

Food from urban agriculture has carbon footprint six times larger than conventional produce, study shows

January 22 2024



University of Michigan researchers evaluate an urban garden in Detroit. Credit: Dave Brenner, University of Michigan.

A new University of Michigan-led international study finds that fruits and vegetables grown in urban farms and gardens have a carbon

footprint that is, on average, six times greater than conventionally grown produce.

However, a few city-grown crops equaled or outperformed [conventional agriculture](#) under certain conditions. Tomatoes grown in the soil of open-air urban plots had a lower [carbon](#) intensity than tomatoes grown in conventional greenhouses, while the emissions difference between conventional and [urban agriculture](#) vanished for air-freighted crops like asparagus.

"The exceptions revealed by our study suggest that urban [agriculture](#) practitioners can reduce their [climate impacts](#) by cultivating crops that are typically greenhouse-grown or air-freighted, in addition to making changes in site design and management," said study co-lead author Jason Hawes, a doctoral student at U-M's School for Environment and Sustainability.

"Urban agriculture offers a variety of social, nutritional and place-based environmental benefits, which make it an appealing feature of future sustainable cities. This work shines light on ways to ensure that urban agriculture benefits the climate, as well as the people and places it serves."

Urban agriculture, the practice of farming within the confines of a city, is becoming increasingly popular worldwide and is touted as a way to make cities and urban food systems more sustainable. By some estimates, between 20% and 30% of the global urban population engages in some form of urban agriculture.

Despite strong evidence of the social and nutritional benefits of urban agriculture, its carbon footprint remains understudied. Most previously published studies have focused on [high-tech](#), energy-intensive forms of UA—such as [vertical farms](#) and rooftop greenhouses—even though the

vast majority of urban farms are decidedly low-tech: crops grown in soil on open-air plots.

The study, [published](#) in the journal *Nature Cities*, aimed to fill some of the knowledge gaps by comparing the carbon footprints of food produced at low-tech urban agriculture sites to conventional crops. It used data from 73 urban farms and gardens in five countries and is the largest published study to compare the carbon footprints of urban and conventional agriculture.

Three types of urban agriculture sites were analyzed: urban farms (professionally managed and focused on food production), individual gardens (small plots managed by single gardeners) and collective gardens (communal spaces managed by groups of gardeners).

For each site, the researchers calculated the climate-altering greenhouse gas emissions associated with on-farm materials and activities over the lifetime of the farm. The emissions, expressed in kilograms of carbon dioxide equivalents per serving of food, were then compared to foods raised by conventional methods.

On average, food produced through urban agriculture emitted 0.42 kilograms of carbon dioxide equivalents per serving, six times higher than the 0.07 kg CO₂e per serving of conventionally grown produce.

"By assessing actual inputs and outputs on urban agriculture sites, we were able to assign climate change impacts to each serving of produce," said study co-lead author Benjamin Goldstein, assistant professor at U-M's School for Environment and Sustainability. "This dataset reveals that urban agriculture has higher carbon emissions per serving of fruit or vegetable than conventional agriculture—with a few exceptions."

Joshua Newell, professor and co-director of the Center for Sustainable

Systems at SEAS, led the University of Michigan portion of the project. The U-M researchers formed an international team of collaborators from universities near the various food-growing sites. Ten of those collaborators are co-authors of the *Nature Cities* study.

Farmers and gardeners at urban agriculture sites in France, Germany, Poland, the United Kingdom and the United States were recruited as citizen scientists and used daily diary entries to record inputs and harvests from their food-growing sites throughout the 2019 season.

Inputs to the urban agriculture sites fell into three main categories: infrastructure (such as the raised beds in which food is grown, or pathways between plots), supplies (including compost, fertilizer, weed-blocking fabric and gasoline for machinery), and irrigation water.

"Most of the climate impacts at urban farms are driven by the materials used to construct them—the infrastructure," Goldstein said. "These farms typically only operate for a few years or a decade, so the greenhouse gases used to produce those materials are not used effectively. Conventional agriculture, on the other hand, is very efficient and hard to compete with."

For example, conventional farms often grow a single crop with the help of pesticides and fertilizers, resulting in larger harvests and a reduced carbon footprint when compared to [urban farms](#), he said.

The researchers identified three best practices crucial to making low-tech urban agriculture more carbon-competitive with conventional agriculture:

- Extend infrastructure lifetimes. Extend the lifetime of UA materials and structures such as raised beds, composting infrastructure and sheds. A raised bed used for five years will

have approximately four times the environmental impact, per serving of food, as a raised bed used for 20 years.

- Use urban wastes as UA inputs. Conserve carbon by engaging in "urban symbiosis," which includes giving a second life to used materials, such as construction debris and demolition waste, that are unsuitable for new construction but potentially useful for UA. The most well-known symbiotic relationship between cities and UA is composting. The category also includes using rainwater and recycled gray water for irrigation.
- Generate high levels of social benefits. In a survey conducted for the study, UA farmers and gardeners overwhelmingly reported improved mental health, diet and social networks. While increasing these "nonfood outputs" of UA does not reduce its [carbon footprint](#), "growing spaces which maximize social benefits can outcompete conventional agriculture when UA benefits are considered holistically," according to the study authors.

Co-authors of the paper are from McGill University in Canada, University Paris-Saclay and the Agroecology and Environmental Research Unit in France, the University of Kent in the United Kingdom, ILS Research in Germany, City University of New York and Adam Mickiewicz University in Poland.

More information: Comparing the carbon footprints of urban and conventional agriculture, *Nature Cities* (2024). [DOI: 10.1038/s44284-023-00023-3](#).
www.nature.com/articles/s44284-023-00023-3

Provided by University of Michigan

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