Thirsty Chinese Cities Getting Drier As Skyscrapers Rise

By Christina Larson

It might seem like a cruel irony: While the growth of cities worldwide requires more water resources, urban growth itself may be a factor in creating a drier, or different, regional climate.

Take China's Pearl River Delta region, which in recent years has gone from being a regional backwater to being the center of the global manufacturing universe. Three decades ago, this area at the southern tip of Guangdong province, where the river spills into the South China Sea, was a relatively quiet spot, where farmers waved off mosquitoes buzzing in capacious rice paddies. Today the region, strategically situated just north of Hong Kong, is the industrial hub of the world's most prolific manufacturing nation—home to some 50 million people and thousands of factories churning out toothbrushes, toys, computer parts and just about everything else that can be packed in shrink-wrap and shipped

around the world. The region's new soundtrack is a constant whir of factory machinery, loading dock whistles and construction crews building ever more roads and apartment blocks on the outskirts of town.

In Shenzhen, one of its busiest port regions, nearly everyone is from somewhere else—from other cities in China, from foreign companies and, especially, from the countryside. More than 95 percent of the workers on the assembly line are estimated to have flocked from nearby villages, a familiar pattern across China, where millions of people each year move to the nation's fast-growing cities. As they settle into factory dormitories and new high-rises, then turn on the faucet for cooking, showering and laundry, demand for water rises. Yet in precisely the same years that skyscrapers have soared and the sky has thickened with smog, rainfall in the region has declined. Why?

To untangle the connection, a team of interdisciplinary researchers compiled readings from 16 meteorological stations in the region, which they compared with maps charting urban growth, derived from NASA satellite data. Their study, published last year in the *Journal of Climate*, found that between 1988 and 1996, urban land cover in the Pearl River Delta increased 300 percent—the equivalent of paving an area the size of Rhode Island in less than a decade. Meanwhile, during the dry winter months (the subtropical region's summer is influenced by the Asian monsoon cycle), rainfall declined. The team created a statistical model linking urban growth with winter rainfall; they found that each percentage point in growth correlated with a decrease of 2.44 millimeters in rainfall.

A growing body of research, conducted in China and elsewhere, now shows that the way a city grows can have the effect of holding an umbrella, or in some cases turning on the sprinklers, over a city. Though debate remains over which factors (land cover conversion, urban topography and pollution) are most significant, scientists agree on the underlying principle: not only are cities impacted by their regional climate, they also shape it.

"Cities are modifying their own climates," says Karen Seto, associate professor in the urban environment at F&ES and a co-author of the study. "If you want rain, you need to start thinking about the way a city grows."

It might seem as though Shenzhen and other fast-growing urban areas—from Dubai, to Bangalore, to Lagos—sprung into being overnight. But to understand how cities influence climate, it's helpful to look closely at the process of converting fields to factories.

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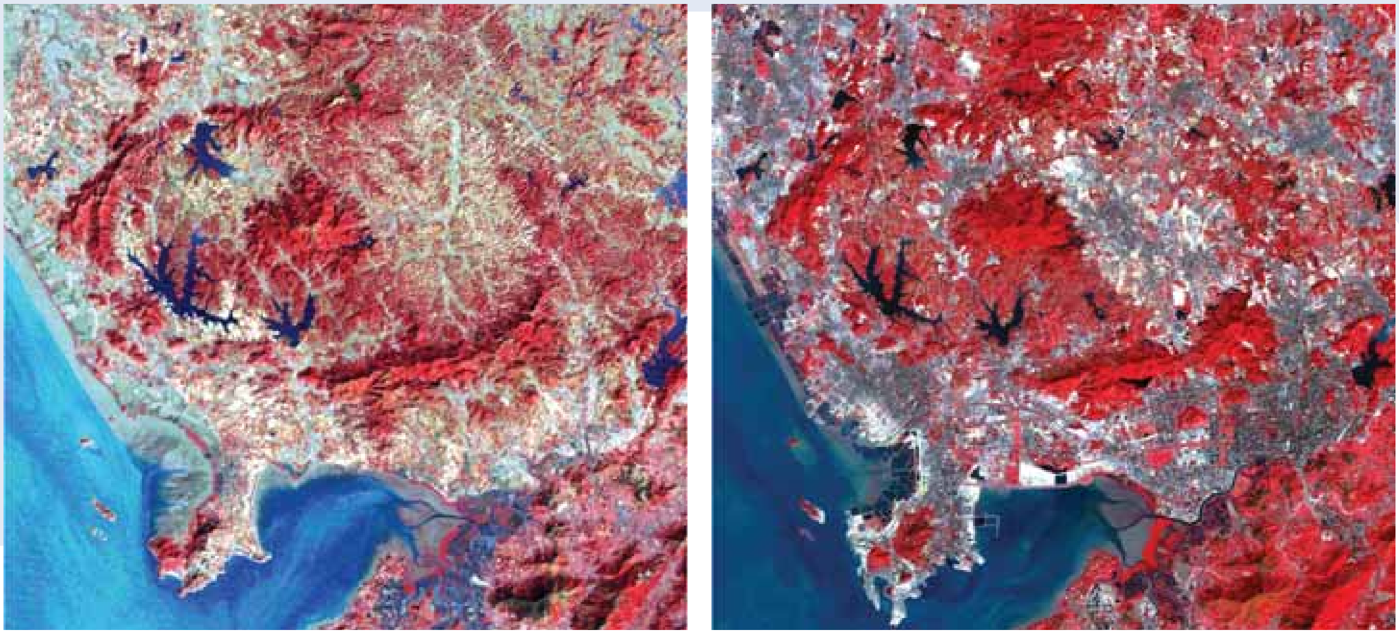
Seto's research focuses on what scientists call "land cover conversion" or, what Joni Mitchell crooned, to "put up a parking

The Shenzhen city skyline



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Left, an image from the NASA Landsat satellite shows areas of vegetation (red) and fallow agricultural regions (white) in Shenzhen in 1973. Right, 28 years later, new urban regions (dark blue grids) and new urban development (bright white) proliferate.

lot." When a forest, prairie or wetland—or even a sand dune or arctic tundra—is replaced by asphalt and concrete, the ground's ability to absorb and retain moisture changes. Simply put, water seeps into soil (to different degrees depending on the soil) but washes off pavement. At the same time, sidewalks and other urban surfaces absorb sunlight, whereas natural foliage reflects it. This contributes to the familiar "urban heat island" effect, where temperatures in a city exceed those in the nearby countryside. Of course, not all newly built parking lots have the same effect. "The types of landscapes that were converted [to pavement] have an impact," she says. "What areas were lost? And what was that land previously? Was that land formerly devoted to agriculture, or forest, or desert? Did the trees and ground absorb a lot of water, or not?" she asks, noting that planners do have a choice where to locate new interstates and residential communities.

Marshall Shepherd, a professor of atmospheric sciences at the University of Georgia and an editor of the *Journal of Applied Meteorology and Climatology*, approaches the question from a background in meteorology. He has studied rainfall patterns near Atlanta, Ga.—a region recently pinched by water shortages—and focused, among other things, on how air circulates around urban terrain. "Visualize wind blowing straight over wheat fields in Kansas," he says. "Now imagine low-level winds blowing around city skyscrapers. Because of the structure of buildings in a city, the air is more turbulent." The combination of turbulent air, elevated temperatures and other factors can trigger more dramatic weather patterns, including more frequent and abrupt rainstorms over and downwind of cities. "What appear to be random thunderstorms around cities aren't so random at all," he says.

In the case of China's Pearl River Delta, where dwindling precipitation is the overarching trend, an additional factor may be at work: pollution. Rapid development has brought billowing smog, also known as the presence of airborne "aerosols," which affects the way clouds "seed" to form rain. Some aerosols are necessary to trigger showers, but an oversaturation of particles impedes the formation of raindrops. Daniel Rosenfeld, a professor at the Institute of Earth Sciences at Hebrew University in Jerusalem, is the lead author of a paper on pollution and precipitation that was published in the journal *Science* in September. Over a 50-year period, his data show that rainfall over the mountains near Xi'an, a congested city in central China, has decreased 20 percent. "This is a serious problem for areas where water availability is scarce," he says, noting that many of today's fastest-growing regions, including much of the Middle East, northern China and Africa, are especially susceptible.

While scientists focus on different aspects of the feedback loop between cities and climate, they agree that planners have some control over the outcomes. Rosenfeld urges tighter emissions controls; new research "should act as a red light," or warning, to all of those responsible for controlling the amounts of pollution we release into the atmosphere." Shepherd recommends evaluating how urban areas influence rainfall when deciding where to build reservoirs.

Seto offers more out-of-the-box proposals that are not so much refinements of existing planning practices as they are new ways to envision a metropolis. Today's cities, seen from an airplane, she notes, are shaped like a dinner plate or, perhaps, a sprawling amoeba. As such, the urban area is a contiguous paved region that extends outward from a defined center. But a new city—in China and elsewhere, new cities are being built virtually from scratch—could be mapped as a series of concentric circles or as a checkerboard, alternating office parks with forest parks. This could augment or disperse the heat island effect, the ground's ability to retain moisture and the impact of pollution. Or, a city could be designed with several small centers—think of a constellation of mini-downtowns—with residential areas, business districts and public transportation planned accordingly. "If you have to lay down 1,000 square kilometers of urban development," she asks, "where are you going to put it?"

One of the remarkable things you notice if you travel around the world today is that older buildings—Chinese courtyards, Venetian canals, Dutch windmills, Iranian wind towers—all look different. But newer structures, with glass and steel exteriors and air-conditioned lobbies, all look relatively the same. At one time architecture was adapted for local topography and climate; today this is far less true.

The same pattern of regional adaptation once held true for urban planning writ large. Planners took advantage of resources at hand and sought particular fixes to distinct problems, mindful of each region's natural margin for error. "The ancient Greeks were masters of matching the buildings, squares and streets of the city to its topography," wrote MIT's Anne Whiston Spirn in her classic history of urban planning, *The Granite Garden*. "New York City owes the distinctive skyscraper skyline of Manhattan Island to the strength of the underlying bedrock and its proximity to the surface."

Now, as planners must account for the impact of urban growth on climate, it may be time to return to more site-specific approaches—not for nostalgic reasons but as a matter of common sense in mapping the future. "A century ago, people lost centuries of knowledge about how to adapt to climate when we began using technology to overcome natural barriers," says Roberto Sánchez-Rodríguez, a professor of environmental sciences at the University of California, Riverside. "But not every city has to strive to look like Los Angeles or New York today."

For the last decade, Sánchez-Rodríguez has been at the forefront of efforts to bring science to bear on real-world decision-making. Among other projects, he has advised planners in Tijuana, Mexico, which a decade ago was devastated by flooding caused by El Niño. "A lot of knowledge has already been generated about environmental planning and how cities affect climate," he says, "and yet so little of this knowledge is used by planners on a daily basis." The collaboration has given him a greater appreciation for the concerns of city officials, helping him to tailor his advice. City planners, who must consider the short-term needs of their constituents, are in general not versed in ecology and climate science. Likewise, ecologists largely are not trained in what issues city planners must confront. "To work together successfully, you have to be very strategic in how you use these people's time, how to present conclusions," he says. "There needs to be someone who can act as an interface between the two domains of knowledge."

Urban density, and the rising global middle class moving to swelling cities, has lately gotten a bad rap—the "crowded" part of Thomas Friedman's book title warning that the Earth is becoming *Hot, Flat, and Crowded*. But because Shenzhen and Manhattan aren't likely to be torn down anytime soon, it may be helpful to rejig-

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Looking south toward Hong Kong across the Sham Chun River. The wetlands on the far side of the river are in Hong Kong. The city on the near side of the river is Shenzhen, which was transformed from a small fishing village into a metropolis in less than 30 years.

ger our thinking. “Urban areas should be where environmental policy starts, not where it ends,” says Margaret O'Mara, a visiting assistant professor of urban history at the University of Washington. “Scientists and environmental planners need to consider landscapes like Rio de Janeiro, not only Amazon rainforests.”

She points out that there may be opportunities in inevitable urban growth, including the possibility of scaling up green-friendly technologies that urban density allows. It will be a simpler matter, for instance, to install new units designed to calibrate household energy usage, or recycle wastewater, in a towering Beijing apartment complex than in 2,000 single-family homes. “We need to think of cities not only as environmental problems, but as a component of environmental solutions; they have to be,” says O'Mara.

The fast-rising skylines in regions like the Pearl River Delta—and the recognition of the impact they have on climate—mean neither a death sentence nor deliverance, but must be seen as a force, like gravity, that scientists and planners should find a way to work with wisely. Or, as *The Granite Garden* put it nearly 25 years ago: “Civilizations and governments rise and fall; traditions, values, and policies change; but the natural environment of each city remains an enduring framework within which the human community builds.” ■