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FOOD SECURITY AND CLIMATE CHANGE

Challenges to 2050 and Beyond

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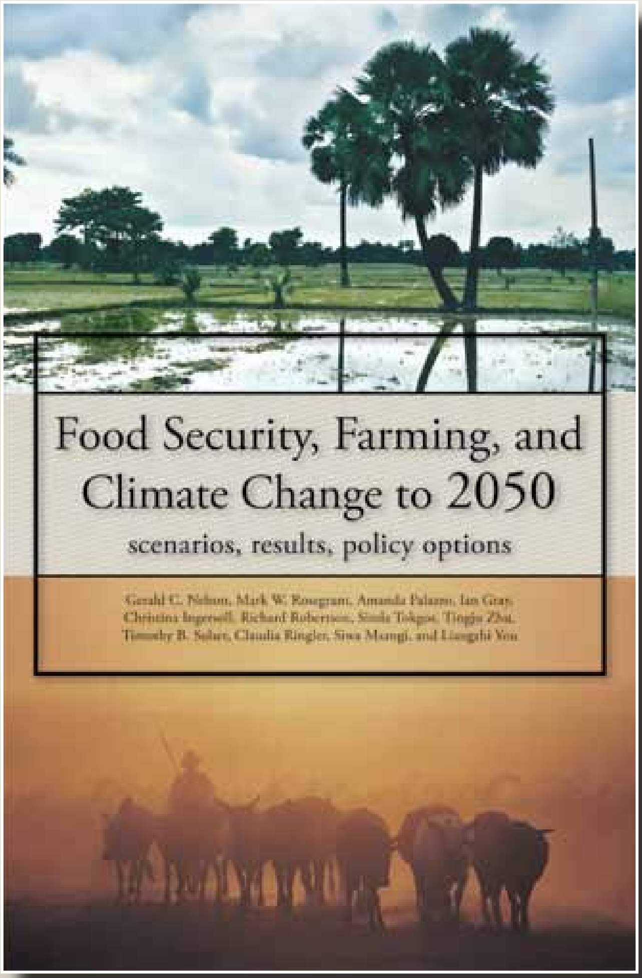
The first decade of the 21st century has brought harbingers of a troubled future for global food security. The food-price spike of 2008 led to food riots and political change in several countries. In 2010, the excessive heat and drought in Russia that led to wildfires and a grain embargo, as well as the unprecedented floods in Pakistan, signal more trouble ahead. A world population approaching 9 billion by 2050 and higher incomes in hitherto poor countries will lead to increased food demand, which means significant challenges to sustainable agricultural production.



To these already daunting challenges, climate change adds more. Because food production is critically dependent on local temperatures and precipitation, any change outside the range of current conditions requires farmers to adapt their practices. The IFPRI study from which this brief is drawn, *Food Security, Farming, and Climate Change to 2050*, suggests that while the adaptations might be beneficial for a few farmers, for most farmers they will pose major challenges to productivity and more difficulties in managing risk. This brief highlights results from the study on possible development and climate change scenarios between now and 2050 and on what these scenarios mean for food security.

WHAT DOES THE FUTURE HOLD?

Identifying Plausible Outcomes

An uncertain future means there is a range of plausible outcomes between now and 2050. The study considers three combinations of income and population growth: a baseline scenario (with moderate income and population growth), a pessimistic scenario (with low income growth and high population growth), and an optimistic scenario (with high income growth and low population growth).

The study combines each of these three income/population scenarios with four plausible climate scenarios that range from slightly to substantially wetter and hotter on average, as well as with an implausible scenario of perfect mitigation (a continuation of today's climate into the future). The results here are thus based on 15 possible scenarios to 2050.

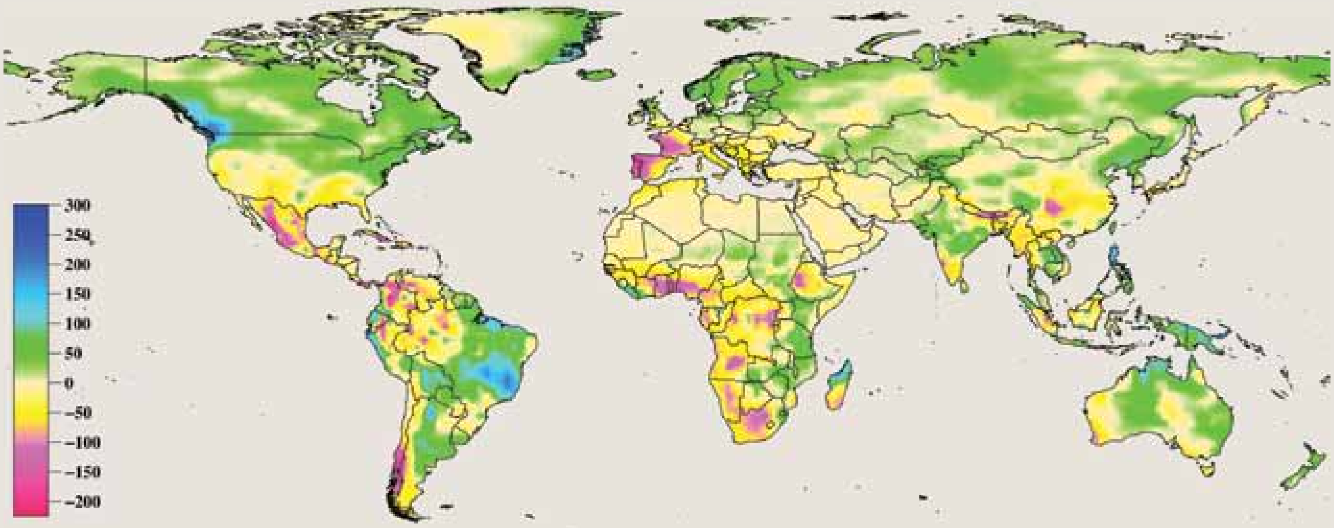
Figure 1 shows rainfall changes between 2000 and 2050 for two of these scenarios—one based on a model produced by Australia's Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the other on the Model for Interdisciplinary Research on Climate (MIROC), produced by the University of Tokyo's Center for Climate System Research. The CSIRO scenarios have smaller but more evenly distributed precipitation increases. The MIROC GCM scenarios have greater increases on average but important agricultural regions of the world see decreased rainfall by 2050.

World prices are a useful single indicator of the future of agriculture. Rising prices signal the existence of imbalances in supply and demand and growing resource scarcity, driven by demand factors such as growing population and income or supply factors such as reduced productivity due to climate change. This analysis suggests that unlike the 20th century, when real agricultural prices declined, the first half of the 21st century is likely to see increases in real agricultural prices. Increasing demand driven by population and income growth is greater than productivity growth which is hampered by the negative productivity effects of climate change. In Figure 2, the price increase called the economic growth effect is for a 2050 world with perfect mitigation. Income and demographic changes between 2010 and 2050 result in price increases that range from 10.8 percent for rice in the optimistic scenario to 53.9 percent for maize in the pessimistic scenario. These substantial increases show the underlying pressures on the world food system, even in the unlikely event that perfect mitigation is achieved. With climate change, price increases will range from 31.2 percent for rice in the optimistic scenario to 100.7 percent for maize in the baseline scenario.

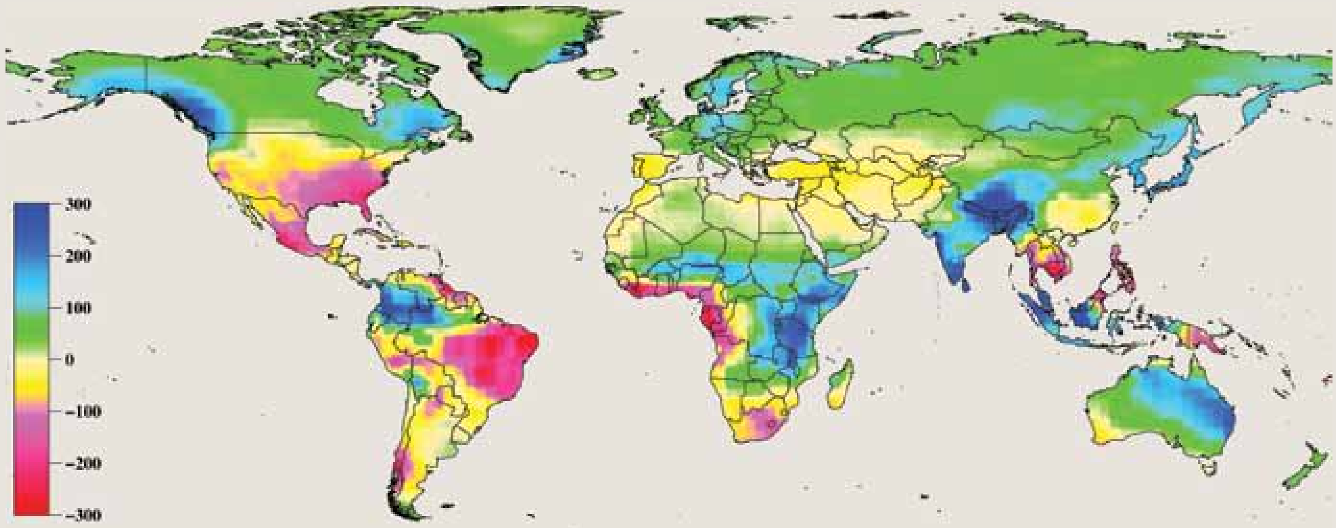
Figure 3 illustrates the combined effects of economic development and climate change on food security. The

Figure 1—Change in average annual precipitation in two climate models, 2000–2050 (millimeters)

CSIRO, AIB



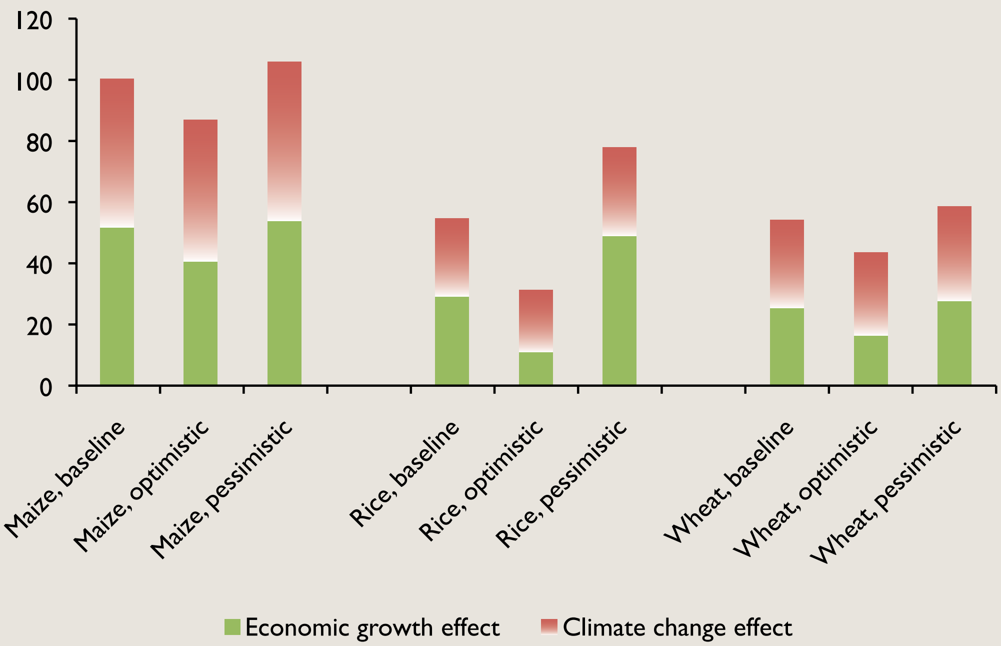
MIROC, AIB



Source: Authors' calculations based on downscaled climate data, available at http://futureclim.info.

Note: A1B is one of the greenhouse gas emissions pathways produced as part of the Intergovernmental Panel on Climate Change (IPCC) Special Report on Emissions Scenarios (2000).

Figure 2—World price increases for selected crops under various scenarios, 2010–2050 (percent change from 2010)



Source: Authors' estimates.

Note: The climate change effect is the mean of the four climate change scenarios.

left side of the graph shows changes in daily kilocalorie availability between 2010 and 2050 under the optimistic scenario; the right side shows outcomes under the pessimistic scenario. The figure presents results for three groups of countries—all developed countries, all developing countries, and the 40 low-income developing countries. This figure illustrates visually the four policy implications for food security and climate change, discussed below.

IMPROVING FOOD SECURITY IN A CHANGING CLIMATE

Although the various scenarios show different plausible futures, together they point to four main policy implications for improving food security.

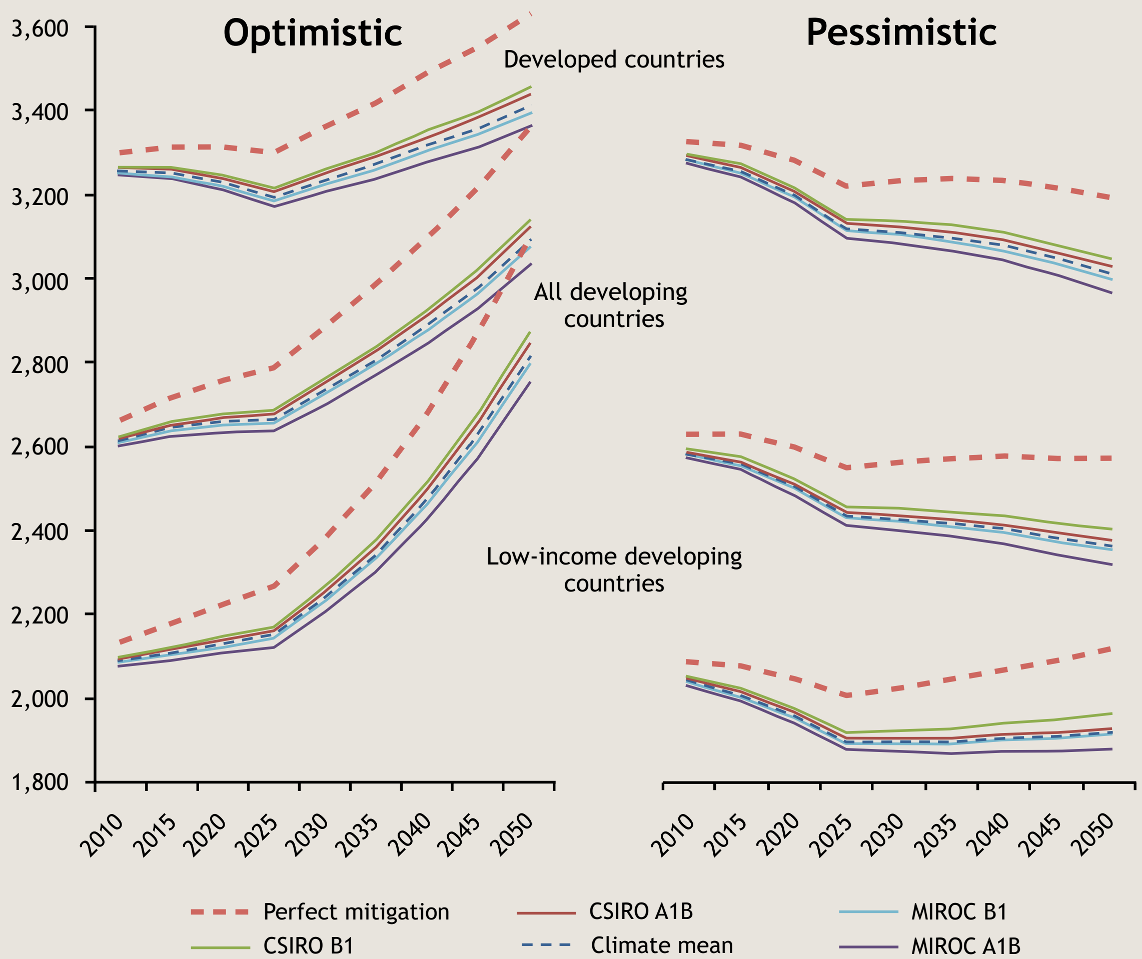
1. Raise poor people's incomes to achieve sustainable food security and resilience to climate change

Broad-based growth in income is essential to ensuring that the optimistic scenario becomes a reality and, in turn, to improving human well-being *and* delivering sustainable food security. Families with more resources at their disposal are better able to cope with any uncertainties that arise, whether natural or human caused. Farming families with higher incomes are able to experiment with new technologies and management systems that might be costly up front but have big productivity and resilience payoffs in the future.

Domestic production and international trade flows determine domestic food availability—but per capita income determines consumers' ability to pay for that food. Today, the average consumer in a low-income developing country has only two-thirds of the calories available in a developed country. This analysis shows, however, that with high per capita income growth and perfect climate mitigation, calorie availability in low-income countries can reach almost 85 percent of that in developed countries by 2050. And because the optimistic scenario allows the poorest countries to grow more rapidly between now and 2050, they catch up to today's middle-income countries. In contrast, under the pessimistic scenario, calorie availability—and human well-being more generally—declines in all regions.

The calorie availability results can be used to provide a graphic illustration of the costs to human well-being—the number of malnourished children under the age of five. In the optimistic income/population scenario, the number of malnourished children in developing countries falls by more than 45 percent between 2010 and 2050. With the pessimistic

Figure 3—Projected impacts of climate change and economic development on food security, 2010–2050 (average kilocalorie availability per person per day)



Source: Nelson et al. 2010.
Note: For each group of countries, the red dashed line represents a future with perfect greenhouse gas mitigation. The cluster of lines below the top line shows the outcomes under different climate scenarios.

scenario, on the other hand, the number decreases by only about 2 percent. The benefits of the optimistic scenario are greatest for the middle-income developing countries, which have the greatest share of world population. For middle-income developing countries, the optimistic scenario results in a 50 percent decline in the number of malnourished children. For low-income developing countries, the decline is 37 percent. In the pessimistic scenario, the number of malnourished children in middle-income developing countries still declines, but only by 10 percent. For low-income developing countries, however, the pessimistic scenario is devastating; the number of malnourished children increases by more than 18 percent. Again, climate change worsens future human well-being, especially among the world's poorest people, increasing the number of malnourished children relative to a world with perfect mitigation.

2. Invest in agricultural productivity improvements to enhance sustainable food security

Increased agricultural production is essential to meeting the growth in food demand resulting from population and income growth and will, in turn, generate the income growth in rural areas needed to improve food security. Although it is still possible to cultivate new land in some parts of the world, doing so would likely cause significant environmental damage. Investing in agricultural productivity improvements would make it possible to meet more of the rising demand from existing agricultural land resources and to reduce the environmental threats from increased production. The study simulated five types of potential productivity enhancements: an overall increase in crop productivity in developing countries of 40 percent relative to the baseline assumptions, an increase in commercial maize productivity, improvements in wheat and cassava productivity in selected developing countries, and an increase in irrigation efficiency. Each scenario has different consequences for food security and human well-being.

The first simulation—an overall productivity increase in developing countries—would have the greatest effect on human well-being, reducing the number of malnourished children in 2050 by 16.2 percent (or 19.1 million children under age five).

Some in the commercial maize industry suggest that commercial maize yields can increase by an annual average of 2.5 percent through at least 2030, so the second simulation is a 2 percent productivity increase through 2050 in countries that produce about 80 percent of world production in 2010. The effects on world maize prices are dramatic: prices increase only 12 percent, instead of 101 percent, between 2010 and 2050. The effect on malnourished children is also significant, with a 3.2 percent decline relative to the baseline in 2050. The effect is larger in the low-income developing countries (a decline of 4.8 percent) because maize food consumption is relatively more important in this group of countries.

The wheat productivity experiment increases productivity growth to 2 percent in selected developing countries that together account for about 40 percent of world production in 2010. Because this simulation affects less production than the maize simulation does, the outcomes for human well-being are less dramatic, with only a 2.2 percent reduction in the number of malnourished children in developing countries in 2050. The middle-income developing countries fare better (a 2.5 percent reduction) than the low-income developing countries (1.6 percent reduction), because India and China are both major wheat producers and consumers and are included in the group of middle-income developing countries.

Cassava is a particularly important crop for consumers in some low-income developing countries. It is the fourth most important source of calories for this group of countries and provides about 8 percent of average daily consumption. The simulation increases productivity growth to 2 percent annually for the six top producing countries (Brazil, the Democratic Republic of Congo, Ghana, Nigeria, Indonesia, and Thailand) that collectively accounted for over 60 percent of world production in 2000. Although the effect on the number of malnourished children is only a 1.1 percent decline in 2050 for all developing countries, it is concentrated in the low-income developing countries, where the decline is 2.2 percent.

Finally, the study looked at the effects of a 15 percent increase in irrigation efficiency in developing countries. The world's irrigated area is concentrated in South and East Asia. In East Asia, increased precipitation from climate change (in most scenarios), along with changing consumer preferences away from rice, reduce the need for irrigated area between 2010 and 2050. Therefore, any irrigation efficiency improvements there have relatively small effects on food production (although they are critical for freeing up water for industrial and urban use). In South Asia, however, the benefits of more efficient irrigation are substantial. And for middle-income countries as a whole, increased irrigation efficiency reduces the number of malnourished children in 2050 by 0.3 percent, or about 0.3 million children. In low-income developing countries, however, because the share of irrigated area is low, the efficiency effect is small, reducing the number of malnourished children by only 0.2 percent (0.1 million children).

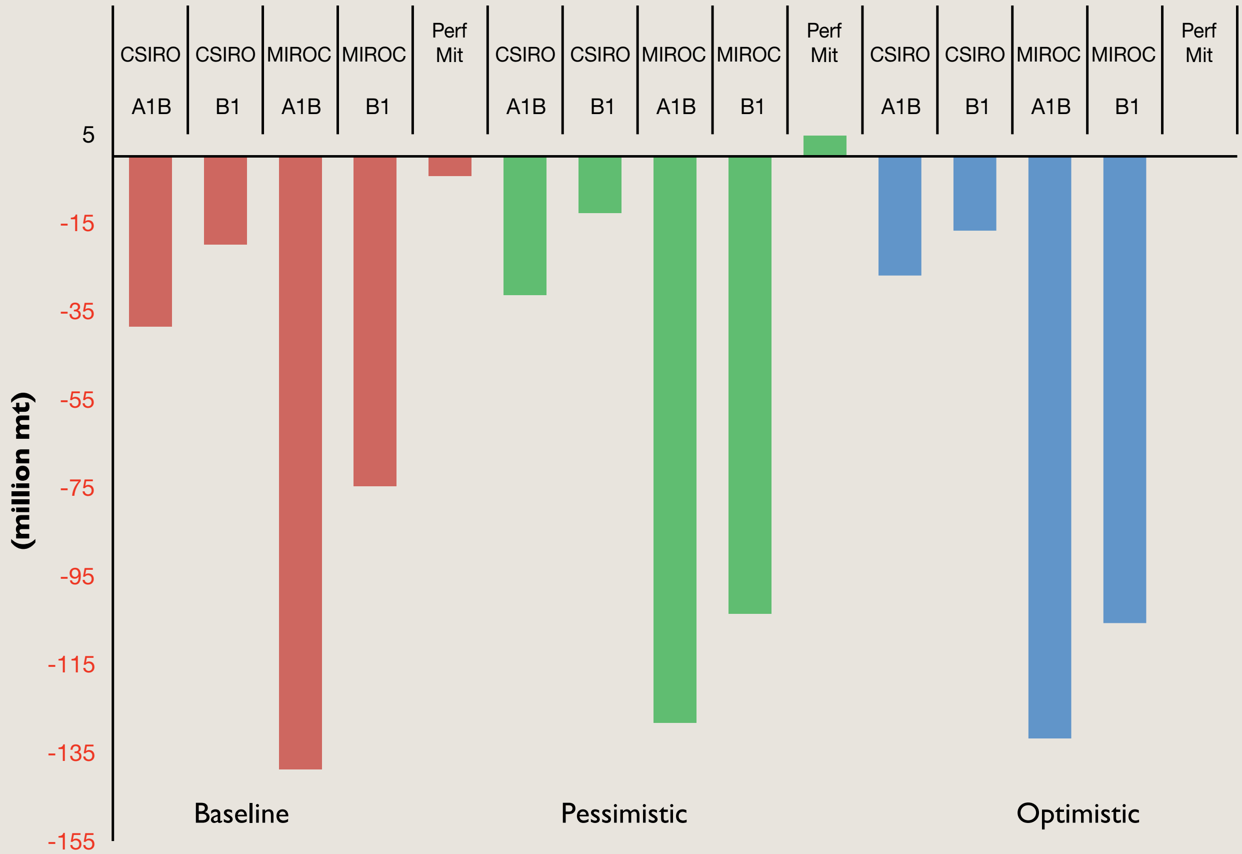
These results collectively demonstrate the power of broad-based productivity increases to increase well-being dramatically. Previous IFPRI research suggests that public spending of at least US$7 billion annually on three categories of productivity-enhancing investments—biological research, expansion of rural roads, and irrigation expansion and efficiency improvements—is needed to compensate for the productivity losses associated with climate change through 2050.

3. Strengthen international trade arrangements to compensate for different climate change effects in different locations

Despite large differences in precipitation amounts and seasonal variation across the climate scenarios, the differences in price and other outcomes are relatively small—except for international trade flows. Different climate models result in dramatically different effects on trade flows, as Figure 4 illustrates. With perfect mitigation, net cereal exports from the developed countries are about the same level in 2010 and 2050, regardless of overall scenario. With the CSIRO scenarios, net cereal exports from the developed countries decline somewhat. With the MIROC scenarios, however, developed countries' cereal trade actually becomes negative by 2050, with substantial imports. This result is driven by a combination of increased maize production in developing countries and the negative effects of the MIROC climate scenarios on U.S. maize. Trade flows can partially offset the effects of climate change on local productivity, allowing regions of the world with fewer negative effects to supply those with more negative effects.

To give some perspective on the effects of increased climate variability for one part of the world, the study simulated one possible outcome of climate change—an extended drought in South Asia, in this case from 2030 to 2040. The analysis shows that substantial increases in trade flows would help soften the blow to Indian consumers.

Figure 4—Change in net cereals trade from developed countries, 2010–2050 (million mt)



Source: Authors' calculations.

During the drought, South Asia would experience large increases in imports, or reductions in net exports, of the three key commodities—rice, wheat, and maize. These imports would drive world prices higher. Other countries' producers and consumers would thus help reduce, but certainly not eliminate, the human suffering that a South Asian drought would cause.

These findings reinforce arguments about the need to complete the Doha Round of world trade negotiations and to put in place the legal instruments to help countries respond to short-term disruptions in domestic production by relying on international transactions.

4. Cut greenhouse gas emissions and facilitate adaptation to minimize the harmful effects of climate change

Climate change exacerbates the challenge of improving food security under any income/population scenario, as Figure 3 makes clear. Compared with perfect mitigation, climate change increases the number of malnourished children in all developing countries in 2050 by 8.5 percent in the optimistic scenario and 10.3 percent in the pessimistic scenario.

Although these results only touch on some elements of the human cost of unfettered climate change, their magnitude and consistency across the scenario results make clear the need for immediate action to reduce greenhouse gas emissions and find ways to facilitate adaptation.

CONCLUSION: REDUCE POVERTY TO IMPROVE SUSTAINABLE FOOD SECURITY

The study whose results are highlighted here breaks new ground in the level of detail in its agriculture-climate interactions, but, like any large model-based analysis, it must use some simplifying assumptions and features. The general directions are likely valid even if the specific magnitudes are uncertain. The modeling will be enriched by newly developed partnerships across the centers of the Consultative Group on International Agricultural Research (CGIAR) and with researchers around the world. This ongoing work provides guidance on how to direct limited financial resources in order to sustainably feed a world confronting the challenges of adapting to climate change, a growing population, and reduced poverty.

The world's poorest people will bear the brunt of the effects of climate change, especially if the world follows a path of low income growth and high population growth. This analysis shows that the most important way to help poor people adapt to climate change is to address poverty. Policy actions to achieve broad-based economic growth that reaches the poor, improve productivity in crops that are important to poor farmers and consumers, and strengthen trade to cope with regional disparities in the agricultural effects of climate change will help increase poor people's resilience to climate change. In fact, under an optimistic scenario, this study shows that food security, even among poor people, could significantly improve. Investments and policy reforms that will increase agricultural productivity are specific actions that governments need to begin immediately.

It is also critical to start slowing emissions growth immediately. Because agriculture, broadly defined, contributes as much as one-third of greenhouse gas emissions, it must be part of this effort. The goal should be carbon-negative agriculture by 2050. Climate change exacerbates risks to human well-being and sustainable food security. The results from this study show that the more the world can mitigate the effects of climate change to 2050, the greater the potential improvements in food security. The challenges are likely to increase beyond 2050, when the climate change threat becomes much more severe. All scenarios now show average temperature increases by 2050 to be on the order of 1° C. After that, they diverge dramatically, ranging from 2° C to 4° C by 2100. Yields of many more crops will be severely threatened. Reducing emissions growth to minimize the effects of climate change is thus essential to avoid a calamitous post-2050 future.

For Further Reading:

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IFPRI's Climate Change website: www.ifpri.org/climate-change

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Nelson, Gerald C., et al. 2010. *Food Security, Farming, and Climate Change to 2050: Scenarios, Results, Policy Options*. Washington, D.C.: International Food Policy Research Institute. DOI http://dx.doi.org/10.2499/9780896291867.

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