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Promising technologies and climate change: *ex ante* scenario analysis of adaptation strategies

Sherman Robinson, Daniel Mason-D'Croz, Shahnila Islam, Richard Robertson, Arthur Gueneau, Nicola Cenacchi, Keith Wiebe, and Mark Rosegrant (IFPRI), Bernardo Creamer (formerly CIAT), Gbegbelegbe Sika (CIMMYT), Guy Hareau (CIP), Ulrich Kleinwechter (formerly CIP), Swamikannu Nedumaran (ICRISAT), and Khondoker Mottaleb (formerly IRRI)

The goals of achieving and maintaining global food security are challenged by a variety of stresses stemming from population growth, income growth, and climate change. The agriculture sector is confronted with increasing demand for food, industrial and energy crops; competition for natural resources (land and water); various stresses including abiotic (e.g., climate change) and biotic (e.g., damage from pests and diseases). Complicating these challenges is that these forces are characterized by large geographic and temporal variability and uncertainty, requiring analysis that accounts for complex interactions and synergies.

Scenario analysis with long-run simulation models

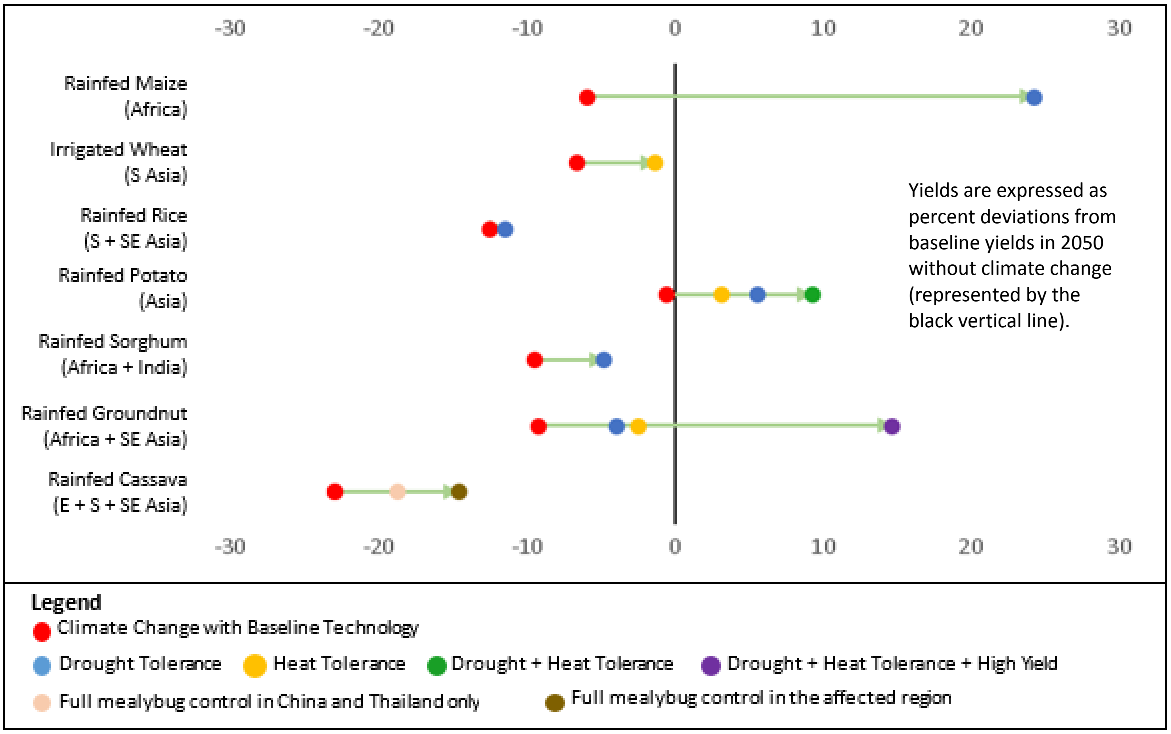
IFPRI has developed a system of linked simulation models of global agriculture to do long run scenario analysis of the effects of climate change and various adaptation strategies. The system includes the core IMPACT multi-country, multi-market, economic model (International Model for Policy Analysis of Agricultural Commodities and Trade), which is linked to water models (global hydrology, water basin management, and water stress on crops) and crop simulation models.

This study focuses on new technologies for adapting to climate change, which are described in the table below. This work is part of the Global Futures and Strategic Foresight Project (GFSF), a collaborative effort led by IFPRI in partnership with eleven other CGIAR Centers. Collaborating CGIAR centers did research to determine the potential biophysical properties and regions of adoption of drought- and heat- tolerant varieties for maize, wheat, rice, potatoes, sorghum, and groundnuts. The DSSAT suite of crop simulation models was used by IFPRI to estimate the biophysical yield gains of the new virtual crops. For cassava, three different management options to control infestation from the mealybug pest were examined. The results were used as inputs to the IMPACT model system to determine the benefits from the new varieties under a no-climate-change baseline scenario and a climate change scenario using the global climate model from the Geophysical Fluid Dynamics Laboratory (GFDL). This scenario was chosen as representative of one of the driest futures from the various climate models—the idea being to test the new crop varieties in a worst-case scenario.

Promising Technologies and Countries of Adoption

CROP	TECHNOLOGY	COUNTRIES
Maize (CIMMYT)	Drought tolerance	Angola, Benin, Ethiopia, Ghana, Kenya, Malawi, Mozambique, Uganda, the United Republic of Tanzania, Zambia, and Zimbabwe
	Heat tolerance	Bangladesh, India, Nepal, and Pakistan
Wheat (CIMMYT)	Drought tolerance	Iran and Turkey
	Heat tolerance	India and Pakistan
	Drought + Heat tolerance	Argentina and South Africa
Rice (IRRI)	Drought tolerance	Bangladesh, Cambodia, India, Lao People's Democratic Republic, Nepal, Sri Lanka, and Thailand
Potato (CIP)	Drought tolerance, Heat tolerance, and Drought + Heat tolerance	Bangladesh, China, Kyrgyzstan, India, Nepal, Pakistan, Tajikistan, and Uzbekistan
Sorghum (ICRISAT)	Drought tolerance	Burkina Faso, Eritrea, Ethiopia, India, Mali, Nigeria, Sudan, and the United Republic of Tanzania
Groundnut (ICRISAT)	Drought tolerance, Heat tolerance, and Drought + Heat tolerance + High yield	Burkina Faso, Ghana, India, Malawi, Mali, Myanmar, Niger, Nigeria, Uganda, United Republic of Tanzania, and Viet Nam
Cassava (CIAT)	Biological controls of Mealybug pest infestation	China, India, Indonesia, Lao People's Democratic Republic, Myanmar, and Thailand

Effects of Climate Change and Promising Technologies on Yields in 2050



Results: new technologies can offset climate shocks

The results from the scenario analysis are summarized in the figure. For all crops in the selected countries, climate change impacts are negative with the baseline technology. All new technologies have beneficial effects on yields in the climate change scenario. The beneficial effect is very small for rice. For maize, potato and groundnuts, yields with the new varieties are greater than under no climate change.

The figure focuses on two non-market forces affecting yields: climate change and adoption of new technologies. Additionally, IMPACT incorporates market effects on yields through the simulation of farmer responses to changes in prices. If supply is increased, the price will tend to fall, and the fall in price will induce changes in farmer behavior that will lower yields (e.g., less use of fertilizer and chemicals). This link through market effects dampens the ultimate effects of climate change and the adoption of new technologies on yields. In this study, the market effects are not very large because the share of global output arising from the adoption of the promising technologies is relatively small, since they only operate in a few countries, and hence the changes have little impact on world prices.

Future research areas

While useful to focus the analysis, the assumption in this study that new promising technologies are introduced in only a few developing countries is conservative, as farmers globally will react to climate change. The synergies across different channels through which the introduction of new technologies ultimately affects yields, output, demand, trade, and prices become very important as larger shares of global output are involved. An important area for future research is consideration of scenarios involving widespread adaptation responses to climate change through introduction of new technologies.

This analysis focused on measuring benefits of the climate adaptation strategy. Costs associated with research, development and dissemination of these new technologies were not analyzed. Such cost analysis would be an important part of any consideration of investment priorities, and an important area for future research.

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INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE

A member of the CGIAR Consortium | A world free of hunger and malnutrition

2033 K Street, NW | Washington, DC 20006-1002 USA
T: +1.202.862.5600 | F: +1.202.467.4439
Email: ifpri@cgiar.org | www.ifpri.org

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