



Shenzhen Explores the Benefits of Designing with Nature

By Matt Jenkins

AT THE HEART OF Shenzhen, China, the city's massive, wavelike Civic Center stands surrounded by a mind-boggling panoply of futuristic skyscrapers. Forty years ago, this area was home to just a few scattered fishing villages on the Pearl River Delta. Today, approximately 24 million people live within Shenzhen's greater urban area. In China, Shenzhen has come to stand for something much bigger than itself.

On a hill downtown, a statue of revered former Chinese leader Deng Xiaoping striding purposefully toward the Civic Center helps explain why. Deng took control of China in 1978, after the death of Mao Zedong. The transition marked an end to decades of isolation from the outside world that had been dominated by command-and-control planning. Deng turned the country in a radically new direction, launching the Reform and Opening program to loosen the strictures that had bound the country for so long. And Shenzhen led the way into the future.

Deng granted the newly created city a license to operate as an economic super-laboratory, a place to explore the promise of the free-market economy. It was a sink-or-swim proposition, and in the years since, Shenzhen has succeeded wildly.

Yet Shenzhen's spectacular growth has come at a cost. As the area transcended its naturally marshy environment and turned from literal backwater into economic powerhouse, much of its land cover succumbed to blacktop and concrete. During storms, the abundance of paved-over land caused widespread flooding, as well as large-scale releases of urban pollution into nearby Shenzhen Bay and the Pearl River Delta.

Shenzhen is hardly alone in facing these problems. But continuing in its role as a national hotspot of innovation, it has become a unique laboratory for thinking about how to build livable cities throughout China and beyond.

Left: Lotus Park, Shenzhen, China. Credit: LZJ via iStock.
Right: A statue of former Chinese leader Deng Xiaoping, who orchestrated Shenzhen's economic boom, overlooks the downtown area. Credit: Matt Jenkins.



SIX MILES NORTHEAST of Deng's statue, Professor Huapeng Qin stands on a rooftop, surrounded by sensors measuring wind speed, temperature, and evaporation. He is looking for solutions. Based at the local satellite campus of Peking University, Qin is at the forefront of an effort to turn Shenzhen into a "sponge city." Using techniques that mimic nature, sponge cities can catch, clean, and store rain, which reduces the risk of flooding and keeps local drainage and water treatment systems from being overwhelmed.

Although it takes its cue from centuries-old thinking, the modern concept of the sponge city began forming in Europe, Australia, and the United States in the early to mid-1990s. The movement was a reaction to two common phenomena in urban development. First, just as happened in Shenzhen, most rapidly developing cities pave over huge amounts of land, eliminating a significant amount of natural forest cover, filling in lakes and wetlands, and severely disrupting the natural water cycle. Second, the traditional approach to urban stormwater management has focused on moving as much

rain as possible off the land as quickly as possible, not capturing it for reuse.

Sponge city thinking marks a significant shift away from traditional "gray infrastructure"—think concrete pipes and dams—to "green," or natural, infrastructure such as rain gardens and forests. The sponge city approach aims to restore some of those natural functions by allowing urban areas to transform the menace of stormwater into a boon: extra water for dry times. Sponge city techniques therefore have multiple benefits. They can help soften the impact of flooding, improve both water quality and water supply, and help fix environmental problems.

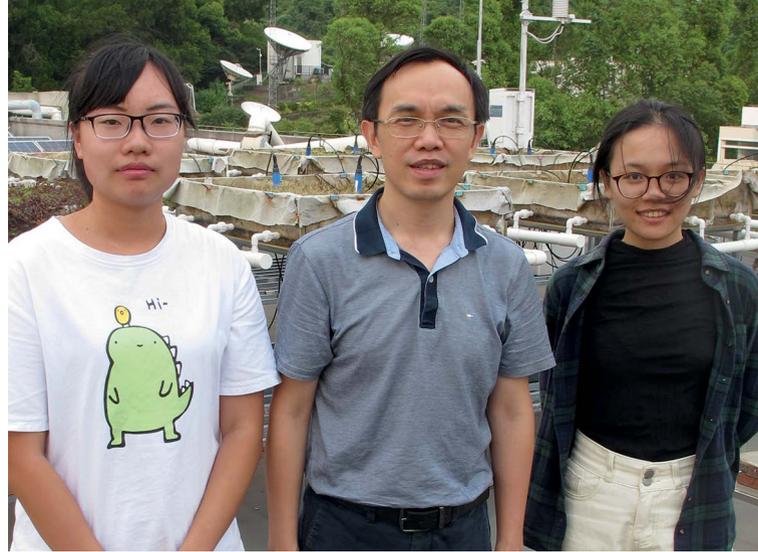
The sponge city concept is a relatively new arrival in China, but it has gained traction here fast. That's partly due to the country's tremendous growth over the past several decades, which has drastically altered the landscape.

It's also due to a new mindset about the risks of pursuing prosperity at all costs. In July 2012, a huge rainstorm in Beijing led to flooding that caused 79 deaths and an estimated \$1.7 billion in damage. The incident galvanized national leaders.

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Graphic: Jiang Rong, designer/www.gochengdu.cn, Chengdu Daily.



Rooftop experiments at the local satellite campus of Peking University are providing researchers in Shenzhen with data about how natural systems can help create a “sponge city.” At right, Professor Huapeng Qin (center) and students. Credit: Matt Jenkins.

In late 2013, President Xi Jinping officially endorsed the sponge city concept, and the following year the Ministry of Housing and Urban-Rural Development issued a set of technical guidelines aimed at ensuring that 70 percent of surface runoff be captured in place. The central government also launched what would ultimately become a 30-city pilot program to prove out the concept.

Shenzhen is one of the pilot cities, and it's no coincidence that the sponge city concept has gotten more traction here than anywhere else in China. From financial policy to the tech sector, “Shenzhen has always been very willing to borrow ideas from outside China and try them out,” says Qin. The sponge city idea is no different. “First it was just scattered pilot projects, but now the concept is being incorporated into Shenzhen’s master plan.”

In this case, Qin and his students are trying to learn more about techniques for creating green roofs, using plants grown in a medium of lightweight engineered soil to catch rain where it falls, slowly metering it out afterward. Such techniques are “very similar to natural systems,” Qin says. “Natural systems look very simple, but the processes are very complex. So we’re trying to understand those processes.”

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A sponge city has several interchangeable building blocks. At a large scale, protecting or restoring forests and natural ground cover helps give water a chance to sink in. At smaller scales, there are several options. Permeable pavement can be used on roadways, sidewalks, and pathways to allow water to infiltrate the ground, rather than wash off into the local stormwater system. Retention ponds and constructed wetlands help catch and filter water, allowing it to slowly percolate into the local water table. So-called rain gardens perform a similar function at a smaller scale, and can easily be incorporated into neighborhood green space or even homes. Green roofs catch and filter rain, along the way watering plants that, Qin says, can help reduce surface temperature by up to nine degrees Celsius.

In 2018, SuperTyphoon Mangkhut blew down half the trees in the city. With climate change expected to increase the intensity and frequency of such extreme weather events, Shenzhen is prioritizing resilience projects and investments. Credit: REUTERS/Jason Lee.



Shenzhen's embrace of the sponge city concept has been driven by its spirit of innovation, but also by the fact that the effects of an unbalanced water cycle are often plain to see here. Heavy rains can overwhelm local water treatment plants, sending nutrient-laden wastewater directly into Shenzhen Bay and the Pearl River Delta, causing large algae blooms.

People are also worried about the impacts of climate change. In what may have been a taste of what's to come, Super Typhoon Mangkhut, which hit in 2018, blew down half the trees in the city. Qin says computer models predict that with climate change, total annual rainfall will be comparable with current levels, but that precipitation will be much "flashier": extreme events like short-duration, high-intensity rainstorms will become more common.

This area has absorbed an influx of millions of people over the past few decades, largely by turning its back on the water that was once its defining characteristic. Now, Qin and others across the city are committed to finding new ways forward. The lessons they are learning and applying here are the first steps in what may soon be a sweeping transformation—not only in the city around them, but also throughout China.

"Sponge cities are just one example of how China is taking up the sustainability agenda," says Zhi Liu, director of the Peking University-Lincoln Institute Center for Urban Development and Land Policy. Acknowledging the urgency of building climate resilience in the face of extreme weather and other challenges, he says, "This is not something China wants to do in order to look good. It comes out of necessity."

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UNTIL TWO YEARS AGO, the 105-acre patch of green space now known as Honey Lake Park was an abandoned agricultural experiment station. The dominant features of the park, which sits not far from downtown Shenzhen, were a neglected grove of lychee trees and two fish ponds. Today, walking into the park feels like walking into an architectural rendering. Yet in the company of an expert, it quickly becomes clear that the park is not only aesthetically pleasing but also eminently functional.

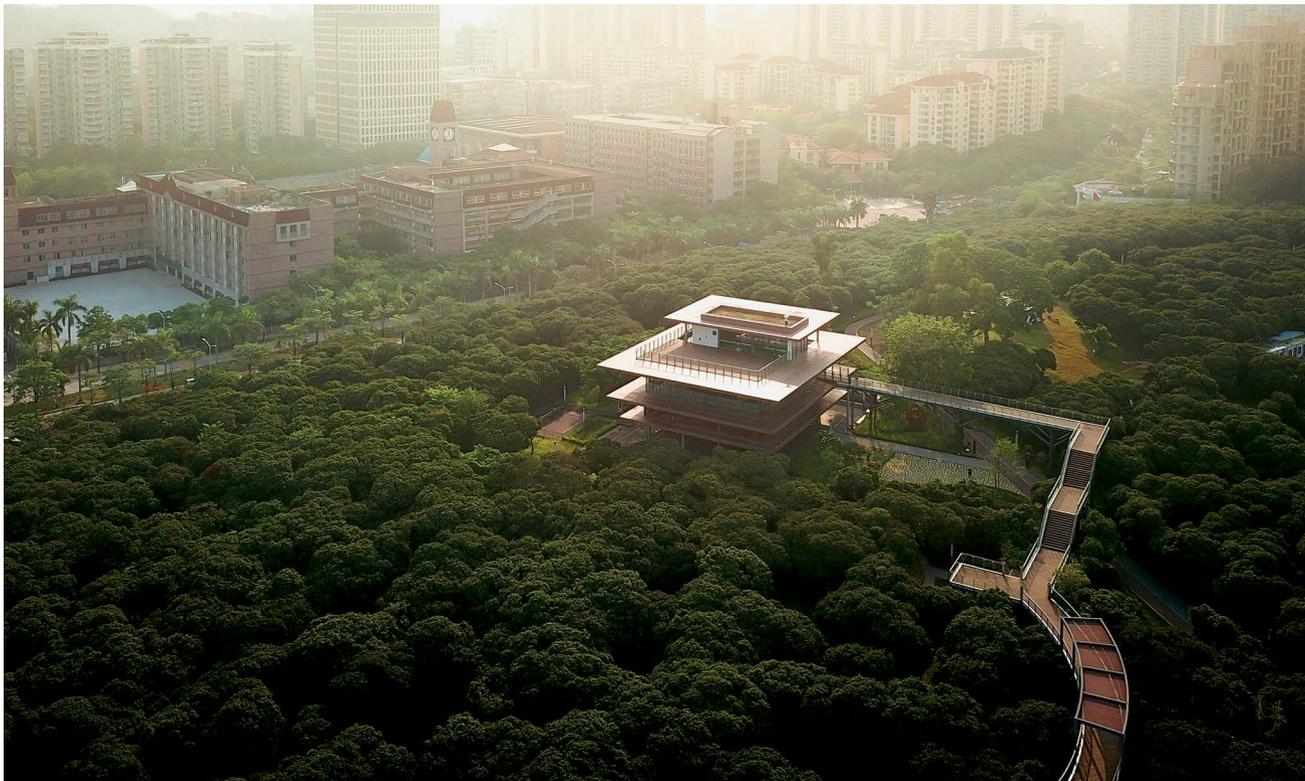
Yaqi Shi, a technical director with the Shenzhen-based Techand Ecology & Environment company, helped design the park. The paths that we are walking on, she explains, are constructed of permeable pavement, and the park's rolling contours are hugged by small swales that help slow and catch runoff. A series of ponds in the middle of the park is sown with native rushes that Techand raised in its own nursery. Signs throughout the park point out the various sponge city elements and explain how they work.

Shi, whose professional focus is ecological restoration, speaks with the brisk economy of an engineer. But the delight in her voice is evident when she speaks of the evolution of this project. "The park turned out to have a really user-friendly feeling," she says.

As we walk, Shi points out a library, a children's play center, and the local wedding registration office, all within the boundaries of the park. A pavilion at the edge of a pond provides an ideal backdrop for cooing newlyweds to pose for portraits.

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Xiangmi Park, also known as Honey Lake Park, is a former agricultural research area that was redesigned for community use. Bioswales, permeable pavement, and other elements allow it to double as a stormwater management tool. Credit: Vlad Feoktistov.





Sponge city elements in the new suburb of Guangming include, from left to right: a green roof on the water treatment plant; planted medians at a local foreign languages school; and permeable roads and parking lots. Credit: Matt Jenkins.

A walk with Shi also makes it clear that much of the technology underlying sponge cities is, in fact, surprisingly low-tech. The real art of the approach lies not so much in being technically clever, but simply in being thoughtful. Shi explains, for example, that much of Shenzhen is underlain by a layer of clay, which prevents water from infiltrating very far into the ground. To make permeable pavements work means hiring contractors to dig out the clay, sometimes to a depth of six feet, and replace it with gravel and more permeable soil.

Nonetheless, once you get a sense of what to look for, Shenzhen suddenly starts to seem like an entirely different city. On the northwest side, a relatively new suburb called Guangming has wholeheartedly embraced the sponge city concept. The suburb's recently built New City Park is a model of retaining stormwater in place,

from a water-absorbing latticework in the parking lot to permeable pavement on the paths, to swales and miniature, artificial wetlands designed to slow and soak up water. The massive adjacent public sports center has a green roof and a vast expanse of permeable bricks and pavement. The anaerobic digesters at the Guangming water treatment plant are covered by an enormous green roof; there's another at the foreign languages school. Over at the high-speed rail station, where bullet trains thunder in from Hong Kong, the streets out front are made of permeable pavement.

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BACK DOWNTOWN, The Nature Conservancy's Xin Yu shows me another side of the sponge city revolution. We meet in the lobby of a Hilton hotel just a mile from the Civic Center and the nearby hilltop statue of Deng Xiaoping. After quick pleasantries, Yu takes me out a back service door. Compared to the airy elegance of the hotel lobby, it feels as if we've passed through a portal into another dimension.

We find ourselves in the narrow alleyways of an area known as Gangxia, a former farming village that Shenzhen gradually engulfed, and that subsequently metamorphosed into a crowded warren of five- and six-story apartment buildings. Gangxia and other so-called urban villages are a phenomenon found in practically every Chinese city, and are testament to the frenetic pace at which the country has urbanized over the past 40 years. They are often gritty, but they're an important haven for low-income migrants who otherwise wouldn't be able to afford the high rents of most urban areas. They typically come to form largely self-contained communities with small businesses that cater to all the needs of their residents, from vegetable sellers to modest karaoke parlors.

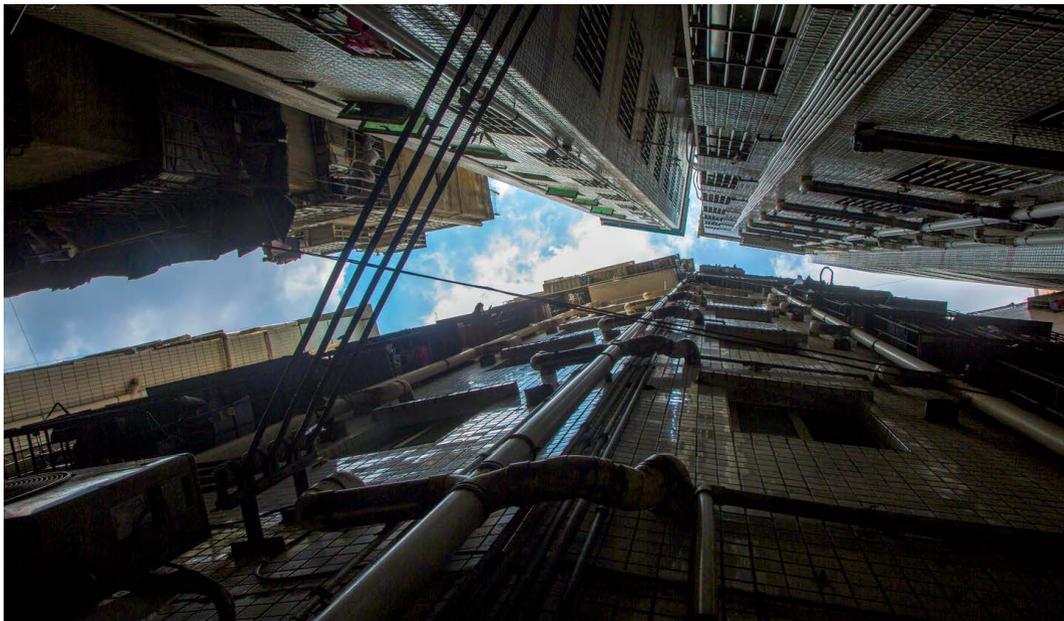
Yu nimbly leads me through the narrow back alleys, and it quickly becomes clear that

"village" is a misnomer. The densely packed buildings here are known as "handshake apartments," built so close together that residents of neighboring buildings can reach through their windows to shake each other's hands. Restaurants are preparing for the lunchtime rush, and the air is filled with the staccato rhythm of vegetables being chopped. Business here, Yu says, is vibrant and extremely competitive: "These alleyways really are alive."

Gangxia's original residents didn't technically own the land upon which their houses were built, but they did have rights to use that land. As Shenzhen grew during the 1980s and 1990s, they replaced their own houses with apartment buildings, often keeping one floor for themselves and renting out the rest, to take advantage of rising rents.

The Nature Conservancy (TNC) has played an important role in showing that it's possible to incorporate sponge thinking even in the heart of the urban jungle. "There are a lot of ideas, but the government or companies can't necessarily try things out," Yu says. "NGOs can. We can figure out what ideas work and take them back to the government to promote more broadly." (Due to the political climate in China, Shenzhen officials were not in a position to meet for this story.)

The "handshake apartments" of Shenzhen's urban village of Gangxia, so close residents can nearly touch each other, are the site of an experimental green roof project. Credit: Yang Xu.



Yu opens a gate to an otherwise nondescript apartment building and climbs several flights of stairs to the roof—and an improbable flourish of lush greenery. A multilevel lattice framework groans with plants of every description. This green roof, Yu says, catches over 65 percent of the rain that lands on it.

Showing what's possible hasn't always been easy. When TNC first started this green roof project, Yu and his colleagues had to contend with angry neighbors who thought they were illegally adding another story to the building.

"People kept calling different government departments: the police, or the construction bureau, or the city administration bureau," Yu says. That led to several visits from local code enforcement teams, who used ladders to gain access to the building and a cutting torch to try to dismantle the garden's supporting framework. "They kept asking for approval documents," Yu says, and laughs. "But those don't really exist. We had nowhere to go to get them."

With time, however, efforts like this have spread broader awareness of the sponge city concept. "Public consultation—how you get the public to understand what this is about—is very important," says Liu of the Lincoln Institute. "I think NGOs can play a big role in this area, and TNC is a trusted international NGO in China."

TNC's work has also gained the backing of officials and business leaders. Yu was invited to be a member of the technical committee for Shenzhen's municipal sponge city program. When corporate tech giant Tencent decided to incorporate sponge city techniques in its iconic new headquarters in Shenzhen, the company turned to TNC for ideas. And Tencent's founder, chairman, and CEO, Pony Ma, is not only a member of TNC's board of directors for China, but also a delegate to the powerful National People's Congress. There, he has made sponge cities part of a broader personal platform of advocating for nature-based solutions. Ma has also inspired fellow business leaders to commit to—and invest in—ensuring that their businesses meet sponge city standards in Shenzhen.

The Nature Conservancy's green roof project in the urban village of Gangxia catches over 65 percent of the rain that falls on it. Credit: John Siu.



SOME 1,200 MILES NORTH of Shenzhen, in Beijing, Kongjian Yu's office seems to sprout a plant from every spot where he hasn't managed to stuff a book. The *Where the Wild Things Are* feel is entirely consistent with Yu's personality, which is driven by a kind of restless energy. It's hard to imagine him sitting in one spot for five minutes.

Yu, who was born in a small farming village in coastal Zhejiang Province, went abroad and earned a Doctor of Design degree at Harvard, in 1995. Upon returning to China, he was deeply disheartened by the direction that development had taken. "When I came back, I was shocked by the scale of urbanization," he says. "I was amazed by how this process ignored all our natural and cultural heritage, filling in wetlands, destroying the rivers, cutting down the trees, and wiping out all these old buildings."

Yu was hired as an urban planning and landscape architecture professor at Peking University. In the staid world of Chinese development theory, he has made his name as something of a flower child—and a gadfly. Yu became a prodigious author and tireless lecturer, and

turned out a series of open letters to China's top leaders. He called for China to abandon its mania for building monumental public squares; advocated for a revival of the traditional Chinese approaches to farming, water management, and settlement; and suggested that the money allocated for annual National Day parades be better spent building good parks.

Above all else, Yu railed against China's obsession with concrete, a repudiation of decades of thinking here. "The philosophy in China, in Mao's era, was that humans can beat nature," Yu says. "And that caused a lot of disasters for us."

That attitude only accelerated in the years after Mao's death, and by the early 21st century, China was setting records for the amount of concrete it was pouring each year. Global systems demystification guru Vaclav Smil has estimated that China used more cement in just three years, 2011 to 2013, than the United States did in the entire 20th century.

While Yu has encountered opposition to his outspokenness, he has also tapped into a growing demand for this new kind of systems thinking. Today, in addition to serving as dean of Peking University's College of Architecture and Landscape, he heads a 600-person landscape architecture and urbanism consultancy called Turenscape. Municipal governments across China routinely seek the company out for help. He also wrote the definitive two-volume practitioners' guidebook on sponge cities in China, and contributed to the Lincoln Institute of Land Policy book *Nature and Cities*.

A core tenet of Yu's overall approach is a concept he calls *fan guihua*. The concept is frequently translated as "negative planning," but might be more accurately rendered as "inverse planning." It's essentially a counter to the type of development that has shaped China's growth for so long.

"You plan what's *not* built," Yu explains. "You plan what should be protected."



In the course of his work, Yu came to a surprising realization: the idea of living with water, rather than battling it, was a concept that had historically been very familiar.

This, obviously, is a fairly radical idea in contemporary China. Yet in the course of his work, Yu came to a surprising realization: the idea of living with water, rather than battling it, was a concept that had historically been very familiar.

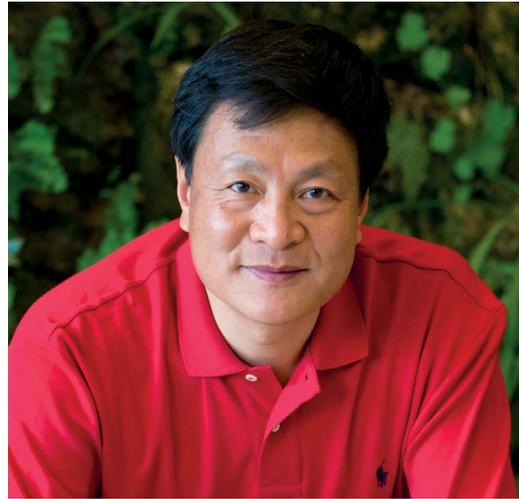
In central and southern coastal China, including the area where Shenzhen now stands, a distinctive method had evolved over centuries to catch rainfall and carefully manage it with earthen dikes to raise mulberries, silkworms, and fish, a sort of landscape-scale aquaponics system. And when Yu and his students looked deeper, they realized that sponge city-like concepts had been a fundamental principle of Chinese city planning for centuries. Traditionally, he says, many Chinese cities had the capacity to absorb two-thirds of local rainfall within their boundaries.

With this discovery, the idea of a different way of managing water—and the perils of a drastically altered hydrologic cycle—became a major theme of Yu’s work.

Nature, for its part, began putting an increasingly fine point on the issue.

During the 2012 flood in Beijing, “seventy-nine people were killed. Drowned. On the street,” Yu says. “In the capital, we drowned 79 people. How is that possible? We lost face. That immediately became a political issue.”

Yu wrote another letter to high-level leaders saying that adopting the sponge city approach and creating a resilient landscape might offer hope. As it happens, Xi Jinping had recently become the secretary general of the Communist Party and president of China.



Landscape architecture professor and practitioner Kongjian Yu. Credit: Courtesy of American Academy of Arts and Sciences.

After decades of the country struggling with notorious pollution and other environmental problems, Xi has staked his reputation on creating an “ecological civilization” in China. The exact contours of that concept are sometimes difficult to discern, but in broad outline it encompasses both a nationwide push for ecological sustainability and the creation of a green, uniquely Chinese alternative development model for the rest of the world. Both sponge city thinking and a more expansive embrace of low-impact development fall squarely within Xi’s larger aspirations.

“China’s in an environmental crisis. We have to do this,” Yu says. “When people can’t breathe, when the water is polluted—I think he’s very sensitive to those issues. I think he really wants to build his legacy on doing this.”

THE BIGGEST CHALLENGE to making sponge cities work on a broad scale has nothing to do with building rain gardens, installing permeable pavement, or placating neighbors. “Finance is a major issue,” says Liu.

Liu, who came to the Lincoln Institute after 18 years with the World Bank, is largely focused on governance and financing issues associated with land use in China. Taking the sponge city

concept to scale won't be easy, and he cites the challenges in Shenzhen as an example. Sponge city improvements in Shenzhen, which officially began in 2017, now cover 24 percent of the city's total surface area. The government has a goal of increasing that to 80 percent by 2030. But hitting that target will be a significant challenge.

The central government has pledged a total of \$5.8 billion (40 billion Chinese yuan) to incentivize Shenzhen and the 29 other pilot cities to invest in and carry out sponge city work. But it wants each of those places to bring at least 20 percent of its developed area up to the sponge city standard by the end of this year.

Liu says that bringing a square kilometer of already developed urban land up to the standard typically costs \$22 million to \$29 million (150 to 200 million CNY). The 30 pilot cities are each eligible for 400 to 600 million Chinese yuan per year from the central government for three years. That's enough to upgrade, at most, four square kilometers per year.

To meet—and actually exceed—the central government's 20 percent by 2020 target, Shenzhen brought about 235 square kilometers up to standard, at a cost that likely ran anywhere from \$5 billion to \$7 billion.

"Asking the municipal government to come up with that kind of money is not easy," Liu says. Shenzhen was able to pull it off because of its strong municipal budget and private commitments from the city's tech and manufacturing giants. But, he adds, "if you go to the interior cities where the municipal finance is very weak, it's very difficult." (See next page for an exploration of the potential role of green bonds in the sponge city financing mix.)

Liu points out that in the case of new development, cities can implement standards that will require developers to pay for improvements, a cost typically passed on to residents and firms. "If you look at the upfront costs for development, sponge cities are not a very expensive thing to do," Liu says. Retrofitting existing development, however, is a much bigger challenge.

"The toughest issue is that public finance is used to finance the public good, with very little opportunity for cost recovery," he continues. "That's really the toughest story about China. It's a matter of priority. The cities just have too much on their plate. So by the end of the day, very few cities can find enough money."

Sponge city infrastructure is "just like a streetlight," Liu says. "It's a shared public good, but nobody wants to pay for it."

IN TRUTH, the biggest challenge of turning the sponge city into reality may well be unraveling the financing mechanics. Yet the cost of not rising to the challenge may be higher than anyone fully appreciates.

"It's really like thinking about buying insurance," Liu says. "We are all facing uncertainties, but the trend of more intense storms is quite clear . . . The cost of inaction might not look that high today, but when we're faced with a catastrophic outcome in 10 or 20 years, we'll regret that we didn't spend the money earlier."

Even given those high stakes, the sponge city idea could ultimately be about even more. Back in Shenzhen, standing on the roof of the apartment building in Gangxia, TNC's Yu says sponge cities do a lot more than tame floods and save water for dry seasons.

"If you only talk about stormwater management or runoff control, the average person won't necessarily buy in, because they'll feel like it doesn't have any connection to them," he says. "But features like green rooftops are different. They can have a synergistic effect. They help absorb rainfall, but they also improve the neighborhood view, contribute to urban biodiversity, and create a green space that everybody can use." □

Matt Jenkins, who has previously worked as an editor for *Nature Conservancy* magazine, is a freelance writer who has contributed to *The New York Times*, *Smithsonian*, *Men's Journal*, and numerous other publications.