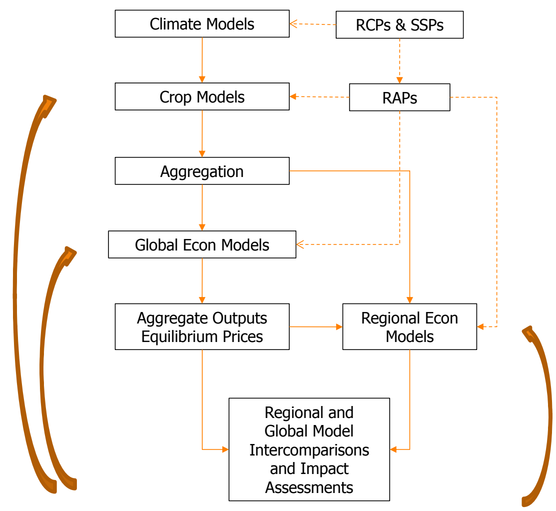
The Agricultural Model Intercomparison and Improvement Project

AgMIP Economics Team: Year 1 Highlights

Regional Economics Team

Economics Protocols and Modeling Framework

A first priority for the Economics Team was development of the Economics Protocols and a conceptual framework for data and model integration. This framework was developed initially at the first AgMIP Global Workshop and was refined through input from participants at subsequent regional workshops and the other AgMIP Teams.



Regional Project RFAs and Workshops

The development and implementation of the Regional Project RFAs and Workshops were two major activities and achievements of Year 1 of the project. As part of the Workshops, a major activity of the Regional Economics Team was identification of economists from Sub-Saharan Africa and South Asia. Participants were provided the Basic Learning Module for the TOA-MD software in advance of the workshop, including exercises to be prepared in advance. The result was an accelerated learning of the TOA-MD software, so that participants could implement analysis of case studies during the workshop. During this first year of the project, 27 economists in Latin America, Sub-Saharan Africa and South Asia trained in use of TOA-MD model and its application to climate impact assessment, and provided with the model software and training materials. The table at the left shows results from the regional economics team's work at the Sub-Saharan Africa workshop held in January 2012.

CC Impacts for Socio-Economic Scenarios (RAPs) with Low (1) and High (2) Challenges to Adaptation, Machakos Kenya

Scenario	% Losers	PC Inc (%)	Poverty (%)
Base	n.a.	100	73.1
RAP1	22.5	150	63.4
RAP2	71.5	56	81

RAP1 = low challenges to adaptation; more commercially-oriented farms with 50% more land allocated to maize, mean relative maize yield = 1, net returns SD reduced 20%, higher maize and dairy prices, 20% increase in farm size, 50% increase in off-farm income

RAP2 = high challenges to adaptation; farms maintain subsistence orientation with minimal adaptation to CC, higher maize and dairy prices, 20% increase in production cost, 20% reduction in farm size

Representative Agricultural Pathways

A recent innovation in climate change impact assessment is the development of new scenario concepts to facilitate model inter-comparison and implementation of impact assessments. The global climate and integrated assessment communities have developed the concepts of "Representative Concentration Pathways" and "Shared Socio-Economic Pathways." AgMIP is now developing agriculture-specific pathways called Representative Agricultural Pathways, or RAPs. AgMIP's work was presented at an international workshop held at NCAR in Boulder, Colorado, in November 2011. RAPs were used in a forthcoming climate impact assessment (Claessens, Antle et al. 2012 *Agricultural Systems*) which provides an example how AgMIP regional teams could use the RAPs concept together with results from the AgMIP Global Modeling group (also see the graphic above from the Sub-Saharan Africa regional workshop). A draft manuscript on RAPs is in preparation for publication.

TOA-MD Model Improvement

The TOA-MD model being used by AgMIP Regional Teams was improved during year 1 through feedback from Regional Team users, and by the ongoing process of model development and improvement by the OSU Tradeoffs Project Team. Progress was made in the following areas:

- Interpretation of model results for climate impact assessment and adaptation analysis.
- Addition of capability to simulate "treatment effects" as defined in the experimental and non-experimental project evaluation literatures.
- Improved documentation and training materials.

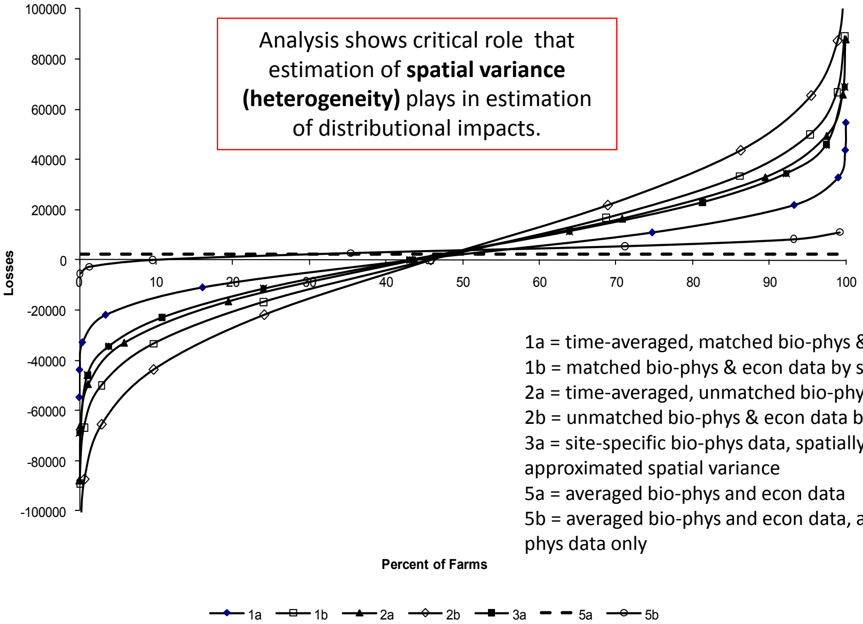
Regional Economics Team Leader Receives Award for TOA-MD Model Development

Regional Economics Team Leader John Antle was awarded the 2012 Quality of Research Discovery Award by the Agricultural and Applied Economics Association for his publication, "Parisimonious Multi-Dimensional Impact Assessment" in the American Journal of Agricultural Economics. This publication provides the methodological foundations of the TOA-MD model being used by the AgMIP Regional Teams.

Methods Development: Linking Crop and Economic Models for Climate Impact Assessment

Research by members of the AgMIP Leadership Team has led to advances in methods to link crop and economic models for regional impact assessment. These developments show how crop model simulations can be used to estimate how spatial yield distributions are affected by climate change, and also how these estimates are affected by the types of data that are available and by different modeling techniques (see graphic below).

Sensitivity analysis of alternative methods of estimating relative yield distribution with matched and unmatched site-specific data and averaged data (simulated CC gains and losses, using TOA-MD model for Machakos, Kenya)



1a = time-averaged, matched bio-phys & econ data by site
1b = matched bio-phys & econ data by site (not time averaged)
2a = time-averaged, unmatched bio-phys & econ data by site
2b = unmatched bio-phys & econ data by site (not time averaged)
3a = site-specific bio-phys data, spatially averaged econ data with approximated spatial variance
5a = averaged bio-phys and econ data
5b = averaged bio-phys and econ data, approximated variance of bio-phys data only

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AgMIP Regional Economics Team – Year 1 Abstracts

Antle, J.M. 2011. "Parsimonious Multidimensional Impact Assessment." *American Journal of Agricultural Economics.* 93(5): 1292–1311.

This article develops the conceptual and empirical foundations for a parsimonious, generic modeling approach to multi-dimensional (i.e., economic, environmental and social) impact assessments of agricultural technologies and environmental change. Joint distributions between technology adoption and outcome variables are characterized, and used to analyze the selection effects of adoption on a general class of impact indicators. The approach is implemented with a generic model that can be parameterized with low-order moments of outcome variables. A case study of adoption of a high-yielding maize variety in Kenya illustrates the model's use and confirms theoretical results. (Supported by USAID and GTZ projects).

Antle, J.M and S. Ogle. (2012). "Agricultural GHG Mitigation in the Central U.S. with No-Till: Accounting for Changes in Soil C, N_2O and Fuel Use." *Climatic Change* 111:609–625.

Previous research has demonstrated that soil carbon sequestration through adoption of conservation tillage can be economically profitable depending on the value of a carbon offset in a greenhouse gas (GHG) emissions market. However adoption of conservation tillage also influences two other potentially important factors, changes in soil N_2O emissions and CO_2 emissions attributed to changes in fuel use. In this article we evaluate the supply of GHG offsets associated with conservation tillage adoption for corn-soy-hay and wheat-pasture systems of the central United States, taking into account not only the amount of carbon sequestration but also the changes in soil N_2O emission and CO_2 emissions from fuel use in tillage operations. The changes in N_2O emissions are derived from a meta-analysis of published studies, and changes in fuel use are based on USDA data. These are used to estimate changes in global warming potential (GWP) associated with adoption of no-till practices, and the changes in GWP are then used in an economic analysis of the potential supply of GHG offsets from the region. Simulation results demonstrate that taking N_2O emissions into account could result in substantial underestimation of the potential for GHG mitigation in the central U.S. wheat pasture systems, and large over-estimation in the corn-soy-hay systems. Fuel use also has quantitatively important effects, although generally smaller than N_2O. These findings suggest that it is important to incorporate these two effects in estimates of GHG offset potential from agricultural lands, as well as in the design of GHG offset contracts for more complete accounting of the effect that no-till adoption will have on greenhouse gas emissions. (supported by USDA National Inst for Food and Ag)

Grace, P., J. Antle, P. Aggarwal, S. Ogle, K. Paustian and B. Basso. 2012. "Soil carbon sequestration and associated economic costs for farming systems of the Indo- Gangetic Plain: a meta-analysis." *Agriculture, Ecosystems and Environment* 146: 137– 146.

Region specific soil organic carbon sequestration rates based on the Intergovernmental Panel for Climate Change (IPCC) methodology were combined with local economic data to estimate the total amount of soil C that could be sequestered in wheat-based production systems of the Indo-Gangetic Plain (IGP). The C sequestration potential of rice-wheat systems of India on conversion to no-tillage is estimated to be 44.1 Mt C over 20 years. Implementing no-tillage practices in maize-wheat and cotton-wheat production systems would yield an additional 6.6 Mt C. This offset is equivalent to 9.6% of India's annual greenhouse gas emissions (519 Mt C) from all sectors (excluding land use change and forestry), or less than one percent per annum. The economic analysis was summarized as carbon supply curves expressing the total additional C accumulated over 20 year for a price per tonne (Mg) of carbon sequestered ranging from zero to USD 200. At a carbon price of USD 25 Mg C-1, 3 Mt C (7% of the soil C sequestration potential) could be sequestered over 20 years through the implementation of no-till cropping practices in rice-wheat systems of the Indian States of the IGP, increasing to 7.3 Mt C (17% of the soil C sequestration potential) at USD 50 Mg C-1. Maximum levels of sequestration could be attained with carbon prices approaching USD 200 Mg C-1 for the States of Bihar and Punjab. At this carbon price, a total of 34.7 Mt C (79% of the estimated C sequestration potential) could be sequestered over 20 years across the rice-wheat region of India, with Uttar Pradesh contributing 13.9 Mt C. (supported by International Energy Agency).

Claessens, L., J.M. Antle, J.J. Stoorvogel, R.O. Valdivia, P.K. Thornton, and M. Herrero. 2012. A method for evaluating climate change adaptation strategies for small-scale farmers using survey, experimental and modeled data. *Agricultural Systems.* In press.

Sub-Saharan Africa (SSA) is predicted to experience considerable negative impacts of climate change. The IPCC Fourth Assessment emphasizes that adaptation strategies are essential. Addressing adaptation in the context of small-scale, semi-subsistence agriculture raises special challenges. High data demands including site-specific bio-physical and economic data are an important constraint. This paper applies a new approach to impact assessment, the Tradeoff Analysis model for Multi-Dimensional impact assessment (TOA-MD), which simulates technology adoption and associated economic, environmental and social outcomes in a heterogeneous farm population for a regional impact assessment. The methodology uses the kinds of survey, experimental and modeled data that are typically available in countries where semi-subsistence systems are important, combined with future socio-economic scenarios based on new scenario pathway concepts being developed by the climate change and impact assessment modeling communities. Characteristics of current and future agricultural systems, including land use, output, output price, cost of production, and farm and household size are analyzed and compared for both current and projected future climate (2030), with and without adaptation, and for different socio-economic scenarios. The methodology is applied to two study areas in Kenya. These case studies show the potential of this approach to provide a flexible, generic framework that can use available and modeled data to evaluate climate impact and adaptation strategies under a range of socio-economic scenarios. (supported by GTZ and AgMIP).

Valdivia, R., J.M. Antle and J. Stoorvogel. 2011. "Coupling the Tradeoff Analysis Model with a Market Equilibrium Model to Analyze Economic and Environmental Outcomes of Agricultural Production Systems." *Agricultural Systems* 110 (2012) 17–29

Analysis of the economic and environmental outcomes of agricultural systems requires a bottom-up linkage from the farm to market, as well as a top-down linkage from market to farm. This study develops this two-way linkage between the Tradeoff Analysis Model of agricultural systems and a partial equilibrium market model. The resulting model can determine the effects of technology and policy interventions on the spatial distribution of environmental and economic outcomes at market equilibrium quantities and prices. The approach is demonstrated with a case study of tradeoffs between poverty and nutrient depletion in a semi-subsistence agricultural system (Machakos, Kenya). The results suggest that the linkage of market equilibrium analysis to farm level Integrated Assessment Models can be important in the analysis of agriculture–environment interactions. (funded by USAID).

Valdivia, R., J. Stoorvogel and J.M. Antle. 2012. "Economic and environmental Impacts of Climate Change and Socio-Economic Scenarios: A Case Study of a Semi-Subsistence Agricultural System." *The International Journal of Climate Change Impacts and Responses*.

In this study we use a spatially-explicit integrated assessment model, TOA-ME, to evaluate the economic (income, poverty) and environmental (soil nutrient depletion) impacts of climate change and future socio-economic scenarios in a case study of the semi-subsistence agricultural production systems of Machakos (Kenya). This model provides a unique capability to assess the distributional effects of climate change on economic and environmental outcomes while also accounting for market-level impacts on prices. We use this framework to examine how a socio-economic scenario based on policy and technology interventions can offset the likely negative effects of climate change. In order to conduct this analysis we propose a three-step methodology: i) analysis of climate change scenarios generated by GCMs, ii) use of GCMs output to estimate crop responses, and iii) modeling the land use decisions and economics of the farming systems. Output data from 5 commonly used GCMs and 3 emission scenarios were used. Outputs from GCMs and emission scenarios are highly variable but present a similar trend of higher temperatures and decreasing precipitation. As a result, crop production decreases with the effects varying by location. Farmers are likely to adapt to the new conditions through changes in land use; however the effects on poverty and soil nutrient depletion rates are small. In contrast, the analysis shows that an effective policy and technology intervention that leads to different socio-economic conditions could offset the negative effects of climate change and reduce this region's vulnerability. The results also imply that ignoring new market conditions could lead to incorrect information for policy making. (funded by USAID).

Schiek, Ben. 2012. "Impacts of Climate Change on Maize-Based Agricultural Systems in Kenya." Ms. Thesis, Dept. of Agricultural and Resource Economics, Oregon State University.

This thesis uses farm survey data from the Tegemeo Institute at Egerton University, Kenya, to estimate statistical production models. These models are combined with the TOA-MD model to simulate impacts of climate change on maize-based farms in Kenya. Results are compared to other studies in Kenya, and an evaluation is made of the usefulness and reliability of statistical models for climate impact assessment. (funded by Oregon State University).

Antle, J.M., J.J. Stoorvogel, J. Jones and A. Ruane. 2012. The Use of Crop Growth Simulation Models to Construct Counterfactuals for Regional Economic Assessment of Climate Change Impacts. Draft manuscript in preparation.

Regional economic assessments of climate change impacts on agriculture require data to construct the "counterfactual" of future climate impacts on the productivity of agricultural systems [footnote: here we use the term counterfactual to represent an unobserved alternative state of the world; it does not imply that climate change will or will not occur]. In this paper we present a methodology for the use of crop growth simulation models to construct these counterfactuals to parameterize the TOA-MD model, an economic simulation model designed for regional impact assessment. We present and compare methods for the use of crop simulation models under the "ideal" situation of matched, site-specific weather, soils and farm survey data, as well as under less ideal conditions that are typical in many parts of the world. (supported by AgMIP).

Antle, J.M. 2011. "Representative Agricultural Pathways for Model Inter-comparison and Improvement." Draft manuscript in preparation.

Most climate impact assessments have investigated the effects of future climates in the context of contemporary socio-economic conditions using averaged data in aggregate models. To increase the relevance and usefulness of impact assessments, coherent future scenarios of climate and socio-economic scenarios are needed that can better represent socio-economic conditions that affect both impacts and adaptation. This letter demonstrates the quantitative importance of such scenarios in the context of climate impact and adaptation in agriculture, using a case study of agricultural systems in two regions of Kenya. We do this using a new approach to modeling impact and adaptation that integrates various types of data to carry out more detailed scenario analysis than has been possible in previous modeling studies. We show that different plausible socio-economic pathways and corresponding quantitative scenarios can be designed that show important interactions between climate impacts and the effects of varying degrees of adaptive capacity. (supported by AgMIP).

Global Economics Team

Introduction

Three sets of activities were undertaken for the first year by the global economics team

- soliciting participation from all of the leading models that are global in perspective and with significant agricultural and natural resource components
- completing a first model intercomparison using a single set of reference data (phase 1)
- developing a consensus on what the second phase of the comparisons should be.

Models included in the global economics intercomparison

Eleven global modeling groups are currently participating in the reference scenario comparison. The following table provides a concise overview of the models and their key characteristics. Seven are general equilibrium models while four are partial equilibrium models. Table 1 provides a list of all models, their institutional affiliations, the contact persons directly involved in the comparison exercise and web links to further detailed information for each model. This is followed by a brief characterization of pedigree and key features for each model.

Table 1. Participating Models

Model	Affiliation	Location	Contact	Documentation Link
General Equilibrium Models				
AIM	NIES	Japan	*Shinichiro Fujimori*	http://www-iam.nies.go.jp/aim/infomation.htm
CIM-Earth	University of Chicago	USA	Joshua Elliott *Alison Brizius*	http://www.cimearth.org/cim-earth/about/
ENVISAGE	FAO	Italy	*Dominique van der Mensbrugghe*	http://siteresources.worldbank.org/INTPROSPECTS/.../Envisage7b.pdf
EPPA	MIT	USA	*Elodie Blanc*	http://globalchange.mit.edu/igsm/eppa.html
FARM	USDA-ERS	USA	Ron Sands	
GTEM	ABARES	Australia	Raymond Mi *Edwina Heyhoe*	http://www.daff.gov.au/abares/models
LEITAP	LEI - Wageningen University	Netherlands	*Hans van Meijl* Andrzej Tabeau	
Partial Equilibrium Models				
GCAM	PNNL	USA	*Page Kyle*	http://wiki.umd.edu/gcam/index.php?title=Main_Page

GLOBIOM	IIASA	Austria	*Petr Havlik* *Hugo Valin*	http://www.iiasa.ac.at/Research/FOR/globiom.html
IMPACT	IFPRI	USA	*Gerald Nelson* *Sherman Robinson*	http://www.ifpri.org/book-751/ourwork/program/impact-model
MAGPIE	PIK	Germany	*Hermann Lotze-Campen Christoph Schmitz*	http://www.pik-potsdam.de/research/sustainable-solutions/groups/landuse-group

AIM - Asian Pacific Integrated Model

AIM is a large-scale computer simulation model developed by the National Institute for Environmental Studies in collaboration with Kyoto University and several research institutes in the Asian-Pacific region. The AIM assesses policy options for stabilizing the global climate, particularly in the Asian-Pacific region, with the objectives of reducing greenhouse gas emissions and avoiding the impacts of climate change.

The AIM comprises three main models - the greenhouse gas emission model (AIM/emission), the global climate change model (AIM/climate), and the climate change impact model (AIM/impact). The AIM/emission model estimates greenhouse gas emissions and assesses policy options to reduce them. The AIM/climate model forecasts concentrations of greenhouse gases in the atmosphere and estimates the global mean temperature increase. The AIM/impact model estimates climate change impacts on natural environment and socio-economy of the Asian-Pacific region.

CIM-EARTH - Community Integrated Model of Economic and Resource Trajectories for Humankind

CIM-EARTH is a dynamic computable general equilibrium model for studying the socio-economic dimensions of climate change and climate policies.

ENVISAGE – Environmental Impact and Sustainability Applied General Equilibrium Model

The ENVISAGE model‘s core is a standard recursive dynamic global general equilibrium model. Incorporated with the core CGE model is a greenhouse gas emissions module that is connected to a simple climate module that converts emissions into atmospheric concentrations, radiative forcing and changes in mean global temperature. The climate module has feedback on the economic model through damage functions, affecting a number of parameters in the model. The combination of the socio-economic CGE model with the climate module turns the model into an integrated assessment model.

EPPA - Emissions Predictions and Policy Analysis Model

EPPA provides projections of world economic development and emissions along with analysis of proposed emissions control measures. It is used to analyze the processes that produce greenhouse-relevant emissions and to assess the consequences of policy proposals, providing estimates of the magnitude and distribution among nations of their costs and clarifying the ways that changes are mediated through international trade.

EPPA is a multi-sector, multi-region computable general equilibrium model of the world economy. It utilizes the GTAP dataset augmented by data on the emissions of greenhouse gases, aerosols and other relevant species, taxes, and details of selected economic sectors. Provision is made for analysis of uncertainty in key human influences, such as the growth of population and economic activity and the pace and direction of technical advance.

FARM – Future Agricultural Resources Model

FARM is an integrated global CGE modeling framework designed to analyze global changes related to agriculture and the environment. The model captures feedbacks between the agriculture and energy sectors in the production of renewable energy. The core model is the GTAP model. Dynamic elements that have been added include an intertemporal forestry model that competes with agriculture for land, and an aggregated stock of physical capital. Extensions to the economic database include a further disaggregation of sectors for biofuels analysis and electricity generation. To capture competition across land of heterogeneous quality, FARM includes an environmental database linked to the production of agricultural and forestry commodities according to agro-ecological zones characterized by length of growing seasons, temperature regime, and plant hardiness zones. Underlying data include GTAP social accounts and global land use; energy balances from the International Energy Agency; and FAO crop, livestock, and forestry production. Production sectors in FARM can be configured as any combination of the 57 production sectors in the GTAP data set. The model incorporates mitigation pricing and accounting for carbon dioxide, methane and nitrous oxide for the energy and agricultural/forestry sectors.

GTEM – Global Trade and Environment Model

GTEM is ABARES' dynamic, multi region, multi sector, general equilibrium model of the world economy. The model has been developed to address policy issues with long term global dimensions. GTEM has been used to analyse issues such as the climate change response policies including the Kyoto Protocol, trade reform under the World Trade Organisation, and trends and issues in international commodity and energy markets. The core economic database of GTEM is derived from the GTAP database. Agriculture in GTEM is comprised of 12 crop and livestock sectors, which can be identified separately or aggregated for different applications**.** GTEM has a single homogenous land type within each region that is assumed to be imperfectly mobile across various agricultural uses—crop and livestock, and forestry activities. Representative landowners in GTEM are therefore able to reallocate land to alternative agricultural and forestry activities in pursuit of higher rents, while limits on mobility prevent a uniform rental rate across the economy.

LEITAP – Landbouw Economisch Instituut Trade Analysis Project

LEITAP is based on the general equilibrium model GTAP. It uses the carbon market and the rough characteristics of the production structure of GTAP-E and the international capital flow accounting system of the dynamic GTAP model GTAP-DYN, and also includes parts of the agricultural variant of GTAP, GTAP-AGR. Various extensions of the model can be switched on or off through a simple change in coefficients or through closure swaps. An integrated production structure, with energy nesting (including biofuels) and feed and fertilizer nesting is included. EU energy policies including first and second pillar measures are implemented and can be switched on. Land supply is modeled, based on biophysical model outcomes from IMAGE (Bouwman et al, 2006; Eickhout et al, 2007). Substitution between different types of land is included.

GCAM – Global Change Assessment Model

GCAM is a partial equilibrium model of the world with 14 regions. GCAM operates in five-year time steps from 1990 to 2095 and is designed to examine long-term changes in the coupled energy, agriculture/land use, and climate system. GCAM includes a 151-region agriculture land-use module and a reduced form carbon cycle and climate module in addition to its incorporation of demographics, resources, energy production and consumption. The model has been used extensively in a number of assessment and modeling activities such as the Energy Modeling Forum, the U.S. Climate Change Technology Program, and the U.S. Climate Change Science Program and IPCC assessment reports.

The agriculture-land-use model (AgLU) endogenously determines land use, land cover, and the stocks and flows of carbon from terrestrial reservoirs. AgLU is fully integrated with the GCAM energy and economy modules. In GCAM 3.0, the model data for the agriculture and land use parts of the model is comprised of 151 subregions in terms of land use, based on a division of the extant agro-ecological zones within each of GCAM's 14 global geo-political regions. Within each of these 151 subregions, land is categorized into approximately a dozen types based on cover and use. Some of these types, such as tundra and desert, are not considered arable. Among arable land types, further divisions are made for lands historically in non-commercial uses such as forests and grasslands as well as commercial forestlands and croplands. Production of approximately twenty crops is currently modeled, with yields of each specific to each of the 151 subregions. The model is designed to allow specification of different options for future crop management for each crop in each subregion. Stocks and flows of terrestrial carbon and other greenhouse gases are determined by associated land use and land cover and land-use-land-cover changes.

GLOBIOM – Global Biosphere Management Model

GLOBIOM is a global recursively dynamic partial equilibrium model integrating the agricultural, bioenergy and forestry sectors with the aim to give policy advice on global issues concerning land use competition between the major land-based production sectors. GLOBIOM covers 18 major crops Four management systems are considered (irrigated, high input – rainfed, low input – rainfed and subsistence) corresponding to the IFPRI crop distribution data classification. Crop supply can enter one of three processing/demand channels: consumption, livestock feeding or biofuel production. Consumption demand is modeled by constant elasticity functions. Biofuel options from crops include first generation technologies for ethanol from sugarcane, corn and wheat, and biodiesel from rapeseed, palm oil and soybeans. Production system based livestock representation has been recently developed in collaboration with the International Livestock Research Institute (ILRI). The model differentiates between 14 production systems consistent with the ILRI/FAO production system classification.

IMPACT – International Model for Policy Analysis of Agricultural Commodities and Trade

The IMPACT model is designed to examine alternative futures for global food supply, demand, trade, prices, and food security. IMPACT covers 30 commodities, which account for virtually all of world food production and consumption, including all cereals, soybeans, roots and tubers, meats, milk, eggs, oils, meals, vegetables, fruits, sugar and sweeteners, and fish in a partial equilibrium framework. It is specified as a set of 115 country-level supply and demand equations where each country model is linked to the rest of the world through trade.

Domestic crop production is determined by area and yield response functions. Harvested area is specified as a response to the crop's own price, the prices of other competing crops, the projected rate of exogenous (non-price) growth trends in harvested area, and water. Yield is a function of the commodity price, the prices of labor and capital, water, and a projected nonprice exogenous trend factor. Domestic demand for a commodity is the sum of its demand for food, feed, and other uses. Food demand is a function of the price of the commodity and the prices of other competing commodities, per capita income, and total population Feed demand is a derived demand determined by the changes in livestock production, feed ratios, and own- and cross-price effects of feed crops. The demand for other uses is estimated as a proportion of food and feed demand.

MAgPIE - Model of Agricultural Production and its Impact on the Environment

The global land-use model MAgPIE is a recursive dynamic programming model with a cost minimization objective function The biophysical supply side of the model is simulated spatially explicit using 0.5 degree data aggregated to 1000 clusters. It distinguishes 16 food/feed crops, 3 bioenergy crops, 5 livestock types and 10 world regions. Demand for calories in each region is a function of exogenous population and per-capita income projections. The biophysical inputs and yields are derived from the grid-based dynamic global vegetation model with managed land LPJmL. LPJmL is a process-based model which considers soil, water, and climatic conditions in an endogenous way. Four categories of costs arise in the model: production costs for livestock and crop production, yield increasing technological change costs, land conversion costs and intraregional transport costs. The model solution is derived by minimizing these four cost components on a global scale for the current time step. In order to increase total agricultural production, MAgPIE can either invest in yield-increasing technological change or in land expansion.

Model intercomparison phase 1

Phase 1 was the first test of doing model intercomparisons with the wide range of models, many of which had been developed for purposes other than a detailed analysis of agriculture and natural resource use. The first comparison consisted of a single set of exogenous drivers. The reference scenario simulations employed common assumptions for a set of regionally differentiated drivers including time paths up to 2050 for

- Population growth - NESA 2010 revision medium projections.
- GDP growth - World Bank Development Prospects Group projections (June 2011 revision)

- Exogenous agricultural land area growth
- Exogenous yield growth

For population growth, the reference scenario used the UNESA 2010 revision medium projections. For GDP growth, World Bank Development Prospects Group projections (June 2011 revision) were used. For area and yield growth, IFPRI long-run assumption were used. The reference scenario assumed no climate change and a constant oil price. It is important to note that the common specification of autonomous growth rates for agricultural areas and crop yields does not entail uniform projections for land use change and yields across the models. In most of the models, equilibrium yields are not only a function of autonomous technical progress but also respond endogenously to (or more precisely, are co-determined with) variations in factor and output prices. Similarly, most of the models assume price-elastic land supply functions, so that equilibrium land use is determined by the interplay of supply and demand for land.

Figures 1 to 3 show selected preliminary results from phase 1 and more results will be part of a paper, in draft. Despite harmonized assumptions on key drivers, the results show a high degree of diversity across models. Three models – FARM, CIM-Earth and IMPACT - project increasing real prices for all commodities by 2050, and a further two models (MAgPIE and EPPA) project increasing producer prices for most commodities. The price increases projected by FARM and CIM-Earth are across the board significantly more pronounced than the price increases suggested by IMPACT, MAgPIE and EPPA.

At the other extreme, LEITAP projects *decreasing* real producer prices for all commodities except sugar and oilseeds as well as falling average export prices for all commodities, AIM projects decreasing prices for all crops except coarse grains and GCAM projects decreasing prices for all crops. ENVISAGE projects real declines in the average export prices for all commodities, but records at the same time moderate increases in the average producer prices for rice, oilseeds, and non-ruminants.

Differences in land use change are a potential source of the differences in price response. Higher prices might occur if less land is pulled into agricultural activities. With respect to global land use change, seven models project an expansion in total agricultural area between 2004 and 2050 at rates between 4 and 33 percent. In two models, global agricultural land use remains virtually constant – though these two models allow for land use variations between crops and pasture and variations in total agricultural land area in individual regions. Finally, one model – AIM – projects an absolute drop in global agricultural land use between 2004 and 2050.

Three models project stronger pasture land growth relative to crop land, while six models project more crop land growth relative to pasture. Agricultural land use expansion projections by region also show considerable variation across models, and the plausibility of some of these projections deserve closer re-examination in the course of the model comparison exercise.

A joint look at the price and land use projections shows that the cross-model variations in land expansion alone do not provide a sufficient explanation for the cross-model variations in price projections. On the one hand, in the case of FARM, strong price increases coincide with very restrictive assumptions about land use growth while in the case of ENVISAGE high area growth goes along with generally moderate increases in world market prices. Yet, on the other hand, the model that projects declining global agricultural land use simultaneously projects generally declining agricultural prices. To arrive at a clearer picture, more analysis is needed. This is currently underway.

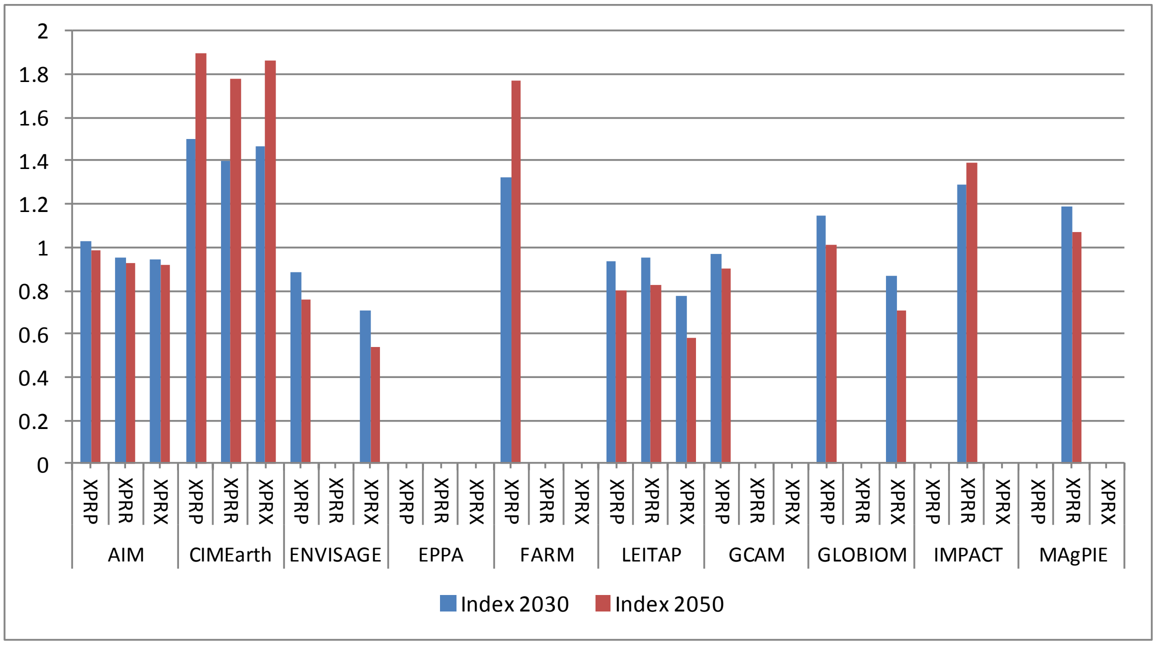

Figure 1. Index of World Wheat Prices 2030 and 2050 (2004 = 1)

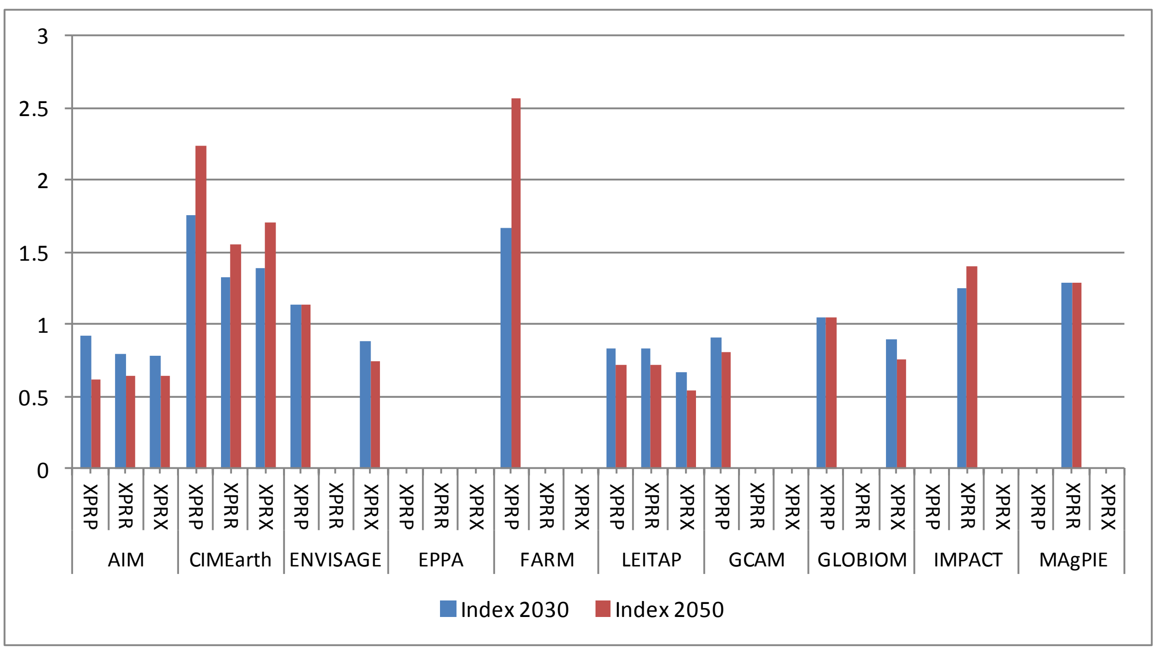

Figure 2. Index of World Rice Prices 2030 and 2050 (2004 = 1)

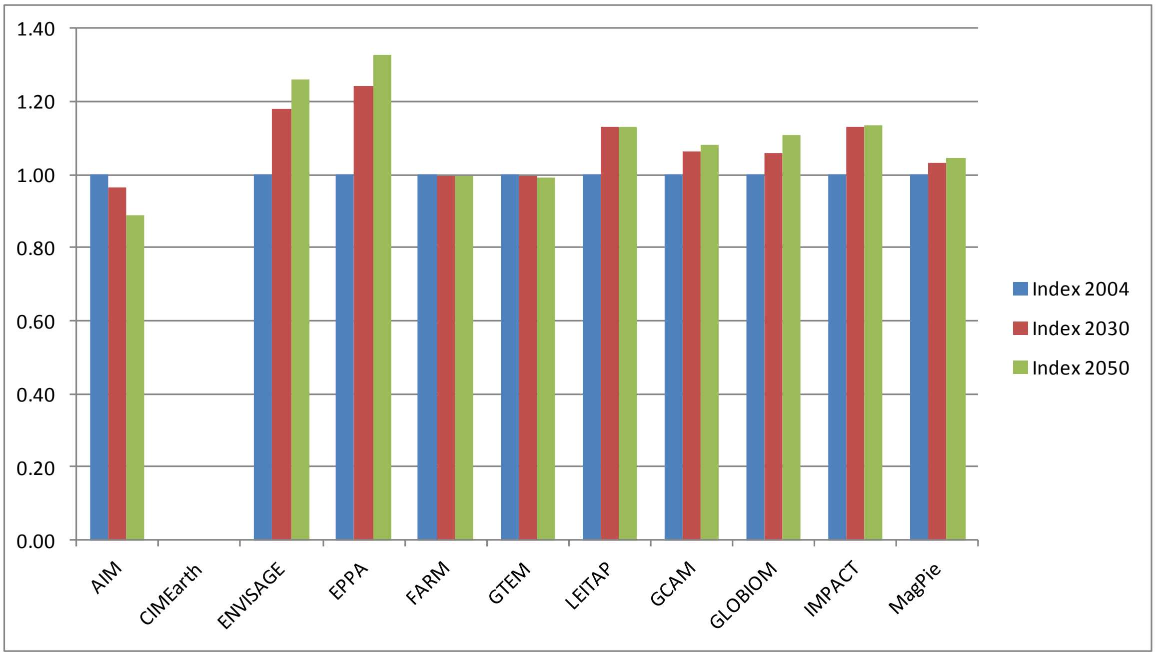

Figure 3. Agricultural Area Change 2030 and 2050 (2004 = 1)

Model intercomparison phase 2

At the January AgMIP meeting in Kenya it was agreed that a phase 2 would use results from the IPCC 5th assessment process (ie biophysical shocks from the GCM RCP results and the SSP socioeconomic drivers) to the extent possible. At a meeting held in April this proposal was further specified. The inter-model comparison would be continued with a reference scenario based on SSP2 with no climate change and a limited number of shock scenarios, orthogonal to each other

- one SSP shock (SSP3 as opposed to SSP2)
- one climate shock (RCP 8.5, hottest and driest GCM, no CO_2 fertilization – based on current climate
- one bioenergy shock (strong growth in bioenergy use as opposed to current mandates, both base and scenario assumptions, including feedstock use

As of June 1, the SSP data are available for the various scenarios but the RCP and biofuels shocks are still under development.

The agreed process is for all model results to be submitted individually by June 29 and one person will develop a database for comparing the results. A technical workshop is scheduled for the end of August with close to final results to be presented in the October annual AgMIP meeting and submission of a set of papers to a special issue of a journal by January 2012.