Climate variability a shock to the crop system, shows study

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Dongyang Wei, a doctoral candidate in the Department of Geography and Spatial Sciences, and Kyle Davis, assistant professor in the Department of Geography and Spatial Sciences and the Department of Plant and Soil Sciences, as well as a resident faculty member with UD's Data Science Institute, led a new study that focused on crop production shocks and how they are affected by variations in planted and harvested areas. Credit: University of Delaware/ Evan

As the world faces more climate variability and extremes in the face of global warming, sudden environmental changes add an extra layer of stress to food production in the United States and around the world. It is critical, then, to figure out how the areas in which crops are planted and harvested respond to these stressors, which can bring on 'shocks' in production—or, put differently, sudden and statistically significant crop declines.

These production shocks are a big concern in terms of food stability and many crops in the United States—such as corn, cotton, soybeans, and wheat—are all experiencing more frequent production reductions as a result of these shocks.

A new study published in *Nature Sustainability* and led by the University of Delaware's Dongyang Wei looked at these production shocks and, specifically, how they are affected by variations in planted and harvested areas.

Kyle Davis, assistant professor in the Department of Geography and Spatial Sciences and the Department of Plant and Soil Sciences, as well as a resident faculty member with UD's Data Science Institute, is coordinating author on the paper.

Wei, a doctoral candidate in the Department of Geography and Spatial Sciences, said prior studies have focused on crop yield and how the yield variability affects production but very few studies have looked at the role of planted and harvested areas. Because production is the combined result of how much area a farmer plants (the planted area), how much of that area they can harvest (the harvested area) and the yield of the crop

in that area, it is important to evaluate all three of these factors when assessing production stability.

"What we did was to focus on the U.S., the world's largest producer and exporter of cereal grains, to see how these three components—crop yield, planted area, and harvested area—affected food production stability and to what degree they are related to climate extremes," said Wei.

For the study, the researchers looked at county-level data on seven crops: barley, corn, cotton, sorghum, soybeans, spring wheat, and winter wheat.

These are the main crops that are grown in the United States, accounting for about 70 percent of the country's total cropland. In addition to being widely produced, they have a lot of readily available data that covers a long time period. As a result, the researchers were able to look at data sets from 1978-2020.

"Agriculture is one of the sectors most directly exposed to the effects of climate change," said Davis. "Understanding how the stability of crop production is influenced by variations in yield, planted area, and harvested area—and how these influences may differ between crops—is critical to more effectively adapting agriculture in the face of rising climate change and extreme climate events. Dongyang's research is an important contribution to our understanding on this topic."

Using time-series data and statistical methods to detect how frequently shocks occur, they found that shocks in planted and harvested areas co-occur with more than half of the production shocks for the study crops.

They then looked at the extent to which each of the three components contribute to the size of a production shock and found that while yield fluctuations contribute more than the other two components for corn,

cotton, soybean and winter wheat, changes in planted and harvested areas play a more important role in the magnitude of production shocks for barley, sorghum and winter wheat.

Wei said this is important because it shows that researchers should focus on all three variables instead of simply focusing on the yield and ignoring the planted and harvested areas.

"We want to raise the importance of considering all three of the components when we are facing rising climate variability and climate disruptions on the food systems," said Wei. "Yield is important, but an exclusive focus on yield stability severely constrains the solution space. If we want to have greater flexibility in adapting agriculture to climate change, we should focus on ways to stabilize planted and harvested areas too. The producers' decisions on cropping patterns can play a crucial role in stabilizing food production."

More information: Wei, D. et al, Key role of planted and harvested area fluctuations in US crop production shocks, *Nature Sustainability* (2023). DOI: 10.1038/s41893-023-01152-2.
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