Interpreting results from using bio-economic modeling for global and regional ex ante impact assessment

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1 Background

The ability to achieve sustainable agricultural growth in developing countries is threatened by numerous challenges, namely climate change, increasingly volatile food and energy markets, natural resource exploitation, and a growing population with aspirations for better living standards. Climate change has been reducing crop productivity in some regions of the word (Field et al., 2014). If not tackled, climate change is expected to negatively affect human health and disrupt livelihoods in vulnerable communities across the globe (Field et al., 2014).

The Global Futures and Strategic Foresight Project, an initiative which brings together 12 CGIAR centers, aims to provide enhanced tools for evaluating the long-term benefits of promising agricultural technologies, investments, and policy reforms within the ever-changing global agricultural environment. The project has so far led to the development and application of a spatial bio-economic framework for global ex ante impact assessment. The framework has been applied to analyze the potential impact of promising food technologies on food security under a changing climate; quantify the potential impact of promising crop traits on the yields of chickpea and sorghum (Singh et al., 2014a, 2014b); estimate projections on livestock futures to 2020; and quantify the impact of weather extremes on global food security (Chung et al., 2014; Gbegbelegbe et al., 2014).

The leading global economic models were all recently compared in terms of the impact of climate change on crop yield, areas and prices as part of the Agricultural Model Intercomparison and Improvement (AgMIP) project (Nelson et al., 2014). Few of these global models, namely GLOBIOM and IMPACT, have been used to project global food security in an ever-changing global agricultural environment (Fuss et al., 2011; Nelson et al., 2010). IMPACT has also been applied to assessing global livestock futures in a revised version that incorporates previously unaccounted for livestock production systems and feed sources (Msangi et al., 2014). In addition, the TOA-MD model has been used to assess vulnerability and adaptation strategies for selected farmers' communities in Kenya (Claessens et al., 2012) and is being used by AgMIP regional teams for impact and adaptation assessments throughout Sub-Saharan Africa and South Asia (see agmip.org).

This organized session will involve the presentation of key studies which have used bio-economic modeling for foresight analysis on agriculture and food security on global and regional scales. The objectives of the symposium would consist of (1) sharing results from using bio-economic modeling for foresight analysis; (2) identify areas of agreement and disagreement on results and model specifications; (3) identify potential research topics to be analyzed using bio-economic frameworks.

2   Speakers' Biographies

Keith Wiebe, PhD, is a Senior Research Fellow at the International Food Policy Research Institute in Washington DC, where he leads the research program on Global Futures and Strategic Foresight. He is also the coordinator of the global economics team under the Agricultural Model Intercomparison and Improvement Project (AgMIP) initiative. Prior to joining IFPRI in October 2013, he was Deputy Director of the Agricultural Development Economics Division of the United Nations Food and Agriculture Organization in Rome, where he managed a program of economic research and policy analysis for food security and sustainable development, and helped coordinate preparation of FAO's annual flagship reports on the *State of Food and Agriculture* and the *State of Food Insecurity in the World*. Previously he was Deputy Director of the Resource and Rural Economics Division of the US Department of Agriculture's Economic Research Service in Washington, DC. He received his B.A. in economics from Carleton College, and his M.A. and Ph.D. in agricultural economics from the University of Wisconsin-Madison. His areas of particular interest include land tenure, natural resource use and conservation, agricultural productivity and food security.

John M. Antle, PhD, is a professor in the Department of Applied Economics at Oregon State University, Corvallis, Oregon, and a University Fellow at Resources for the Future, Washington, D.C.; and previously a professor at the University of California, Davis, and Montana State University. He received the Ph.D. in Economics from the University of Chicago in 1980. He has served as a senior staff economist for the President's Council of Economic Advisers in Washington, D.C. (1989-90); as a member of the National Research Council's Board on Agriculture (1991-97); and was a lead and contributing author to the IPCC third and fourth assessment reports. He is a Fellow and past President of the American Agricultural Economics Association. He is currently a co-PI of the Agricultural Model Inter-comparison and Improvement Project (AgMIP), and leading the Regional Economics component of AgMIP. He is the lead

developer of the Tradeoff Analysis Model for Multi-dimensional Impact Assessment, a model being used globally by CGIAR centers and various other institutions for agricultural sustainability and impact assessment. His current research focuses on the quantitative assessment of the sustainability of agricultural systems in industrialized and developing countries, including climate change impacts, adaptation and mitigation; and ex ante assessment of environmental and social impacts of agricultural technologies and policies.

Ma Cynthia S Bantilan, PhD, is the Research Program Director of ICRISAT's Research Program on Markets, Institutions and Policy. Formerly, she was the Global Theme Leader of ICRISAT's Global Theme on "Institutions, Markets, Policy and Impacts". Earlier, she was Principal Scientist and Project Leader for Research Evaluation and Impact Assessment of the Socioeconomics and Policy Program at ICRISAT; then, she led the same program as Program Director. Dr. Bantilan obtained her Ph.D. degree in Economics and Statistics from North Carolina State University. Before joining ICRISAT, she held the position of Associate Professor of Economics and Professor of Statistics at the University of the Philippines at Los Banos. She specializes in agricultural research evaluation and impact assessment, monitoring and evaluation, poverty and income distribution, econometrics, agricultural economics and agricultural statistics, information systems management, and applications for decision support and policy analysis. At ICRISAT, she is involved in strategic analysis, research evaluation, monitoring and impact assessments, poverty and income distribution analysis, econometrics, analysis of livelihood strategies and development pathways, applications for decision support and policy analysis, and science policy. She spearheaded the Research Evaluation and Impact Assessment Program at ICRISAT, covering sub-Saharan Africa and Asia. She led the conceptualization of ICRISAT's Policy and Implementation Plan for Monitoring and Evaluation and the Policy on Technology Exchange and Partnerships.

3   Proposed Abstracts

Presentation 1 - New Crop Varieties and Climate Change Adaptation: Ex-Ante Analysis of Virtual Technologies Using DSSAT and IMPACT

Keith Wiebe, Bernado Creamer, Ulrich Kleinwechter, Sika Gbegbelegbe, Guy Hareau, Shanila Islam, Daniel Mason-D'Croz, Khondoker MOTTALEB, Sherman Robinson, Nedumaran Swamikannu

We evaluate selected "virtual crops", specifically drought- and heat-tolerant varieties not currently available at large scale but needed to adapt to climatic changes, and also analysis of the effects of crop protection measures, with a focus on the mealybug pest on cassava. The assessment relies on the Decision Support System for Agrotechnology Transfer (DSSAT) family of crop models, hydrology and water supply-demand models, and a multi-market economic model, the International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT). These models are linked in order to estimate future production, consumption, and trade of key agricultural commodities, following different scenarios of climate change, water availability, and population and income growth (among other factors). The result is a powerful simulation tool to assess the potential impact of selected promising technologies on some of the world's most important agricultural commodities.

The results suggest that all improved technologies led to improved production. In general the Heat Tolerant (HT) traits performed better than the Drought Tolerant (DT) traits, although in regions under greater water scarcity, the yield from DT traits were close to those from the HT varieties. In addition, the combined-trait (DT + HT) varieties clearly performed better than the single trait varieties. This suggests that more work should be focused on integrating these traits to ensure more robust adaptation.

The biophysical productivity gains from adopting the improved technologies were relatively small when compared to the overall socioeconomic effects. In addition, the productivity gains observed in all of the technologies improved the regions' terms of trade. For importing regions, the share of imports compared to production declined. For exporting regions, the increased productivity is outpaced by the increase in exports, with most of the added production being exported. These changes suggest all of the adopting regions would be less vulnerable to global price shocks under these scenarios.

Presentation 2 –Using geo-spatial bio-economic modeling framework for ex ante impact assessment

Cynthia Bantilan, Bernado Creamer, Enahoro Dolapo, Ulrich Kleinwechter, Sika Gbegbelegbe, Guy Hareau, Daniel Mason-D'Croz, Nelgen Signe, Nedumaran Swamikannu, Roberto Telleria

We use a bio-economic framework involving crop, spatial and economic modeling for ex ante impact assessment on food systems and food security under alternative climate change scenario. Crop and spatial modeling are combined to estimate baseline and future crop productivity under alternate General Circulation Models (GCMs), emission scenarios (SERS) and farm technologies on a regional or global scale. They are also used to estimate regional or global crop productivity under climate extremes. The baseline climate is typical of the late 20th century (2000s) while future climates are selected based on the purpose of the study. The analysis uses the Geographic Resources Analysis Support System (GRASS) to handle and aggregate spatial data and the Decision Support System for Agrotechnology Transfer (DSSAT) to simulate crop yield and other biophysical variables running in a parallel fashion on a high performance computing cluster.

The projected crop productivity levels derived from crop and spatial modeling are inputted into the economic model (the International Model for Policy Analysis of Agricultural Commodities and Trade, IMPACT) to derive socio-economic results. IMPACT is a multi-country and multi-commodity model that uses various assumptions on production, consumption and trade patterns to project national and global food and nutrition security under alternative scenarios on population growth, income growth and future climates.

The application of the geo-spatial bio-economic modeling framework was used in various studies: quantification of the impact of 2012 weather extreme on maize yields in USA and related effects on food security in developing world; quantification of the potential impact of improved chickpea varieties tolerant to heat and drought in South Asia and East Africa; quantification of global livetsock futures; quantification of impact of drought tolerance trait and heat tolerant trait in sorghum in selected sites in India and Mali; establishing the impact of climate change on wheat production in Jordan to identify the direction of breeding/deploying new wheat cultivars for adaptation; and quantification of the impact of differing adoption pathways of drought-tolerant wheat in the CWANA region.

The study results will be briefly presented with the objective of identifying additional research topics that should be tackled using geospatial bio-economic modeling.

Presentation 3 – AgMIP's Trans-disciplinary Approach to Regional Integrated Assessment of Climate Impact, Vulnerability and Adaptation of Agricultural Systems: Lessons from Regional Assessments in Africa and South Asia

John Antle, Roberto Valdivia

We describe the methods developed by AgMIP to implement a trans-disciplinary, systems-based approach for regional-scale (local to national scale) integrated assessment of agricultural systems under future climate, bio-physical and socio-economic conditions. The AgMIP methodology systematically integrates climate, crop, livestock and economic models to assess climate impact, vulnerability and adaptation. We use results from the AgMIP Regional Research Teams in Sub-Saharan Africa and South Asia to illustrate key elements of the approach and discuss key challenges that need to be addressed to enhance the relevance of climate impact assessment to key stakeholders at regional and global scales.

4   Proposed session format

- Presentations: 20 minutes
- Clarification questions (after each presentation): 10 minutes
- Plenary session: 30 minutes

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