Representative agricultural pathways and scenarios for integrated assessment

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Representative agricultural pathways and scenarios (RAPS) are projections of plausible future biophysical and socioeconomic conditions used to carry out climate impact assessments for agriculture. The development of RAPS is motivated by the fact that various global and regional models used to assess the impact of climate change on agriculture have been implemented with individualized scenarios using various data and model structures, often without transparent documentation or public availability. These practices have hampered attempts at model intercomparison and improvement, and at synthesis of model results across studies. For purposes of integrating impact assessments, therefore, the development of RAPS is important not only for building consistent sets of pathways and scenarios for intercomparison, but also for extending those scenarios to relevant future pathways and scenarios with a consistent set of drivers, both globally and regionally.

IMPACT

The development of representative agriculture pathways and scenarios (RAPS) can help scientists better characterize the range of uncertainty in climate change impacts and in adaptation and mitigation efforts. The framework of RAPS will also allow scientists to assess a wider range of individual studies by grouping them according to common assumptions they make about socioeconomic conditions or climate change outcomes.

The need for RAPS is demonstrated by recent research on climate impacts in agriculture. Preliminary research has shown that on average, farmers producing winter wheat could potentially obtain higher yields with future climates. However, the future world is uncertain in many dimensions, including commodity and input prices, production technology, and policies, as well as increased probability of disturbances (pests and diseases) associated with a changing climate. Existing models incorporate only a few of these factors, so we need a tool to represent and quantify these factors for modeling purpose.

To develop pathways and corresponding scenarios at regional or local scales, teams of scientists and other experts with knowledge of the agricultural systems and regions work together

Photo by Nita Robinson.

Table 1. *Likely trends of variables for REACCH representative agricultural pathways and scenarios (RAPS).*

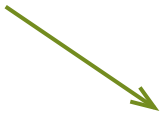
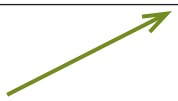
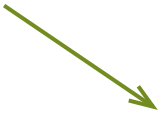
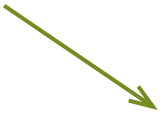
Category	Variable/ indicator	RAP1 (business as usual)	RAP2 (dysfunctional world)	RAP3 (sustainable development)
Biophysical	Reduction in soil erosion			
	Irrigation			
	Pests, weeds, and diseases control			
Institutional/ policy	Commodity subsidies			
	Crop insurance subsidies			
	Conservation and environment programs			
Socioeconomic	Farm size: commercial			
	Gross domestic product (GDP)			
	Population			
	Adaptive capacity	XXX	XXX	XXX
Technology	Improvements in conservation technologies			
	Pest management effectiveness			

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Table 1 (*continued*)

Category	Variable/ indicator	RAP1 (business as usual)	RAP2 (dysfunctional world)	RAP3 (sustainable development)
Prices from global/national models (without climate change)	Wheat			
	Corn			
	Cattle			
	Chemicals			
	Fertilizers			
Prices from global/national models (with climate change)	Wheat			
	Corn			
	Cattle			
	Chemicals			
	Fertilizers			

through a stepwise process. In this process for the REACCH project, team members document the basis for the likely trends in key variables, and then use this information to develop model-specific quantitative scenarios. Using historical data, global economic model projections, and experts' opinions, we developed three RAPS for the REACCH region by midcentury:

Business as usual. In this scenario, rural development continues, with moderate increases in population in regional centers, larger and more diversified regional economies, and continued trends toward mechanical, chemical, and biological technology. Trends toward environmental regulation to protect air and water quality also continue, but fiscal pressures lead to real reductions in traditional commodity subsidies and other agriculture-specific conservation programs, making conservation more individualized. Agricultural prices increase in real terms due to continued growth in demand, especially for feed grains and for politically mandated production of biofuels. Some rural farm-based communities continue to sustain infrastructure and social cohesion, while others continue to experience net out-migration;

Dysfunctional world. In this scenario, unbalanced rural development occurs, with an almost complete loss of "agriculture in the middle" and consolidation of most commodity production

into large corporate entities with contract arrangements for farm management and subsequent effects on rural farm-based communities. Suburban development continues largely unregulated in periurban areas as well as in more rural areas. Traditional farm subsidy programs are largely eliminated, conservation and environmental programs are limited due to budget constraints, and social conflict in agricultural communities escalates. Advances in large-scale mechanical, chemical, and biological technology continue, but disruptions to global agricultural research and development and agricultural trade result in substantially higher and more volatile agricultural commodity prices.

Sustainable development. Here rural development continues, with moderate increases in population in regional centers and larger and more diversified regional economies having a positive impact on community and social well-being. Traditional commodity subsidies are replaced by a carbon tax and an expansion of conservation and environmental programs, which slow the consolidation of land into larger farms and support some expansion of mid- and small-scale farms. Recent trends in mechanical, chemical, and biological technology continue, but in response to the carbon tax there is more innovation in technology that helps reduce fossil fuel intensity. Global commodity prices rise moderately along with the increases in fossil fuels due to the carbon tax.

Each RAP includes a set of variables to project plausible future biophysical, institutional/policy, socioeconomic, and technological conditions. As shown in Table 1, the team developed likely trends for each variable in each RAP. Table 2 quantifies these likely trends for modeling purposes, showing the possible range for each trend. This will enable other modeling teams to calibrate parameters to incorporate uncertainties from future world developments into their impact assessments. For an application that uses RAPS in the economic model, please refer to the companion article "Economic impacts of climate change on winter wheat" on page 110.

Table 2. *Possible range of variables for REACCH representative agricultural pathways and scenarios (RAPS).*

Category	Variable/indicator	RAP1 (business as usual)	RAP2 (dysfunctional world)	RAP3 (sustainable development)
Biophysical	Reduction in soil erosion	–10 to 0	–10 to 0	–10 to 0
	Irrigation	–5 to 0	–10 to –5	+10 to 20
	Control of pests,, weeds and diseases	–10 to +10	–10 to +10	20 to 40
Institutional/ policy	Commodity subsidies	–30 to –50	–80 to –50	–100 to –80
	Crop insurance subsidies	+50 to 100	–80 to –50	–100 to –80
	Conservation and environment programs	+20 to 40	–80 to –40	+50 to 100
Socioeconomic	GDP	+130 to 150	+50 to 80	+100 to 130
	Population	+20 to 40	+20 to 40	+20 to 40
	Farm size – commercial	+40 to 60	+60 to 80	+10 to 30
	Adaptive capacity	XXX	XXX	XXX
Technology	Improvements in conservation technologies	+20 to 40	No change	+60 to 100
	Pest management effectiveness	+20 to 40	No change	+60 to 100
Prices from global/ national models (without climate change)	Wheat	–30 to 0	–70 to –30	+0 to 30
	Corn	–30 to 0	–70 to –30	+0 to 30
	Cattle	–30 to 0	–70 to –30	+0 to 30
	Chemicals	+0 to 30	+30 to 60	+70 to 100
	Fertilizers	+0 to 30	+30 to 60	+70 to 100
Prices from global/ national models (with climate change)	Wheat	–20 to 50	–60 to 20	+10 to 80
	Corn	–20 to 50	–60 to 20	+10 to 80
	Cattle	–20 to 50	–60 to 20	+10 to 80
	Chemicals	+30 to 60	+60 to 90	+100 to 130
	Fertilizers	+30 to 60	+60 to 90	+100 to 130

Note: All changes are in percentages from the low to high end of the range. For scenario construction, all variables are simultaneously set to the low, middle, and high range (3 RAPS × 3 levels per RAPS = 9 scenarios). XXX = not used.