Sustainability

How to buffer against an urban food shortage

Zia Mehrabi

There is widespread concern that the risk of food shocks — sudden disruptions to food supply — is increasing. It emerges that a city's vulnerability to food shocks can be reduced by diversifying its supply chains. **See p.250**

More than half of the world's population lives in urban areas, a proportion that is set to increase[1] to 68% by 2050. These urban residents depend on supply chains to produce, procure, prepare and deliver food, and they are exposed to potential supply-chain disruptions and food shortages from changes in human activity and natural processes. There is growing recognition that food-system resilience needs to be improved, but how best to buffer against urban food shortages remains an open question for both research and policy. On page 250, Gomez *et al.*[2] assess how the flow of agricultural products to a city depends on the diversity of the city's trading partners. The authors apply ideas from engineering — such as those used when ensuring infrastructure is protected from flooding — to inform the design of food systems that can buffer cities against food shortfalls.

For decades, scientists and industry have been warning governments and consumers about the risks of food shortages. Such shortages have a range of possible causes, including droughts and heatwaves, pest and disease outbreaks, financial downturns and trade policies[3]. More recently, the COVID-19 pandemic has led academics, and society more generally, to revisit the question of how fragile urban food supplies really are (Fig. 1).

There have been many proposed solutions to deal with the dangers of food shortages, from climate-resilient agricultural management practices to promoting local food systems and self-sufficiency[4]. One solution that is gaining attention is to increase the number and variety of agricultural products, farms and companies procuring and delivering food. Diverse food supply chains might buffer cities against food shortages — in the same way that, in finance, a varied portfolio of stocks limits investment risk and, in ecology, a diverse mixture of species maintains ecosystem functions.

Gomez *et al.* used data on the origin and destination of different agricultural commodities for 284 cities and 45 non-city geographical areas in the United States. They identified domestic food systems for each city — that is, all of the geographical areas that supply crops, meat, live animals or animal feed to that city. The authors then determined how many cities faced different thresholds of abrupt food-supply disruptions, known as food shocks, using the percentage difference between the minimum and mean of supply amounts for each food sector over four years for each city. More specifically, they counted the number of cities in which the minimum was more than a particular percentage (ranging from 3% to 15%) smaller than the mean in any one of those four years.

Next, Gomez and colleagues combined those data with simple indicators of geographical similarity — such as the physical distance and difference in climate between each city

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Figure 1 | Empty supermarket shelves during the COVID-19 pandemic. Many city dwellers around the world experienced such scenes, which were largely driven by panic buying and changing consumer behaviour. Gomez *et al.*[2] demonstrate that the resilience of food supply chains can be increased by boosting their diversity.

and the geographical areas in that city's supply network. With this information in hand, the authors tested the idea that groups of cities with more-diverse supply chains are better able to buffer against food shocks than are groups whose supply chains are less diverse. Indeed, they found that cities importing food from suppliers that are more dissimilar from themselves are less likely to face shocks than are cities whose supply-chain partners are less diverse. Such supply-chain benefits would not be reaped from having solely local food systems.

Gomez *et al.* then considered design concepts from engineering, where infrastructure systems should be planned to withstand shocks — such as extreme flooding — of a given frequency and magnitude. The authors undertook some bold extrapolations, in which they estimated the size of food shocks that would be faced by different US cities given their current supply-chain diversity. They found that a rare shock, such as one occurring once in 100 years, would cause a food-supply loss of about 22–32% across different cities.

The other implicit finding from Gomez and colleagues' model is that even moderate supply-chain diversity is effective at reducing the probability of extremely large shocks. The authors also applied their analysis to shocks happening in multiple food sectors simultaneously. They obtained similar results to those for single-sector shocks — with supply-chain diversity also providing a buffering effect for these even rarer occurrences.

Gomez and colleagues' work has major implications for the way in which resilient food systems should be built, but it also has a few caveats. First, the authors used only four years of data for each city, posing problems for characterizing the distribution of shocks at each city. This limited time series makes it difficult to define the baseline variation in food supply — that is, what is considered normal — for consumers and retailers alike. It also makes it hard to see to what extent diversified supply chains buffer against food shortages under normal conditions compared with years marked by extreme events, and whether the net benefits are large enough to trigger a change in food-procurement policies.

Second, the food-flow data used by Gomez *et al.* do not represent actual flows for each year, but instead are simply annual production quantities proportionally distributed according to observed flows[5] in 2012. Therefore, the authors' analysis does not capture, or allow for, rerouting or other social responses at the onset of extreme events. Such social responses within and after shock years would result in changing food flows across the supply network.

Third, Gomez and colleagues did not validate the predictive worth of their model beyond the four years considered, or outside the United States. This lack of verification is perhaps most limiting for applying the findings in practice — partly because the stability of food supply is itself dynamic, and will change with increasing volumes and types of food consumed, as well as with production technology. Although the observed phenomenon and general patterns might hold in other years and geographical regions, no data or analyses exist to validate whether the authors' design suggestions will protect against future shocks to the degree claimed.

Designing urban food systems to specification is not as easy as engineering a bridge or dam that won't fail in 100 years. The major global concern with respect to urban food shortages and food security is for populations of middle- to low-income countries, particularly those that are dependent on imports[6]. Theoretically, supply-chain diversity will also have a buffering effect for these populations when the number of urban dwellers starts to drastically increase in the coming years, especially in Africa. However, such nations are probably not accurately described by the model presented. Moreover, they have different policy options and capacities for producing diverse supply chains compared with those possible in the United States. Nevertheless, Gomez and colleagues' work provides a timely and refreshing reminder that building diverse supply chains offers a crucial mechanism for protecting urban dwellers from food shortages.

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Immunology

Single-domain antibodies tackle COVID variants

James E. Voss

Camels and llamas make antibodies that bind to targets using small, 'nanobody' protein domains. Mice have now been engineered to make nanobodies that might be more effective than conventional antibodies in treating COVID-19. **See p.278**

How might the emergence of SARS-CoV-2 variants affect efforts to control the COVID-19 pandemic? The threat posed by such variants is focusing attention on vaccination and therapeutic options to grapple with the evolving coronavirus. On page 278, Xu *et al.*[1] describe the development of a genetically engineered mouse that can generate antibodies similar to those produced by camelids (an animal grouping that includes camels and llamas). These antibodies recognize targets using a single, small protein domain called a nanobody, also known as a VHH domain. Vaccination of these mice using proteins based on the SARS-CoV-2 spike protein resulted in the generation of antiviral nanobodies. These nanobodies could be produced in formats that were highly effective against COVID-19 variants that are impervious to many conventional antibodies being developed as therapies.

Conventional antibodies such as those produced by humans and mice recognize antigens (protein fragments of disease-causing agents) by means of two variable domains (VH and VL), which are components of separate heavy- and light-chain proteins (Fig. 1). By contrast, camelids and cartilaginous fishes (such as sharks) can make heavy-chain-only antibodies that recognize antigens using single, variable VHH domains, or nanobodies. One advantage of nanobodies is their small size, which enables them to penetrate tissues and recognize epitopes (the region of an antigen to which an antibody binds) that are normally inaccessible to conventional antibodies.

Nanobodies are generally extremely stable and soluble, and their modular nature means they can be readily expressed alone or in a variety of formats: for example, fused to the human antibody Fc domain that boosts