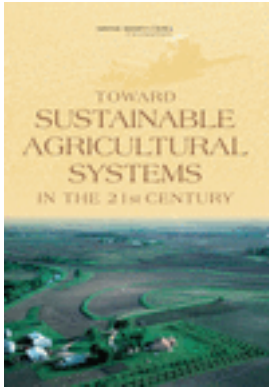


Free Summary



Toward Sustainable Agricultural Systems in the 21st Century

Committee on Twenty-First Century Systems
Agriculture; National Research Council

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Executive Summary

U.S. agriculture has had an impressive history of productivity that has resulted in relatively affordable food, feed, and fiber for domestic purposes and increases in agricultural exports. Fewer farmers are producing more food and fiber on about the same acreage, while input and energy use per unit output has decreased over the last 50 years. Despite these tremendous advances, U.S. farmers are facing the daunting challenges of meeting the food, feed, and fiber needs of the nation and of a growing global population and of contributing to U.S. biofuel production, under the constraints of rising production costs, increasingly scarce natural resources, and climate change. Agriculture is at a pivotal stage in terms of meeting societal demands for products while improving sustainability.

This report of the National Research Council Committee on Twenty-First Century Systems Agriculture reviews the state of knowledge on farming practices, technologies, and management systems that have the potential to improve the environmental, social, and economic sustainability of agriculture, and it discusses the tradeoffs and risks that might occur if more farms were to adopt those practices, technologies, and systems. The report also identifies knowledge gaps and makes recommendations for future actions to improve agricultural sustainability.

DEFINING AGRICULTURAL SUSTAINABILITY

Improving sustainability is a process that moves farming systems along a trajectory toward meeting various socially determined sustainability goals as opposed to achieving any particular end state. Agricultural sustainability is defined by four generally agreed-upon goals:

- Satisfy human food, feed, and fiber needs, and contribute to biofuel needs.
- Enhance environmental quality and the resource base.
- Sustain the economic viability of agriculture.
- Enhance the quality of life for farmers, farm workers, and society as a whole.

The sustainability of a farming practice or system could be evaluated on the basis of how well it meets various societal goals or objectives. To be sustainable, a farming system needs to be sufficiently productive, robust (that is, be able to continue to meet the goals in the face of stresses and fluctuating conditions), use resources efficiently, and balance the four goals.

TOWARD AGRICULTURAL SUSTAINABILITY IN THE 21ST CENTURY

All farms have the potential and responsibility to contribute to different aspects of sustainability. However, the scale, organization, enterprise diversity, and forms of market integration associated with individual farms provide unique opportunities or barriers to improving their ability to contribute to global or local food production, ecosystem integrity, economic viability, and social well-being. Dramatic and continuous improvement in agricultural sustainability will require long-term research, education, outreach, and experimentation by the public and private sectors in partnership with farmers.

The committee proposes two parallel and overlapping efforts to ensure continuous improvement in the sustainability performance of U.S. agriculture: incremental and transformative. The incremental approach would be directed toward improving the sustainability performance of all farms, irrespective of size or farming system type, through development and implementation of specific sustainability-focused practices, many of which are the focus of ongoing research and with varying levels of adoption. Most, if not all, farms have adopted some practices for improving sustainability, but such methods have not been adapted to all environments, and none of the practices has reached its full potential for adoption. Continuous research, extension, and experimentation by researchers and farmers are necessary to provide the toolkit necessary for farmers to adapt their systems to the changing environmental, social, market, and policy conditions to ensure long-term sustainability.

Research has to address multiple dimensions of sustainability and explore agroecosystems properties if systemic changes in farming systems are to be pursued. Therefore, the incremental approach to improving agricultural sustainability needs to be complemented by a transformative approach that would dramatically increase integrative research by bringing together multiple disciplines to address key dimensions of sustainability simultaneously beyond the agroecological dimension. The transformative approach would apply a systems perspective to agricultural research to identify and understand the significance of the linkages between farming components and how their interconnectedness and interactions with the environment make systems robust and resilient over time.

KEY DRIVERS OF CHANGE: MARKETS AND FEDERAL AND LOCAL POLICIES

The decisions of farmers to use particular farming practices and their ability to move toward increasingly sustainable farming systems are influenced by many external forces, including science, knowledge, skills, markets, public policies, and their own values, resources, and land tenure arrangements. Although market, policy, and institutional contexts are important drivers of the trajectory of U.S. agriculture, the response of individual farmers to the incentives and disincentives created by market conditions and policy contexts can be diverse. Efforts to promote widespread adoption of different farming practices and systems for improving sustainability will require an understanding of how variability among individual, household, farm, and regional-level characteristics affect farmers' response to incentives and disincentives.

Toward Sustainable Agricultural Systems in the 21st Century

Committee on Twenty-First Century Systems Agriculture

Board on Agriculture and Natural Resources

Division on Earth and Life Studies

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Preface

Since the National Research Council published the report *Alternative Agriculture* in 1989, there has been a remarkable emergence of innovations and technological advances that are generating promising changes and opportunities for sustainable agriculture in the United States. At the same time, the agricultural sector worldwide faces numerous daunting challenges that will require innovations, new technologies, and new ways of approaching agriculture if the food, feed, and fiber needs of the global population are to be met.

This report, *Toward Sustainable Agricultural Systems in the 21st Century*, assesses the scientific evidence for the strengths and weaknesses of different production, marketing, and policy approaches for improving agricultural sustainability and reducing the costs and unintended consequences of agricultural production. It also evaluates the transferability of principles underlying farming systems and practices that could improve the sustainability of small-scale agricultural systems in less developed countries, with an emphasis on sub-Saharan Africa. The report includes case studies of different kinds of farms and farming systems in different regions of the United States that actively pursue the goal of sustainability and revisits some farms originally featured in *Alternative Agriculture*. We want to thank the farmers who so generously shared their expertise and experiences and to wish them well in their future farming endeavors. We also want to thank the consultants who conducted and documented the farmer interviews.

The study committee included 15 members with expertise in food production and agribusiness; crop, soil, and horticultural sciences; water-use and water-quality science; farming systems and agroecology; agricultural economics and social science; and federal farm, trade, international development, environmental, and regulatory policies (Appendix B). Two of the committee members are farmers. The committee also solicited information from a wide range of experts (Appendix C) with complementary expertise and experience. We are grateful for their willingness to give of their time and knowledge. During the development of the report, the committee held two workshops. The first focused on the state of the science on agricultural methods and systems for improving sustainability, and a

second was on the lessons learned and transferability of agriculture practices and systems to improve sustainability of agriculture in developing countries. Two public committee meetings, in which other experts were invited to provide the committee with information on U.S. agricultural economics and policies, and their effect on farming systems, farmers' behavior, and the environment, were also held. Some of the committee members also attended the Sustainable Agricultural Research and Education (SARE) conference in Kansas City, Missouri, in 2008 to gather information.

Challenges that the committee immediately faced included understanding and interpreting the rapid changes and developing crises in the global economy and their effect on sustainable agriculture. For example, when the committee began its study, global price of crude fuel oil rose from about \$75 per barrel to a peak of \$147 in July 2008. This increase caused harmful reverberations across the global agriculture sector and shortages of corn, rice, and other food, especially in developing countries, and a significant increase in the demand for biofuels. It was immediately followed by the global economic crisis, which, among other impacts, restricted farmers' access to credit, lowered land values, and lowered prices for biofuels when fuel oil costs declined by half. On a more positive note, the committee faced a virtual cascade of new information and programs relating to sustainable agriculture, such as important new advances in science and in federal and state programs and policies. The new federal farm bill places greater emphasis on agricultural sustainability, organic agriculture, and renewable energy and fuels, and support is growing for regional and local food production systems.

The committee notes that although most farms have the potential and responsibility to contribute to different aspects of sustainability, U.S. agriculture needs both incremental and transformative changes to address the many challenges of the future. Incremental changes—such as pest-resistant varieties, conservation tillage, integrated pest management, and use of crop diversity including cover crops, crop rotations, and other biologically integrative technologies and practices—have been increasingly used in many regions, but have not yet been adapted to some fragile areas and to low-rainfall cropland. Transformative changes include the development of new farming systems that represent a dramatic departure from the dominant systems of present-day American agriculture and capitalize on synergies and efficiencies associated with complex natural systems and broader social and economic forces using integrative approaches to research and extension at both the farm and landscape levels. Examples include development and broad adoption of water-conserving production systems in areas of water shortage and overdraft, landscape-scale reduction of nutrient and other materials runoff from agricultural lands that contributes to major hypoxic zones, and assessment of the potential and cost for broad adoption of alternative animal production systems that address many environmental and social concerns of some dominant production systems.

The committee believes that its report identifies many of the most important challenges that U.S. agriculture faces today, but it is well aware that unforeseen threats as well as new opportunities could surface tomorrow. We hope that the sponsors of this study, the Bill & Melinda Gates Foundation and W.K. Kellogg Foundation, as well other groups and organizations, will find the report's conclusions and recommendation to be of value in their efforts to understand and develop sustainable agricultural systems that will meet the food, feed, fiber, and biofuel needs of a growing global population.

On behalf of the committee, we would like to express our thanks and appreciation to Robin Schoen, director of the Board of Agriculture and Natural Resources (BANR), and

Evonne Tang, the senior program officer responsible for our study. Without their planning, organization, and editing expertise, this large and complex report would have been impossible. We also want to thank all the BANR study staff for their support and assistance with our meetings and in preparing the final report.

Julia L. Kornegay, *Chair*
Richard R. Harwood, *Vice-Chair*
Committee on Twenty-First Century
Systems Agriculture

Acknowledgments

This report has been reviewed in draft form by persons chosen for their diverse perspectives and technical expertise in accordance with procedures approved by the National Research Council's Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making its published report as sound as possible and to ensure that the report meets institutional standards of objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process. We wish to thank the following individuals for their review of this report:

P. Stephen Baenziger, University of Nebraska-Lincoln
Jon T. Biermacher, The Samuel Noble Foundation, Inc.
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Thomas Dobbs, South Dakota State University
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Although the reviewers listed above have provided many constructive comments and suggestions, they were not asked to endorse the conclusions or recommendations, nor did they see the final draft of the report before its release. The review of this report was overseen by Drs. R. James Cook and Harley W. Moon. Appointed by the National Research Council, they were responsible for making certain that an independent examination of this report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of this report rests entirely with the authoring committee and the institution.

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