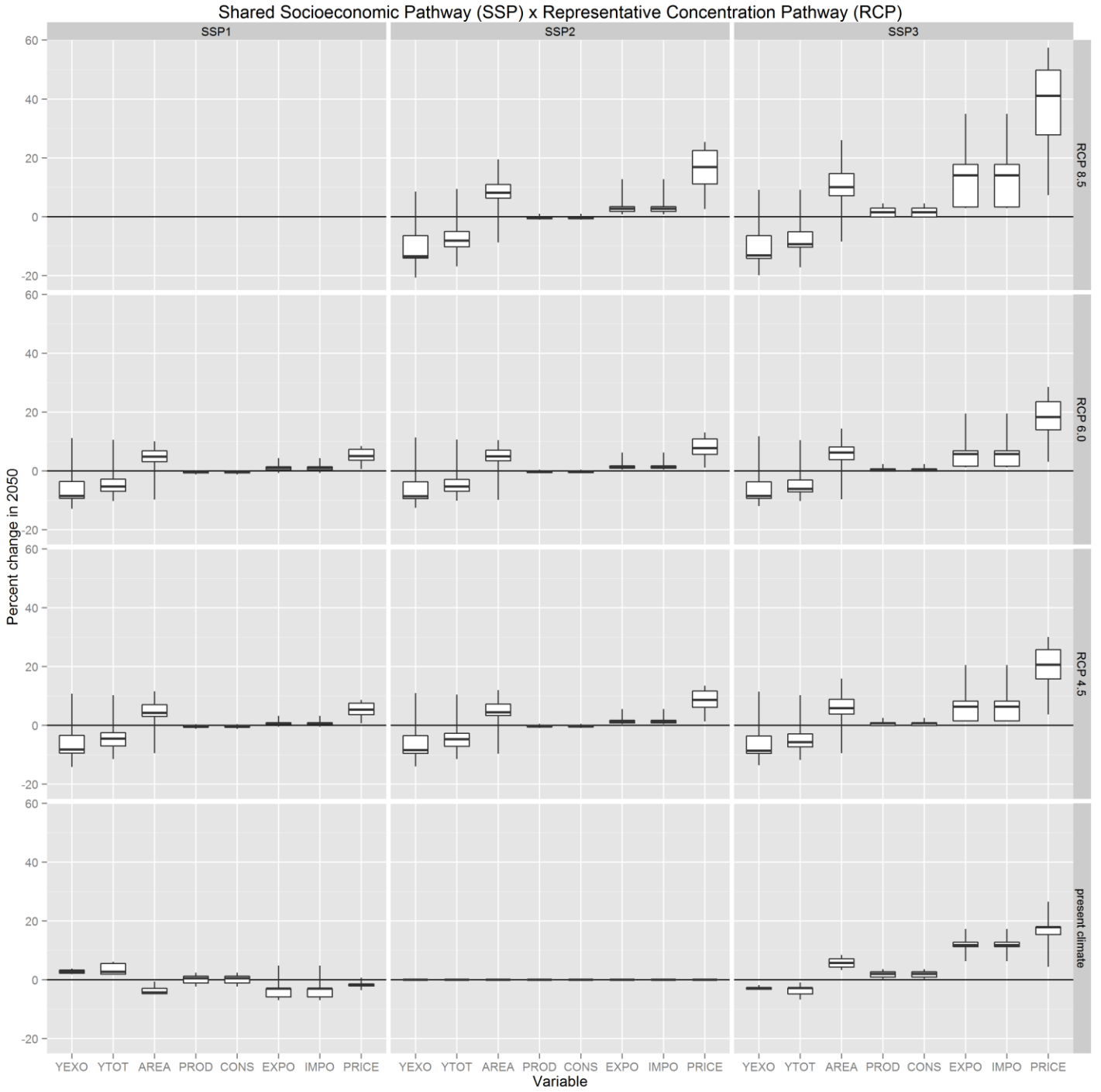


Based on three GCMs and one crop model (LPJmL). Each dot depicts the result for one crop and one GCM.
WHT = wheat; RIC = rice; CGR = coarse grains; OSD = oil seeds; SUG = sugar

Economic variables

Code	Variable	Comments
YEXO	Exogenous yield shocks	Expressed as either: • Percent change over time, from 2005 through 2050 or • Percent change at a point in time (2050), relative to reference scenario
YTOT	Realized yield after management adaptation	
AREA	Agricultural area in production	
PROD	Total production	
CONS	Total consumption	
EXPO	Exports	
IMPO	Imports	
PRICE	Price	

Impacts of climate change under different SSP x RCP/GCM combinations using the FARM model (percent change relative to SSP baseline in 2050)

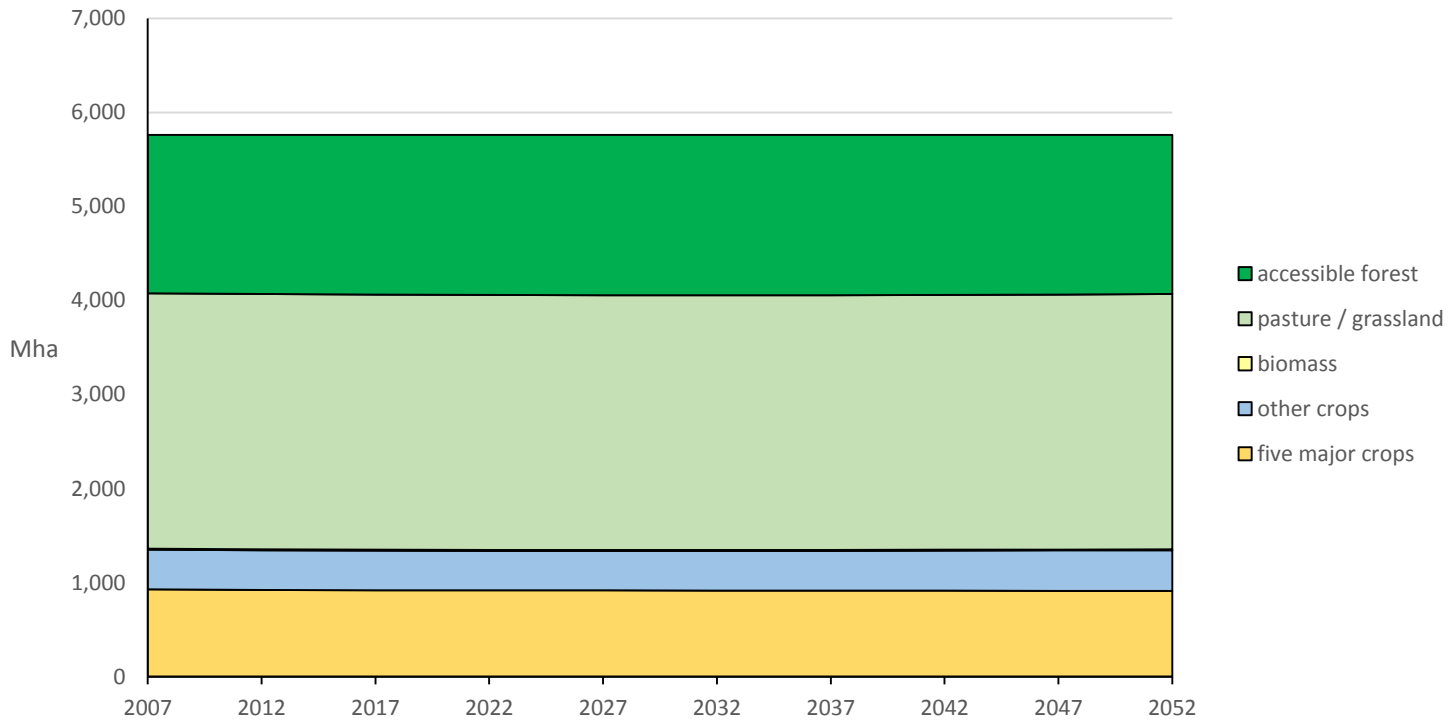


Pooled results for five commodities (rice, wheat, coarse grains, oil seeds, sugar) from three GCMs and one economic model (n = 15), aggregated across 13 world regions. The boxes and whiskers depict 5th, 25th, 50th, 75th, and 95th percentiles.

Global Biomass Supply

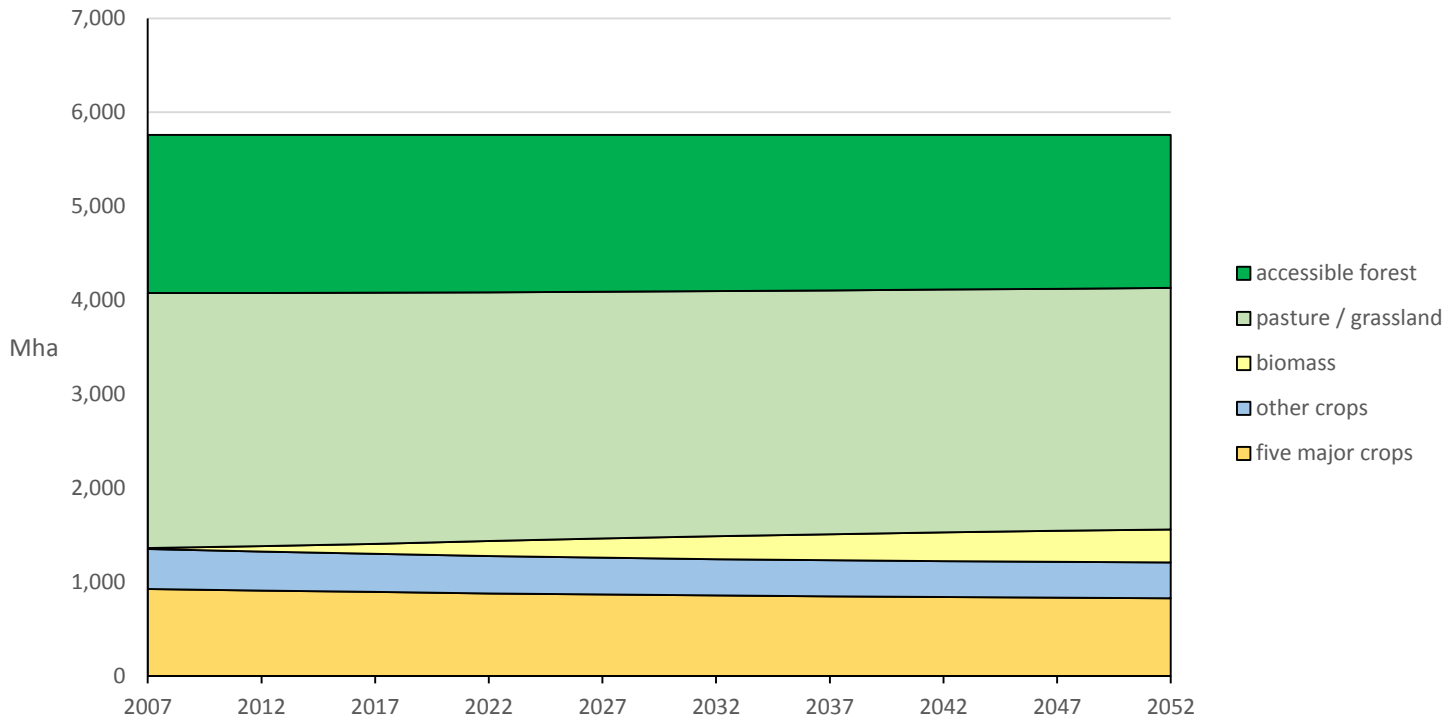
- EMF-33 study has two parts
  - Scenarios of biomass supply by 2100 (100, 200, 300, 400 EJ)
  - Integrated biomass and demand scenarios with stringent global emissions targets
- A big challenge for computable general equilibrium (CGE) models such as FARM
  - Not feasible to isolate biomass supply from biomass demand
  - Double-entry accounting: revenue equals expenditure for all economic agents
  - Strategy is to increase biomass supply by subsidizing bio-electricity
- Biomass competes for land with all other land uses
  - Intensification of crop and forest production

Reference Global Land Use Scenario



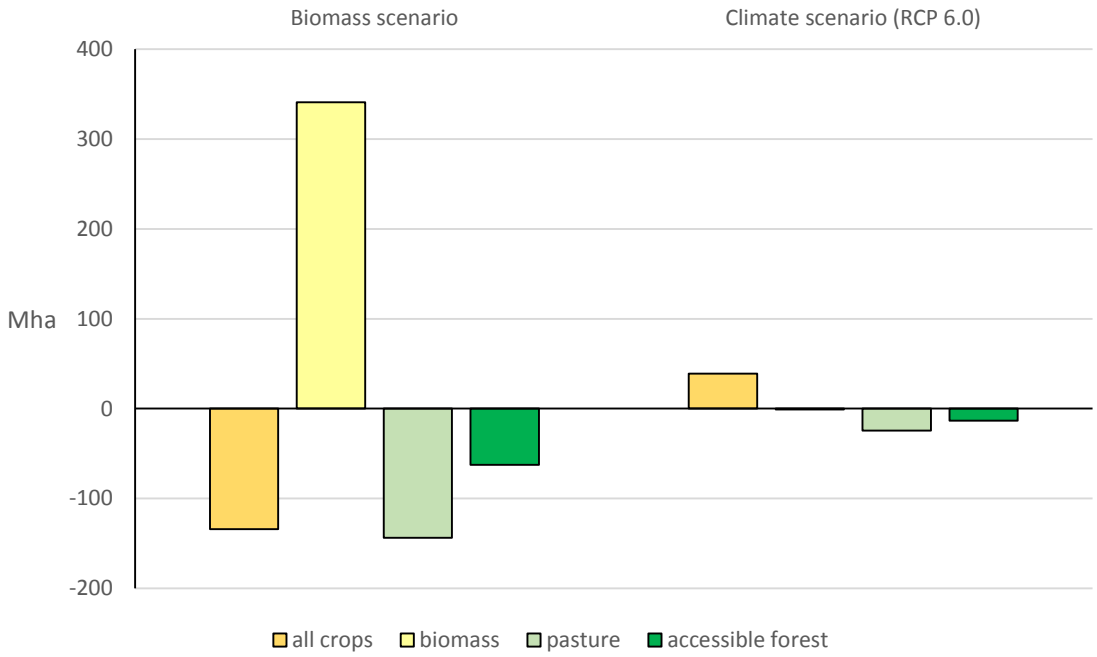
Global land use can remain stable through 2050 with increases in agricultural productivity that offset an increasing population and increasing per-capita incomes.

Biomass Supply Scenario



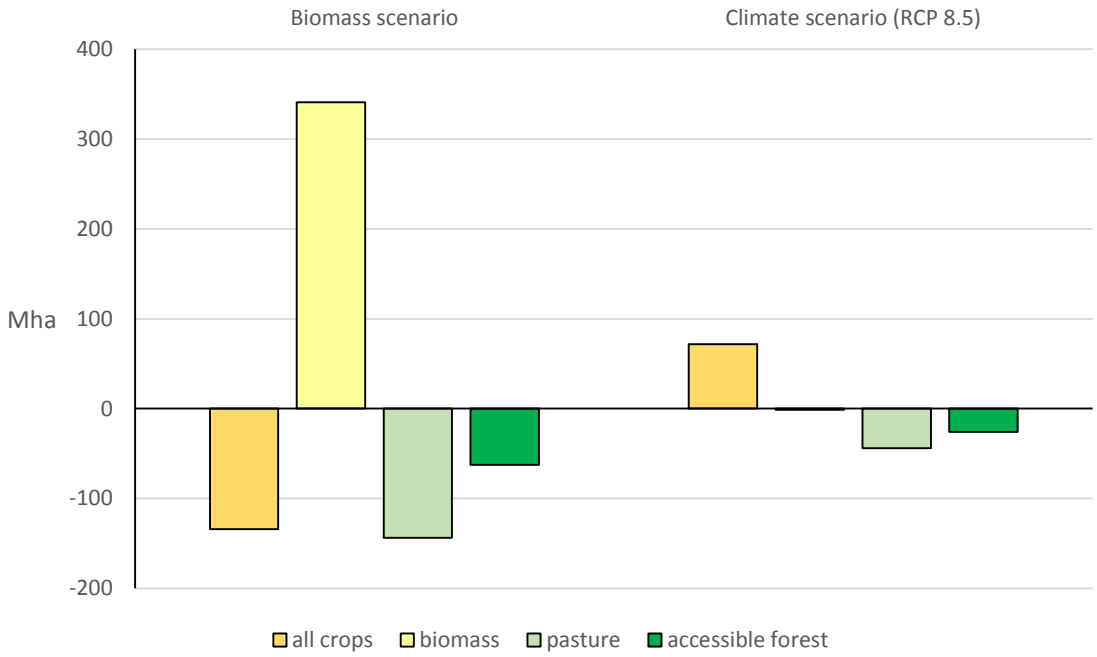
This is the most extreme EMF-33 biomass supply scenario, with 187 EJ of biomass by 2052 (and 400 EJ of biomass by 2100). Biomass (switchgrass) productivity increases by 1 percent per year.

Change in Global Land Use relative to Reference Scenario in 2052



This biomass scenario (187 EJ of biomass in 2052) displaces 10 percent of all cropland in the reference scenario.

Change in Global Land Use relative to Reference Scenario in 2052



This biomass scenario (187 EJ of biomass in 2052) displaces 10 percent of all cropland in the reference scenario.

Results

- Reference scenario
  - Global land use can remain stable through 2050 with increases in agricultural productivity that offset an increasing population and increasing per-capita incomes
  - We use productivity projections from the International Food Policy Research Institute
- Economic adaptation to climate change
  - We used Representative Concentration Pathways (RCP 6.0 and RCP 8.5) as the climate scenarios
  - Cropland area increases to partially compensate for decline in agricultural productivity relative to reference scenario
- Biomass supply
  - Biomass competes for land with all other land uses
  - Area for cropland, forest, and pasture decline
  - If demand for biomass becomes large, as in this scenario, biomass can have a much greater impact on land use than climate in 2050

Outstanding Issues

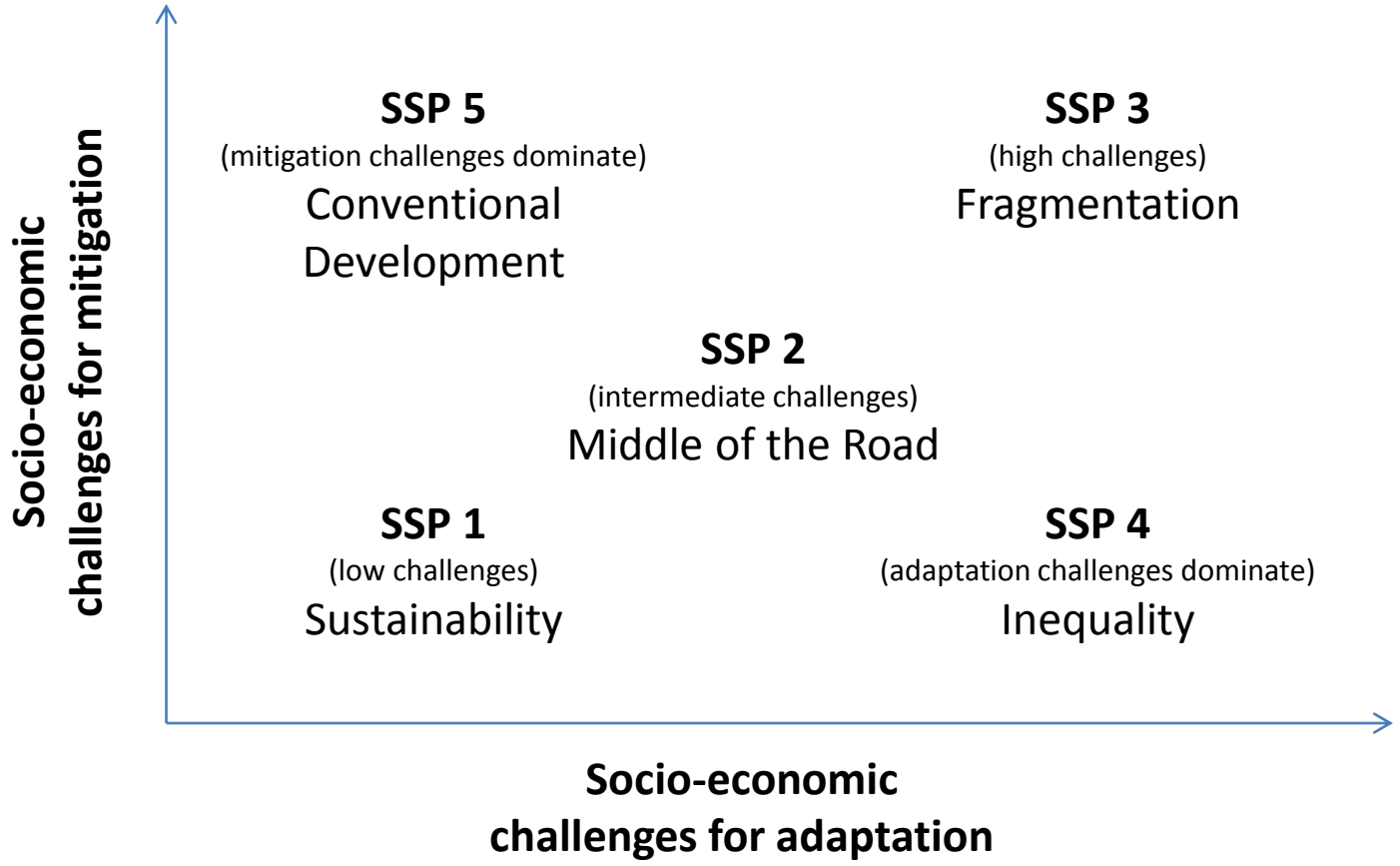
- Response of food consumption to increasing per-capita income
- Extreme events such as multi-year drought
- How to apply output from crop process models to global economic models
- Income distribution within world regions
- CO_2 fertilization
- Link to analysis at sub-national level

Extra Slides

Regional aggregation

Code	Region name	Comments
USA	United States of America	
CAN	Canada	
BRA	Brazil	
OSA	Other South America, Central America & Caribbean	
EUR	Europe	Excl. Turkey
FSU	Former Soviet Union	European and Asian
MEN	Middle-East North Africa	Incl. Turkey
SSA	Sub-Saharan Africa	
CHN	China	
IND	India	
SEA	South-East Asia	Incl. Japan
OAS	Other Asia	Incl. Other Oceania
ANZ	Australia/New Zealand	

Shared Socio-economic Pathways (SSPs)



Source: O'Neill, B.C., E. Kriegler, K. Riahi, K. Ebi, S. Hallegatte, T.R. Carter, R. Mathur, D.P. van Vuuren. February 2014. "A New Scenario Framework for Climate Change Research: The Concept of Shared Socio-Economic Pathways," Special Issue on "A Framework for the Development of New Socioeconomic Scenarios for Climate Change Research," *Climatic Change* 122(3): 387-400.