Research outlines the interconnected benefits of urban agriculture

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From a vacant plot in a blighted neighborhood springs neatly combed rows of plants put in by the neighbors. They meticulously care for this small piece of land and among the drab looking buildings sprouts a patch of green. Cultivating the land may have started as a way to unite a neighborhood; to give pride to place, or it might be the project of a local high school to teach land stewardship.

The urban agriculture phenomenon has grown over the years for many reasons, each specific to the plot of land or rooftop it covers. While most of the benefits from these efforts seem to be limited and very local, when taken collectively there is a significant environmental impact that results from them.

Now a team of researchers led by Arizona State University and Google has assessed the value of urban agriculture and quantified its benefits at global scale. They report their findings in "A Global Geospatial Ecosystems Services Estimate of Urban Agriculture," in the current issue of *Earth's Future*.

"For the first time, we have a data-driven approach that quantifies the ecosystem benefits from urban agriculture," said Matei Georgescu, an ASU associate professor of geographical sciences and urban planning and corresponding author of the paper. "Our estimates of ecosystem services show potential for millions of tons of food production, thousands of tons of nitrogen sequestration, billions of kilowatt hours of energy savings and billions of cubic meters of avoided storm runoff

from agriculture in urban areas."

The researchers analyzed global population, urban, meteorological, terrain, and Food and Agricultural Organization (FAO) datasets in Google Earth Engine to come to their global scale estimates. They then aggregated them by country.

Overall, the researchers estimated the annual value of four ecosystem services provided by existing vegetation in urban areas to be on the order of $33 billion. In this scenario, they projected an annual food production of 100 to 180 million tons, energy savings of 14 to 15 billion kilowatt hours (insulation properties provided by soil on roofs), nitrogen sequestration between 100,000 to 170,000 tons and avoided storm runoff of 45 to 57 billion cubic meters annually.

With intense urban agriculture implementation, the researchers estimate the overall annual worth of urban agriculture could be as much as $80 to $160 billion. Importantly, urban agriculture could help feed a world that may face future challenges in industrial agriculture as a result of climate change.

"We've known there are benefits to having these small plots of land in our cities, but we found that the benefits extend well beyond having fresh food in the hands of those who will consume it," explained lead author Nicholas Clinton of Google, Inc.

"By integrating across elements that comprise the food-energy-water nexus, our work characterizes the heterogeneous nature of ecosystem services. It is a benchmark global scale assessment," added Georgescu, who also is a senior scientist in the Julie Ann Wrigley Global Institute of Sustainability at ASU.

In addition to Georgescu and Clinton, co-authors of the paper are Albie

Miles of the University of Hawaii; Peng Gong of Tsinghua University, Beijing; ASU graduate students Michelle Stuhlmacher, Nazli Uludere and Melissa Wagner; and Chris Herwig of Google.

Urban agriculture's full effect

"The most obvious benefit of urban agriculture is that it improves access to healthy foods," said co-author Michelle Stuhlmacher. "In addition to considering yield, our analysis evaluates the potential ecosystem services - such as urban nitrogen fixation, pollination, biological control of pests, control of damaging storm water runoff and energy conservation - that result from urban agriculture."

The work, the researchers say, provides more than an accounting of the effect of urban agriculture in one scenario. It can be used as a tool for future assessments of the changing urban agriculture landscape to better understand tradeoffs between urban design strategies.

"The value of this approach to the global community - research, governmental organizations, political groups - is that it provides local stakeholders with a quantitative framework that they themselves can use. For example, they can assess local implications of varying urban agriculture deployment scenarios based on current or projected urban extent, current or projected building height and facades, different yields, etc., that are all specific to the location under consideration," explained Clinton.

"The global estimates that we provide are useful because they provide a benchmark for other researchers but the societal benefits extend well beyond that because of the implementation of Google's Earth Engine platform," added Georgescu. "Anyone on the planet who wants to know whether and how much urban agriculture can provide for their locality can now do so using open data and code provided with the paper."

Looking at the future of urban agriculture, Clinton said countries that have the most incentives to encourage it share two primary characteristics - sufficient urban area, and a national-scale mixture of crops that lends itself to urban cultivation.

"Relatively temperate, developed or developing countries with the right mix of crops are expected to have the greatest incentives for urban agriculture," he said. "These would include China, Japan, Germany and the U.S."

Seeing the whole picture

"Analysis of the food-energy-water nexus sometimes leaves the impression that benefits are concentrated in one place and costs in another," said Tom Torgersen, program director for the National Science Foundation's (NSF) Water, Sustainability and Climate program, which supported the research. "But that's not always the case. Urban agriculture, for example, is an underdeveloped industry that could produce food, sequester urban nitrogen, generate energy savings, help moderate the urban climate and reduce storm water runoff, as well as provide more nutritious foods."

Provided by Arizona State University