Stanford Woods Institute for the Environment

Research Brief

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Climate Change Impact on Agriculture: Implications for Food Security and Hunger

Background

Since 2000, the United Nations' Millennium Development Goals (MDGs)* have been a driving force behind global development efforts. With the target achievement date of 2015 now upon us, the international development community is reflecting on lessons learned from the MDGs, and is drafting a new set of goals and targets — the Sustainable Development Goals — to galvanize poverty alleviation efforts over the course of the next fifteen years. Guided by the Rio+20 Summit of 2012** consensus, the post-2015 development agenda will more closely link poverty eradication with sustainable development.

Eradicating "extreme poverty and hunger" was the first of the original goals adopted in 2000, which set out to halve the proportion of hungry and malnourished people in the developing world by 2015. Thirty-eight countries beat the deadline for this objective, and the developing world as a whole is on track to achieve it by the end of this year.

However, 795 million people remain undernourished. Sub-Saharan Africa, where one in four people are hungry, bears a disproportionate share of this burden. Food security is therefore a top priority in the SDGs, which include a goal to "End hunger, achieve food security and improved nutrition, and promote sustainable agriculture."

Poverty, food security, and nutrition are clearly linked, and marked by a growing awareness of the impact of climate change on food security. The SDGs recognize the need for agricultural adaptation to a changing climate, as do programs in the United States — the world's largest producer and exporter of maize (corn) and wheat. For example, the USAID Feed the Future program, and the Obama administration's Global Alliance for Climate-Smart Agriculture both formally recognize the

About the Researcher

David Lobell is an associate professor of earth system science at Stanford University, the deputy director of Stanford's Center on Food Security and the Environment, and William Wrigley Senior Fellow at the Stanford Woods Institute for the Environment and the Freeman Spogli Institute for International Studies. His research focuses on identifying opportunities to raise crop yields in major agricultural regions, with an emphasis on adaptation to climate change. His current projects span Africa, South Asia, Mexico, and the United States, and involve a range of tools including remote sensing, GIS, and crop and climate models. In 2013 he was awarded a MacArthur Fellowship for his research on the impact of climate change on crop production and food security, and was named one of *Foreign Policy Magazine*'s "100 Leading Global Thinkers."

Reuters/Henning Bagger

importance of integrating climate resiliency into future food security plans.

This research brief is based on the latest scientific findings from the Center on Food Security and the Environment, a joint initiative of the Stanford Woods Institute for the Environment and the Freeman Spogli Institute for International Studies at Stanford University. The brief provides critical information for decision-makers on the impacts of climate change on cereal crops around the world and ultimately on global food security.

Climate Change impacts on Crop Yields

Rice, wheat and maize (corn) provide over half the world's food energy. These grains are crucial dietary staples for billions of people in the developing world. To adapt to climate change, farmers and policymakers alike need a precise understanding of how shifting patterns of heat, rainfall and extreme weather affect these crops.

Recent studies by David Lobell and his team clarified and quantified these impacts, including:

- Maize yields in the Midwestern United States are more sensitive to drought now than 20 years ago. New seed varieties are more drought-tolerant, but they are planted closer together, and that results in higher yields when the weather is good. But during a drought, densely planted maize suffers higher stress and produces lower yields.[1]
- Increased carbon dioxide will improve the water use efficiency of crops. In the U.S. this will help to reduce, but not eliminate, the negative effects of increased hot and dry conditions.[2]
- In the absence of human-driven climate change, the chance that maize or wheat would suffer a 10 percent global yield loss over the next 20 years would be only one in 200. After factoring in climate trends, however, the odds jump to one in 10 for maize and one in 20 for wheat. The odds that climate change could cut yields in half in the next 10 years have risen sharply, to a 25 percent chance for maize and a 17 percent chance for wheat.[3]
- Global wheat production is estimated to fall by 6 percent for every one degree Celsius of future temperature increase. Wheat yields are also expected to become more variable over time and between geographic regions.[4]
- On average, cereal yields are expected to fall by an average of 4.9 percent for every one degree Celsius rise

in average temperature, based on a meta-analysis of hundreds of studies.[5]

- With the average 3.5 degrees Fahrenheit of warming expected by 2040, yields of wheat and barley across Europe are expected to be more than 20 percent lower than they would be without warming. For corn, the loss is 10 percent, but corn farmers could reduce yield losses by as much as 87 percent through long-term adaptation.[6]
- Between 1988 and 2012, the amount of U.S. farmland on which farmers were able to harvest two crops per year (known as "double cropping") grew by as much as 28 percent due to warmer temperatures and later fall freezes. Future climate changes could cause a doubling or tripling of land suitable to double cropping by the year 2100, but the yield gains from double cropping are expected to be eclipsed by the yield losses from future climate change.[7]

Considerations for international development stakeholders

As decision-makers work to improve food security through the SDGs and other initiatives, it is critical to incorporate new knowledge about the current and future impacts of climate change on global crop yields. Lobell's published and ongoing research highlights several potential solutions and tools available to farmers and policymakers:

- Develop new crop breeds and varieties, such as by exploiting genetic variability in heat tolerance around flowering.
- Adjust sowing and harvesting dates to manage the effects of rising temperatures, such as by encouraging technologies that enable earlier wheat sowing throughout India
- Expand the practice of double cropping in areas of the world where it is suitable
- Irrigate previously rain fed fields, such as by using small-scale groundwater-based systems.

Conclusions

Lobell's research indicates that negative impacts to the global agriculture system are much more likely, more severe and wider-ranging in the face of human-caused climate change. Primarily, temperature increases drive these diverse, far-reaching impacts.. There are several pathways toward adaptation, though none of them appears to completely offset the losses. Research highlighted in this brief offers insights for institutions and decision-makers concerned with protecting food security and international stability throughout the coming decades.

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* The Millennium Development Goals were established after the United Nations Millennium Summit of 2000, under world wide agreement by countries and development institutions. These eight goals address poverty, HIV/AIDS, and education, among other challenges.

** The Rio+20 Summit of 2012, a United Nations conference on sustainable development, convened governments worldwide, which committed to sustainable development policies and actions.

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