Journal of Agricultural Science; Vol. 6, No. 9; 2014
ISSN 1916-9752 E-ISSN 1916-9760
Published by Canadian Center of Science and Education

Book Review: *Food Security in a World of Natural Resource Scarcity - The Role of Agricultural Technologies*

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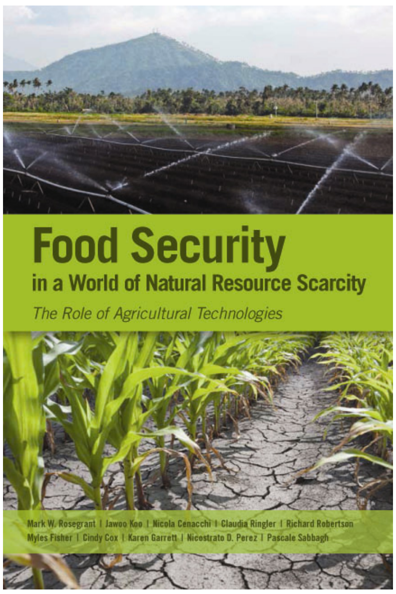
Online Published: August 15, 2014 doi:10.5539/jas.v6n9p232 URL: http://dx.doi.org/10.5539/jas.v6n9p232



Food Security in a World of Natural Resource Scarcity - *The Role of Agricultural Technologies*

Edited by Mark W. Rosegrant, Jawoo Koo, Nicola Cenacchi, Claudia Ringler, Richard Robertson, Myles Fisher, Cindy Cox, Karen Garrett, Nicostrato D. Perez, and Pascale Sabbagh.

International Food Policy Research Institute (IFPRI): Washington, DC, USA. 2014. 174 pages.

ISBN: 978-0-89629-847-7

DOI: http://dx.doi.org/10.2499/9780896298477

Summary of Review and Endorsements

In 2011, the world's population reached 7 billion, and over the next four decades, an extra 2 billion people will be added, nearly all in low- and medium-income developing countries. The authors recognize the serious challenges faced by these countries in satisfying basic needs, including provision of food, water, and energy. The book sets out to address the challenge of how to grow food sustainably - meeting the demands of a growing ever increasing world population without degrading our natural resource base. This book provides a concise overview of key areas that need to be considered when moving toward accelerated technology development and uptake for sustainable agriculture and food security. It also provides up-to-date detail presentation of current knowledge and focuses on analysis of agricultural technologies on countries and regions that are at risk of hunger (as measured by the 2013 Global Hunger Index), as well as on the world's breadbaskets. The authors have analyzed the environmental impacts of nitrogen emissions and water savings of the eleven technologies examined, advocating for more research to assess the greenhouse gas emissions and energy requirements of these technologies.

"Food Security in a World of Natural Resource Scarcity: *The Role of Agricultural Technologies"* provides useful information and will be of interest to junior faculty, active researchers, policy makers, and natural resource managers, national agricultural research institutes, funding organizations and agencies, as well as to postgraduate students in farming systems research, agronomy, soil science and climate change. I therefore strongly recommend the book for these categories of people.

I specifically like the organization of the book. And I am particularly impressed by how the book introduces an interdisciplinary framework mainly consisting of a combination of DSSAT (a process-based crop model) and IMPACT (a global, partial-equilibrium, agricultural sector model) for estimation of impacts of agricultural technologies. The book provides a good guide for future research. Personally, I learned a lot of things that will carry into my future research.

Body of the Review

Chapter 1 (Introduction) recognizes the fact that significant improvements in the quality, transparency, and objectivity of strategic investment decisions about agricultural technologies and associated policies are urgently needed. And that this book seeks to fill this gap. The chapter further stresses on the fact that this book contributes to the understanding of future benefits from alternative agricultural technologies by assessing future scenarios for the potential impact and benefits of technologies on yield growth and production, food security, the demand for food, and agricultural trade. This is in view of the recognition that the future pathways for agricultural technology generation, adoption, and use will have major effects on agricultural production, food consumption, food security, trade, and environmental quality in developing countries. The overall objective of this book is to identify the future impact of alternative agricultural technology strategies for food supply, demand, prices, and food security for the three key staple crops: maize, rice, and wheat. The authors did this by (1) analyzing the potential payoffs (yield growth and food security) of alternative agricultural technologies at global and regional levels, taking into account the spatial variability of crop production, climate, soil, and projected climate change; and (2) assessing the market-level consequences of broad adoption of yield-enhancing crop technologies at regional and global scales, as mediated through impacts on commodity markets and trade.

Chapter 2 (Technology Selection and Its Effects on Yields and Natural Resources) introduces the research methodology used for the study, data collection & analysis, and development of theory. The data collection phases consisted of a mobile phone tracking pilot study, in-depth interviews and a survey. The chapter concludes by explicating the analysis approach for the empirical data. The authors selected both high- and low-tech solutions, ranging from new traits in varieties (such as drought-tolerant & heat-tolerant crops) and water-saving irrigation technologies to practices that are considered more efficient in terms of resource use (such as integrated soil fertility management & no-till). The technologies assessed in the book by the authors were identified by experts from agricultural research organizations, the private sector, and practitioners as key options to increase cereal yields rapidly and sustainably in the face of growing natural resource scarcity and climate change. These technologies cover a broad range of traditional, conventional, and advanced practices with some proven potential for yield improvement and wide geographic application. No-till, integrated soil fertility management (ISFM), precision agriculture (PA), organic agriculture (OA), nitrogen-use efficiency (NUE) and crop protection are among the eleven (11) technologies covered.

Chapter 3 (Methodology: Choice of Models, Limits, and Assumptions) presents the detailed description of model framework used in the book. The framework relied on the combination of DSSAT (a process-based crop model) and IMPACT (a global, partial-equilibrium, agricultural sector model). Here, a baseline of existing dominant management practices and inputs (germplasm, nutrients, supplemental water, and pesticides) were assembled by water management system (e.g., rainfed or irrigated) and by agroecological zone. This baseline was then simulated with high granularity (0.5-degree, or about 60-kilometer, grids) in the process-based DSSAT model separately for rainfed and for irrigated farming systems. This was followed by characterizing alternative agricultural technologies in DSSAT (rainfed and irrigated farming systems done separately). The results of DSSAT were later fed into IFPRI's model, IMPACT, using adoption pathways that consider profitability, initial costs and capital, risk-reduction, and complexity of the technology. The authors then simulated global food supply and demand, food trade, and international food prices, as well as the resulting population at risk of food insecurity, which leads to comparisons of the benefits from different technologies. DSSAT simulates the main processes of crop growth and can measure changes in yields as affected by changes in geographic location, varietal use (that is, crop varieties), soil, climate, and management (that is, agricultural technologies and practices).

Chapter 4 (DSSAT Results: Yield Impacts from the Process-Based Models) shows how climate change when simulated through a series of scenarios interacts with various agricultural practices encoded in the DSSAT baseline to affect baseline yields of maize, rice, and wheat by 2050, compared to yields in 2010. Their results show that climate changes have negative effects for all crops and both rainfed and irrigated systems, with rice having the most impacts. The authors show for maize and rice, the most adverse effects of climate change are on rainfed systems (particularly maize), with most rice being irrigated. For wheat, the largest impacts of climate change are in irrigated systems. Further in Chapter 4, the authors provide the *ex ante* yield impacts for the various regions of the world. The authors find high ex ante yield impacts for heat tolerance for North America and South Asia; drought tolerance for Latin America and the Caribbean, the Middle East and North Africa and Africa South of the Sahara (SSA); and crop protection for SSA, South Asia, and Eastern Europe and Central Asia. The last 2 sections in Chapter 4 talk briefly about the results for organic agriculture and resource use.

Chapter 5 (IMPACT Results: Effects on Yields, Prices, Trade, and Food Security) provides information on the estimated resulting changes in food and water supply and demand, trade, and prices over four decades for the 11 technologies examined. Impact baseline projections indicate substantial increases in world prices of maize, rice, and wheat between 2010 and 2050, with the price of maize almost doubling under Model for Interdisciplinary Research on Climate. The projections in this chapter also present changes in yields, production, area, and malnutrition levels under the baseline for the same period. It is important to note that, despite continued growth in cereal yields, the number of people at risk of hunger increases by about 10 percent between 2010 and 2050 across developing countries in both climate change scenarios. For instance, in SSA, the projected increase is a staggering 45-51 percent, and the share of malnourished children would grow by 4-5 percent as well. Further in Chapter 5, the authors indicate that the number of people at risk of hunger could be reduced by as much as 40 percent with the use of combinations of these technologies. And where combinations of technologies are adopted on farm, production and profitability for producers can be increased, prices for consumers can be lowered, and nutrition and food security of the population can be substantially improved.

Chapter 6 (Implications for Technology Investment) discusses the policy implications of the authors' results and offers conclusions. The chapter recognizes that accelerated investments in agricultural R&D will be crucial to support food production growth. Chapter 6 further summarizes important findings for the several technologies and the three crops (maize, rice and wheat) examined, with the largest relative yield gains occurring in SSA, South Asia and parts of Latin America and the Caribbean. The authors have shown that agricultural technology impacts differ substantially by region and within regions by country. And given the heterogeneity in yield response, it is therefore important to target specific technologies to specific regions and countries. NUE is critical to reduce resource use for sustainable development and improves yields substantially in most developing regions, particularly in South Asia, East Asia and the Pacific, and SSA. The largest potential for ISFM is in low-input regions in Africa, in South Asia, and in parts of East Asia and the Pacific. Also, the effects of agricultural technology are amplified with irrigation. Although direct yield impacts from substituting furrow irrigation with drip and sprinkler irrigation are small for maize and wheat, water savings are substantial, indicating that yield levels can be sustained in a given area while releasing water for use elsewhere. As yield impacts of other technologies tend to be larger with irrigation, continued investment in cost- effective irrigation should go hand in hand with technology rollout. The authors indicate that technologies are important for addressing abiotic stresses that are expected to increase as a result of climate change. Drought-tolerant varieties perform as well as susceptible varieties under no drought stress and have significant yield benefits under drought conditions. Heat-tolerant varieties can also help reduce the projected adverse effects of climate change.

The section on policies and institutions for technology implementation, in this chapter, indicates that policy advances will be required in all areas of the technology development cycle and need to be combined with appropriate institutions and governance mechanisms to continually improve the final technology outcomes. The most common policy measures aimed at promoting technology adoption directly are: 1) investments in agricultural R&D and extension services; 2) provision of incentives to private developers of technology when the appropriation of rewards is more difficult, or to early adopters, or as a second best policy when other issues that constrain adoption (for example, the absence of sustainable finance services) cannot be overcome in the short and medium term; and 3) expansion of sustainable finance arrangements to farmers for investing in technologies.

About the Book Authors

Mark W. Rosegrant has a PhD in public policy. With extensive experience in research and policy analysis in agriculture and economic development, Rosegrant currently directs research on climate change, water resources, sustainable land management, genetic resources and biotechnology, and agriculture and energy at IFPRI. Rosegrant is a Fellow of the American Association for the Advancement of Science and a Fellow of the Agricultural and Applied Economics Association.

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Cindy Cox has a PhD in plant pathology. She is a technical writer at IFPRI. Before attending graduate school, Cox was a Peace Corps volunteer in the Central African Republic and taught secondary school mathematics.

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Nicostrato D. Perez holds a PhD in agricultural and applied economics. He is a senior scientist in the Environment and Production Technology Division, IFPRI, and works on projects related to agricultural growth, sustainable development, and environment-economy modeling. Prior to joining IFPRI, he was a professor in the Sustainable Development Program of the Mindanao State University in the Philippines.

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