

Vulnerable system? What if world's breadbaskets experience crop failure at same time?

Less than one-quarter of Earth's total cropland produces nearly three-quarters of the staple crops that feed the world's population – especially corn, wheat and rice, the most important cereal crops. These areas are our planet's major breadbaskets.

Historically, when a crop failed in one of these breadbaskets, only nearby areas had to contend with shortages and rising prices. Now, however, major crops are traded on global markets, which means that production failures can have far-reaching impacts. Moreover, climate change is expected to generate heat waves and drought that could [cause crop losses](#) in most of the world's breadbaskets. Indeed, failures could occur simultaneously in several of these key regions.

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Top 10 grain-producing countries (5-year average, 2012/2013 – 2016/2017), based on 5-year USDA PS&D data.

Pardee Center postdoctoral scholar [John Patrick Connors](#) and I are using mathematical models to study the potential environmental and economic impacts of failures in multiple breadbaskets around the world. It is already clear from our preliminary work that this is a real, near-term threat.

The good news is that not all of these regions respond in the same way to shocks in other places in the world. Some could bring new land into production quickly, easing stresses caused by crop failures elsewhere. But in order to make global food systems more robust, we need to know more about the most damaging consequences of multiple breadbasket failures.

A vulnerable system

In the past several decades, many of the world's major breadbaskets have experienced shocks – events that caused large, rapid drops in food production. For example, regional droughts and heat waves in the Ukraine and Russia in 2007 and then again in 2009 damaged wheat crops and [caused global wheat prices to spike](#) by substantial amounts in both years. In 2012 heat and drought in the United States slashed national corn, soybean and other crop yields by [up to 27 percent](#). And yields of important food crops are [low and stagnating](#) in many countries due to factors including plant diseases, poor soil quality, poor management practices and damage from air pollution.

At the same time, many experts assert that world food production [may have to double by 2050](#) to feed a growing population and satisfy rising demand for meat, poultry and dairy products in developing countries. Global agricultural production has risen over the past 50 years, largely fueled by improvements in plant breeding and [more intensive use of inputs](#), such as mechanized equipment, fertilizers and pesticides. This trend has eased pressure to bring new land into production. But it has limits, especially in the developing

world, where the need to produce more food has been a main driver of deforestation in recent decades.

It is clear that rising demand, growing international trade in agricultural products, and the potential for weather-, climate- and soil-related shocks are making the world food production system less resilient. Global agricultural trade can mean that price spikes in one region, if they are severe enough, can be felt broadly in other regions. Minor shocks, on the other hand, could be lessened by trade and by using grain reserves.

There is [increasing evidence](#) that in very poor countries, food price increases and shortages can lead to civil unrest and worsen other social and political stresses. And more wealthy countries are not immune, given the concentration of world food production and the global nature of trade. For example, the Russian/Ukrainian heat wave referenced above led to spikes in food prices, not just in the price of wheat. However, more wealthy countries also typically have more ability to buffer price shocks by either using grain reserves or increasing trade.

Modeling potential shocks

How can we understand this risk and its potential consequences for both rich and poor nations? Programs already exist to [provide early warning of potential famines](#) in the world's poorest countries, many of which already depend heavily on food aid. There also are programs in wealthier nations that monitor food prices and provide [early warnings of price spikes](#).

But these programs focus mainly on regional risks, and often are not located in major food production areas. Very little work has been done to analyze risks of simultaneous shocks in several of the world's breadbaskets.

We want to understand the impacts that shock events could have if they occur in the real world so that we can identify possible contingency plans for the largest-impact events. In order to do that, we have used an integrated assessment model, the [Global Change Assessment Model](#), which was developed by the U.S. Department of Energy and is freely available to users around the world. Integrated assessment models have been designed specifically to simulate the interactions among Earth's energy, economic and land use systems.

We have developed scenarios in which small shocks (10 percent crop loss) and large shocks (50 percent crop loss), averaged over five years, are applied to corn, wheat or rice in their major production regions, and then to all the combinations of one, two or all three crops in one, two or the top three production



Unsurprisingly, our results to date suggest that large shocks

have larger effects than smaller shocks, as measured in subsequent changes in land use, the total amount of land dedicated to agriculture and food prices. But more interestingly, not all breadbasket regions respond to shocks in the same way.

Some of these areas are quite unresponsive to shocks occurring elsewhere in the world. For example, the total amount of land in agricultural production in South Asia changes relatively little due to shocks elsewhere in the world, largely because most of the arable land is already in use.

But other regions are extremely responsive. Notably, Brazil has the ability to bring a lot of new land into production if large shocks occur elsewhere, because it still has a significant amount of potentially arable land that is not currently being farmed. However, this land currently is mostly forest, so clearing it for agriculture would add significantly to atmospheric concentrations of carbon dioxide, and thus to global climate change.

Mapping risks

The Pardee Center has published a [research agenda](#) that discusses what we still need to know about these risks. Key questions include understanding the full distribution of risks, whether increased international trade can ameliorate risk and where the most responsive and the most sensitive regions are.

Ultimately, understanding and preparing for multiple breadbasket failures will require input from climate scientists, agronomists, ecologists, remote sensing experts, economists, political scientists and decision-makers. Mounting such an effort will be challenging, but the costs of failing to do it could be devastating.

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