

Land Lines

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PKU–Lincoln Center’s
10th Anniversary

GIS-Assisted Mass Appraisal,
Shenzhen-Style

Sponge Cities, Panda Habitat,
and the Nature Conservancy

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As a private operating foundation whose origins date to 1946, the Lincoln Institute seeks to inform public dialogue and decisions about land policy through research, training, and effective communication. By bringing together scholars, practitioners, public officials, policy makers, journalists, and involved citizens, the Lincoln Institute integrates theory and practice and provides a forum for multidisciplinary perspectives on public policy concerning land, both in the United States and internationally.

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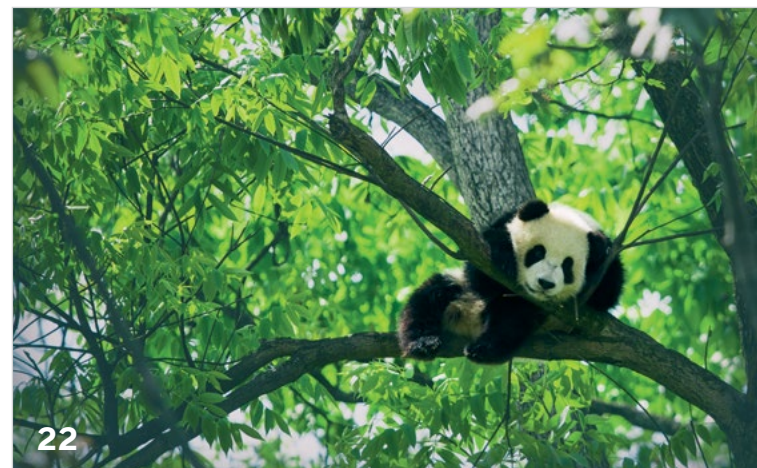
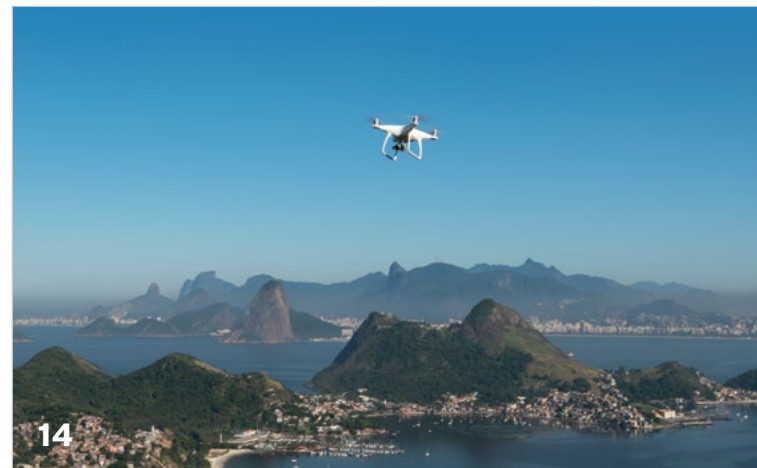
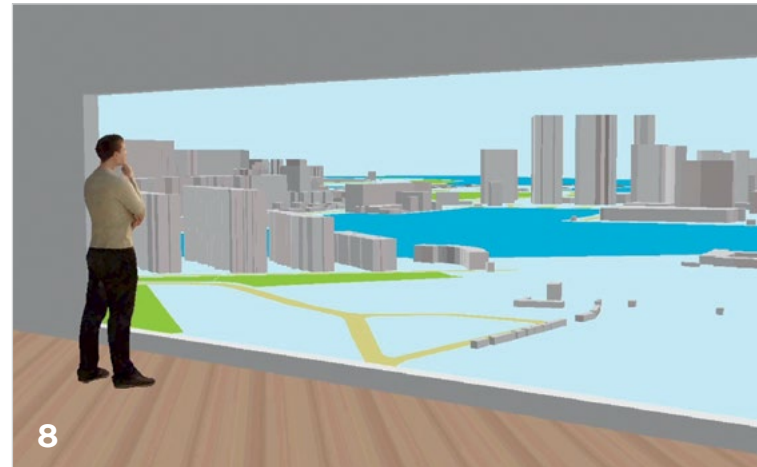
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Shenzhen city in China. Credit: pa_YON/ Getty Images



MESSAGE FROM THE PRESIDENT GEORGE W. McCARTHY

The Future of the PKU-Lincoln Center

ON OCTOBER 14, WE WILL CELEBRATE THE 10TH ANNIVERSARY OF THE PEKING UNIVERSITY-LINCOLN INSTITUTE CENTER FOR URBAN DEVELOPMENT AND LAND POLICY, MORE AFFECTIONATELY KNOWN AS THE PKU-LINCOLN CENTER, OR PLC. To commemorate the occasion, we are dedicating this issue of *Land Lines* to illustrate some of the PLC's land policy work in contemporary China. While it is impossible to cover the broad set of activities and issues addressed by the PLC, we hope that the stories presented here will represent the relevance and rigor of our work. Since its founding, the PLC has both observed and participated in land policy formation in China. In this message, I will reflect on the future of the PLC in light of our experiences over the last decade and the current trends we've observed. In addition, we've asked Lincoln Institute President Emeritus Gregory K. Ingram to provide a retrospective reflection on the Lincoln Institute's program in China. Dr. Ingram and Peking University President Lin Jianhua were the PLC's principal architects, bringing the center to fruition in October 2007.

It is hard to imagine a more extraordinary decade in China's remarkable economic history than the last one. Ten years ago, China's annual GDP growth was 14.2 percent, a near-peak in the post-reform era, culminating a 25-year run of double-digit average increases in real GDP. This growth rate, more than double that of global GDP, propelled the nation's global economic stature so that China now challenges the United States for worldwide economic dominance.

Importantly, this growth was fueled by land. Huge infrastructure investments facilitated industrial expansion around major cities, which

grew by leaps and bounds using land-based financing. China now has more than 100 cities with over 1 million residents and some 15 "megacities" or urban agglomerations with populations over 10 million. In 2007, only Shanghai and Beijing were home to this many people, according to the United Nations Department of Economic and Social Affairs.

During the decade, the economy lost some momentum, and policy makers adjusted to a "new normal" of roughly 7 percent annual real GDP growth—but this is still twice the rate of global GDP growth, positioning China to double the size of its economy in the next decade. The dizzying performance of the last few decades drove major population migrations from rural to urban areas. When the PLC launched in 2007, China was urbanizing at an unprecedented pace, adding more than 20 million urban residents annually. In 2007, 45 percent of China's population was urban, up from 20 percent in 1980. Today, the population is 57 percent urban and is expected to reach 60 percent by 2020. A significant share of new urban growth occurred in the increasing number of megacities such as Beijing, Shanghai, and Shenzhen.

China's unprecedented growth and mass urban migration generated both intended and unintended consequences. For example, the rapid expansion of megacities is beginning to level off. Many young professionals have begun gravitating toward second- and third-tier cities instead. When surveyed, recent migrants indicated four main reasons for their moves: high housing costs in megacities, stress from the frenetic pace of life, difficulty managing the care of aging parents, and air pollution. Over the next decade, the PLC will observe and track this trend to determine the

implications for land and housing policies in both the megacities and the second- and third-tier cities that are receiving new migrants.

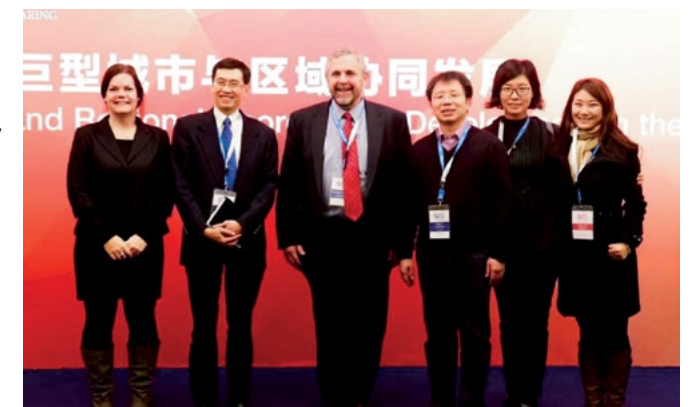
The housing market, a significant tailwind for economic development over the last decade, has become a major impediment to growth in recent years. China's fast-rising house prices are an artifact of widespread speculation by a fast-growing middle class looking for good yields on long-term investments. In past years, this investment was encouraged by the national government, which recognized that property development would significantly drive up GDP. However, increasing shortages of affordable housing are now becoming a big problem in many cities, locking out first-time home buyers. This trend has been accompanied by a decline in land-based financing for municipalities as land reforms have curtailed the practice. Recently, the central government signaled a new policy direction when President Xi Jinping stated that "Houses are built for living, not for speculation." At the same time, lenders have begun rationing credit to cool housing demand. The PLC will continue to track the housing sector to see whether it can help craft a "soft landing" for it.

Urbanization in China, as in other countries, was accompanied by a dramatic decline in poverty as well as increased inequality in the early years. But in this regard, China departed from some international patterns: Although inequality, as measured by the Gini coefficient, rose steadily from the 1980s until 2010, it has been declining since 2012. We expect that this is not the only way that China's transformation will break from common development patterns. The habit of breaking from common, historic development patterns is testament to China's ability to study and learn from the experiences of other countries, a process in which the PLC has played a role.

In the last decade, the PLC contributed to policy debates by nimbly and quickly mobilizing international experts connected to global Lincoln Institute networks. In the coming decade, we expect to respond similarly to requests for high-level international exchange from government and institutional counterparts including the Budget Affairs Commission of the National

People's Congress, Ministry of Finance, the Ministry of Land and Resources, Ministry of Housing and Urban and Rural Development, State Administration of Taxation, Development Research Center of the State Council, China Center for International Economic Exchange, and China Land Survey and Planning Institute in topical areas such as property taxation, municipal finance, land policy, housing policy, and land conservation.

It is hard to imagine a more extraordinary decade in China's remarkable economic history than the last one. Ten years ago, China's annual GDP growth was 14.2 percent, a near-peak in the post-reform era, culminating a 25-year run of double-digit average increases in real GDP. Importantly, this growth was fueled by land.



At the Beijing Forum 2016 Panel Session II: Global Megacities, and Regional Coordinated Development, Kate Austermitter, Zhi Liu, George W. McCarthy, Canfei He, Tao Jin, and Xinrui Shi. Credit: PLC

A hallmark contribution of the PLC over the last decade has been knowledge dissemination and policy advice on the property tax law, property value assessment, and local tax administration. While the National Property Tax Law is not on the legislative timetable this year, there is mounting political pressure to introduce



The PKU-Lincoln Center in Retrospect

a property tax. We expect that the approval of the national property tax law will generate future demand for technical support to implement the new tax, particularly in smaller cities, especially for property value assessment and municipal administrative systems. The PLC will promote research to lighten administrative burdens on municipal governments by studying, for example, how combining drone technology and property registration data can quickly establish cadastral systems for cities with weak technical capacity. The PLC also will investigate the applicability of other land value capture instruments, such as negotiable developer obligations, as another way to build a fiscal base for local governments.

select group of cities, the way it introduces many new policies, before establishing it on a national stage. The PLC will participate in the pilot city programs, studying implementation and suggesting ways to improve policy approaches before the program is deployed nationally.

The PLC has helped advance the evolution of urban land and housing policies in China through its intellectual output—through research, dissemination of knowledge, and international exchange. In ten years, the PLC built a network of hundreds of urban development and land policy experts through its flagship Training the Trainers course. The program will remain a primary way that we expand our academic and policy networks in China. Currently, our networks heavily represent senior scholars and policy makers. This has exacerbated a bias in China's research funding system, which favors established scholars, leaving young academics with very limited funding opportunities. Recently, we decided to cultivate a pipeline of young scholars in China using our domestic research support. Following recommendations from our board of directors, we plan to hire established academics to mentor our young scholars. Beginning this year, we will bring on affiliated research advisers on a part-time basis, to supervise projects and foster higher quality research from our young scholars. In addition, we will bring young PLC fellows and graduate students or affiliated scholars to the Lincoln Institute in Cambridge to conduct research as visiting scholars and work closely with the U.S. staff. Through these efforts, we hope to replenish academic and policy networks to serve China in perpetuity.

The Lincoln Institute of Land Policy is tremendously proud of the work of the PLC. The enormous role that land and land policy have played in China's unprecedented transformation over the last decade has fascinated, daunted, challenged, and sometimes overwhelmed us. We are honored and humbled to have the opportunity to work with Peking University and its visionary leadership. We look forward to future decades of collective efforts to find the answers to some of our most vexing social, economic, and environmental problems in land. □



Zhi Liu, Allan Cochrane, George W. McCarthy, Robert Yaro, and Peter Wallace discuss managing megacity development at the Beijing Forum 2016 Panel Session II. Credit: PLC

China has encountered the limits of carbon-fueled growth and is now becoming a world leader in renewable energy generation. This orientation toward “green growth” also characterizes new government policies that emphasize qualitative aspects of economic and urban development over quantitative measures. The “sponge cities” program, for example, illustrates the national commitment to use green infrastructure to improve water management in cities. The national government will pilot the program in a

THE STRONG COMPLEMENTARITY BETWEEN THE LINCOLN INSTITUTE'S EXPERTISE AND CHINA'S LAND POLICY CHALLENGES PROVIDED THE RATIONALE FOR THE LINCOLN INSTITUTE'S ACTIVITIES IN THE PEOPLE'S REPUBLIC OF CHINA. China's rapid economic growth over the past 35 years involved the usual structural changes in the economy (a declining share of agriculture; an expanding share of manufacturing and services; growing trade; and increasing urbanization), but it has also involved an institutional transformation, as the centrally planned economy moved pragmatically to a greater reliance on market mechanisms. This institutional change has been especially challenging in the case of land, because of the dual land tenure system whereby land is owned either by the state or collectively. China's growth has produced many land-related problems ranging from property rights and urban growth, to property taxation and municipal finance reform, to land conservation and housing affordability. The Lincoln Institute's extensive international experience with these issues and China's impressive track record in using international expertise to inform its policy implementation led us in the early 2000s to believe that cooperation between the Lincoln Institute and China had great potential.

Lincoln Institute's activities in the People's Republic of China were initiated in 2001, and its China Program was formally established on July 1, 2003. Activities were originally carried out by staff and consultants based in the United States who travelled to China. Professors Chengri Ding and Gerrit Knaap of the University of Maryland were heavily involved in the China Program's beginnings. These early years saw the initiation

of training programs, sponsorship of research with government agencies, support of research fellowships, and the organization of research conferences and policy symposia. Early areas of focus were property taxation, farmland preservation, and urban planning. The idea of creating a center in partnership with a Chinese university soon emerged as the travel and logistical challenges of managing the program from abroad became evident. In addition, the Lincoln Institute's change in status from an educational institution to a private operating foundation in 2006 required greater programmatic involvement of its own staff in all of its activities.

Preliminary discussions to explore a partnership with Peking University began in 2005 and continued through 2006, culminating in a formal agreement to establish the Peking University-Lincoln Institute Center for Urban Development and Land Policy (PLC) on October 9, 2007—one decade ago. On the university side, this process was overseen by the then-executive vice president of Peking University, Professor Lin Jianhua, who skillfully facilitated the establishment of the PLC. It provides support for education, training, and research in urban economics, urban policy, land management, land policy, property taxation, local government finance, urban and regional planning, and urban affairs. Its mission has been to study land, urban, and fiscal policies; to disseminate results from its studies and research; and to facilitate education, training, policy analysis, and research involving scholars, policy makers, and practitioners. In mid-2007, Joyce Man was appointed director of Lincoln Institute's Program on the People's Republic of China and became the founding

director of the PLC. In late 2007, office space at Peking University was quickly prepared and local staff hired under her direction, enabling the PLC literally to open its doors in January 2008. Its establishment was memorialized in an inauguration ceremony on April 21, 2008 with featured speakers Arnold C. Harberger, distinguished professor at UCLA, and Gang Yi, vice president of the People's Bank of China.

From its beginning, the PLC annually offered several specialized training courses for government officials on topics proposed by government departments. Involved government agencies have included State Administration and Taxation, Ministry of Land and Resources, Ministry of Finance, Ministry of Housing and Urban-Rural Development, and the Ministry of Transportation. Topics have ranged from real estate appraisal techniques and property tax administration, to transit-oriented development and affordable housing. In addition, the PLC has arranged many symposia attended by international experts and government officials to review international experience in particular public policy areas. Topics have included local public finance, property rights, urban transport, housing markets, and urban planning. Participating agencies, in addition to those just mentioned, include the Development Research Center of the State Council and the National Development and

Reform Commission. Chinese officials have proved to be skillful at drawing on good practices from international experience and incorporating them in new policies adapted to the special conditions in China.

The Lincoln Institute has a long track record of providing education and training on land related issues directly to academics and practitioners. Given the scale of China, the PLC shifted audience to focus on those who train others. This approach, called Training the Trainers, aims to enhance the capacity and awareness of young scholars throughout China to address issues related to urban development and land policy. This annual PLC program targets assistant and associate university professors and professional researchers. It increases competence through intensive professional seminars. The one- to two-week sessions are generally attended by about 60 participants, the majority of whom have doctorate degrees and a high level of English proficiency. Instructors are leading international experts who offer participants an invaluable international perspective. The sessions have normally taken place in Beijing, but in recent years the sessions have also been offered by video conference to include participants in other locations. Since the PLC's founding, nearly 600 scholars have benefitted from this training program.

In addition to training and education, the PLC has supported land-related research in a variety of ways. Using an open call for proposals and expert panels to review submissions, the PLC has annually granted about 10 dissertation fellowships to support the research of Ph.D. students in China and seven research fellowships to senior researchers in China. Similarly, the PLC has granted about three international research fellowships annually to scholars outside of China. All of these fellowship recipients have gathered to discuss their draft reports at an annual research conference in China, whose attendees include international experts and notable Chinese scholars of land policy. An overall objective of the training and research program has been to create a community of scholars knowledgeable about land-related policy issues and the state of current research on such topics, and these in-person conferences, training sessions, and symposia have contributed mightily to this objective.

Staff and faculty of the PLC have also carried out research on urban and land issues, and three contributions deserve special mention. First, in 2010 PLC staff realized that municipal indebtedness was growing and poorly understood. Many municipalities had created local government financing vehicles that used urban land as collateral to borrow funds from banks. This debt was not included in local government accounts. The PLC produced some of the first estimates of the surprising size of this indebtedness, and subsequent work by the National Audit Office confirmed the magnitudes. Second, although it was widely recognized that housing prices in China's major cities had been rapidly rising, available housing price indices understated the increase. The PLC worked jointly with Professor Siqi Zheng, then of Tsinghua University, to develop a new housing price index based on the repeat sales method used in the Case-Shiller housing price index for the United States. Launched in 2014, this China Quality-Controlled Urban Housing Price Index is recognized as the most accurate index currently available. Third, Professor Canfei He, Associate Director of the PLC, has over the past several years produced a

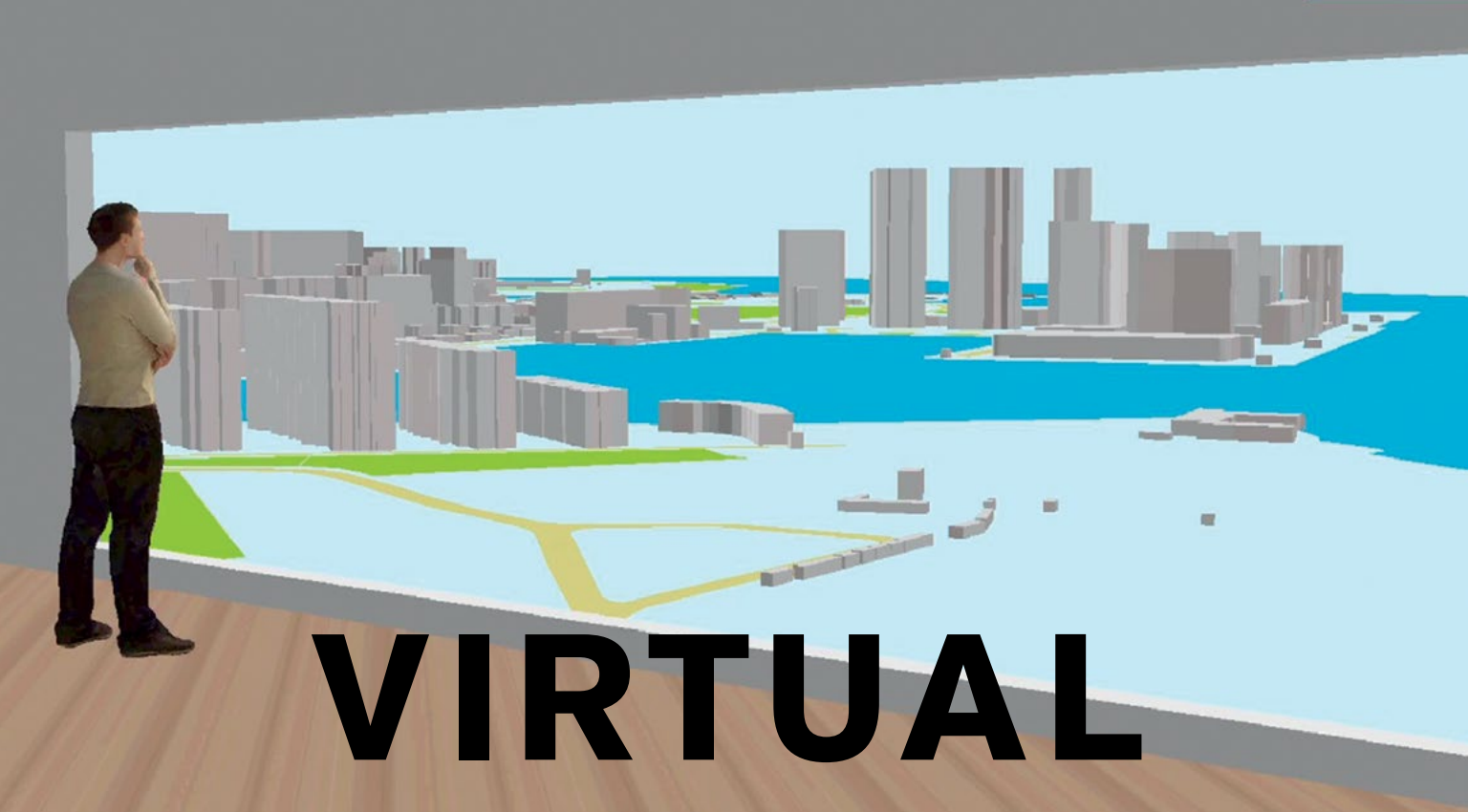
body of empirically based research on the economic geography of China's cities, including how the restructuring of China's export-oriented industries is affecting patterns of urban growth. His work has improved understanding of the determinants of urban growth across China's provinces.

The PLC worked jointly with Professor Siqi Zheng to develop a new housing price index based on the repeat sales method used in the Case-Shiller housing price index for the United States. Launched in 2014, this China Quality-Controlled Urban Housing Price Index is recognized as the most accurate index currently available.

The PLC has done a very credible job in meeting its original objectives and it has proven to be a sustainable institution enduring through the many changes in China and the world that have occurred since its founding. One reason for its success is that the PLC is not the Lincoln Institute's "office in Beijing" but was conceived of and operated as a true joint center between Peking University and the Lincoln Institute. Another reason is that it has been skillfully led, originally by Joyce Man and now by Zhi Liu. In addition, land-related issues in China have proven to be extremely challenging, not amenable to simple and quick solutions, and often linked to other policy issues. Accordingly, revenue from land—whether from conversion of rural to urban use or from land-based taxes—is inexorably linked to local fiscal health, and land conversion from rural to urban use is a key determinant of the location and speed of urban growth. My hope when the PLC was established was that it would work itself out of a job by helping Chinese policy makers resolve many land-related issues or at least dramatically reduce their salience. This hope has proven elusive, and it appears that the PLC still has much work to do. □

Gregory K. Ingram and Jianhua Lin (seated) at the signing ceremony for the Peking University-Lincoln Institute Center for Urban Development and Land Policy. Credit: PLC





VALUATION

GIS-Assisted Mass Appraisal in Shenzhen

By Tom Nunlist

CHINA IS ONE OF A SMALL NUMBER OF COUNTRIES AROUND THE WORLD THAT DOES NOT LEVY PROPERTY TAX ON PRIVATELY OWNED RESIDENTIAL PROPERTIES. AFTER THE COMMUNIST PARTY ESTABLISHED A SOCIALIST REGIME IN 1949, CHINA ADOPTED A PUBLIC LAND OWNERSHIP SYSTEM AND THEREBY LACKED A REAL ESTATE MARKET UNTIL THE REFORM ERA.

Since the reform, property sales, along with the economy as whole, have boomed. First-tier cities such as Shanghai and Beijing are now home to some of the world's most expensive real estate. But taxes are imposed only at the point of property sales and transactions, not annually on ownership.

It may come as a surprise, then, that China is driving the evolution of valuation technology, particularly in Shenzhen—the brand-new southern city that has grown from a small town of 50,000 residents to a major metropolis of 12 million since 1982. The Shenzhen Assessment Center—a municipal statutory agency that was

Above: Using GAMA, the Shenzhen Assessment Center can model and value the line of sight from individual apartments: a view of the city park, for example, is more valuable than a view of neighboring high-rises. Credit: Shenzhen Assessment Center

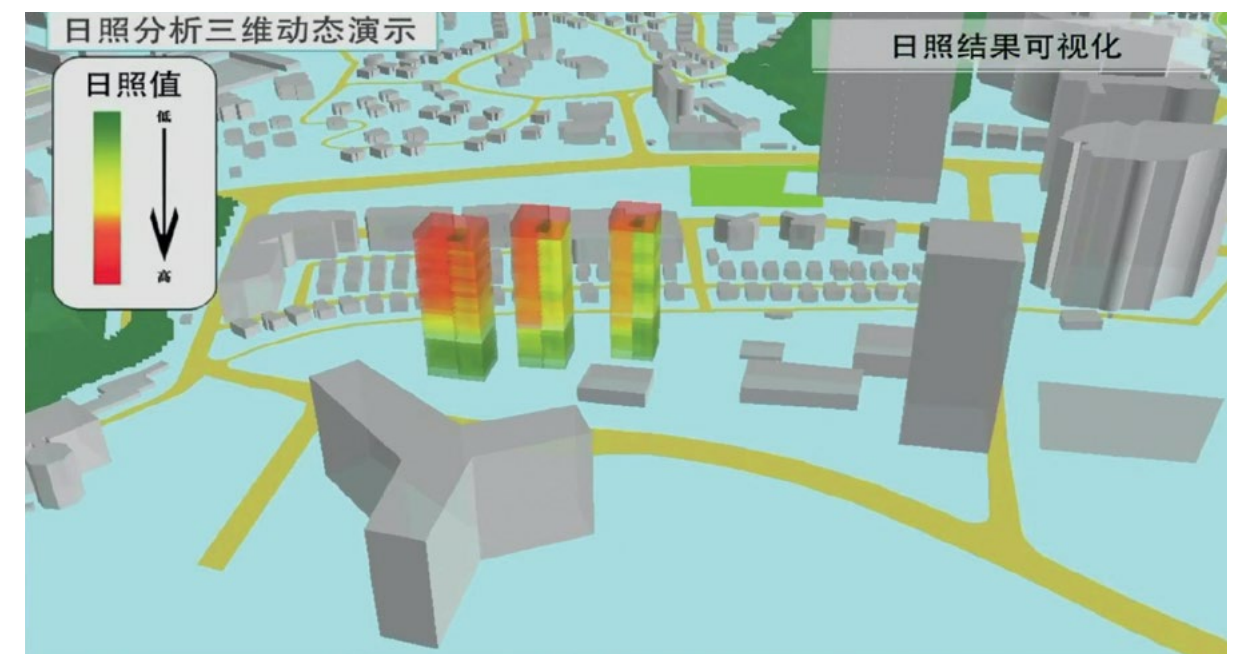
established to assist the collection of taxes on real estate sales and transactions—has developed what is arguably the most advanced property valuation system in the world. It is a logical extension of the computer-assisted mass appraisal (CAMA) system that the Lincoln Institute was instrumental in developing for desktop computers decades ago. The Peking University–Lincoln Institute Center for Urban Development and Land Policy (PLC) has helped several Chinese cities implement CAMA in anticipation of a future property tax. What makes Shenzhen's system different is that it uses GIS technology and new techniques that elevate CAMA to the next level.

Today, CAMA is an international standard that has made it possible to assess entire metro areas from a desktop computer. But CAMA by nature is mainly a two-dimensional system,

whereas modern geographical information system (GIS) software is capable of efficiently rendering three-dimensional (3-D) maps. The future of property assessment lies in marrying CAMA techniques with GIS tools in a system known, naturally, as “GAMA.”

CAMA systems are, broadly speaking, not overly exciting to look at, with lots of data tables and highly detailed two-dimensional maps. GAMA by contrast is dazzling. Using GIS tools, the system constructs 3-D models of entire cities, with streets, buildings, the individual properties within them, landscape features, and so on. Imagine the feel of an open-world video game. The aim is to be able to appraise every property from computers in the assessment office.

The Shenzhen Assessment Center has developed what is arguably the most advanced property valuation system in the world. It is a logical extension of the computer-assisted mass appraisal (CAMA) system that the Lincoln Institute was instrumental in developing decades ago.



“In my view, Shenzhen is dragging CAMA into the next generation, doing things in their valuation that nobody else can do,” says George W. McCarthy, president and CEO of the Lincoln Institute.

Shenzhen: Center of Progress

In many ways, the development of Shenzhen’s property assessment system is the classic story of modern China: starting from far behind, absorbing knowledge from more advanced economies, adapting to local needs, and ultimately coming to rival the best in the world. The fact that it happened in Shenzhen—the Special Economic Zone that launched the experimentation that transformed China from a largely rural economy to a global power—is unsurprising. In 1979, as China was charting the course of its new reform, four cities were declared “Special Economic Zones (SEZs),” pilot projects where the government would experiment with market mechanisms. Shenzhen, a fishing town of just 30,000 people, was one of them. Adjacent to Hong Kong, which was administered at that time by the British and highly internationalized, Shenzhen was in a perfect position to perform the mission of SEZs—attract global companies to trade, bring in foreign direct investment, and obtain for China the tools necessary to forge a modern developed nation.

Imagine the feel of an open-world video game. The aim is to be able to appraise every property from the computers in the assessment office.

As investment poured in and factories sprang up, Shenzhen became the beating heart of China’s new economy, and one of the world’s most advanced cities. In just 30-odd years, it grew into a bustling metropolis of nearly 12 million. Its official GDP in 2016 was US\$284 billion (RMB 1.88 trillion), with a per capita GDP of US\$25,790 (RMB 171,013), more than triple China’s average. Sometimes called China’s

Silicon Valley, it is home to some of the world’s most powerful tech companies, including Internet giant Tencent.

As early as 2003, the central government started to consider introducing a property tax. Six cities were selected as pilot experiment cities for mass appraisal of properties. Shenzhen was one of them. Shenzhen’s Center for Assessment and Development of Real Estate was founded that same year to commence the enormous task of citywide valuation. At first, they were more or less on their own and progress was slow. It took three years to designate basic prices in 56 neighborhoods, in order to assign a single price for the whole area.

The initiative coincided with the Lincoln Institute’s foray into China in 2003, when it began developing relationships with government agencies and conducting research projects on topics ranging from property tax and municipal finance to public land management and land expropriation. “We saw the changes as the economy was being opened up, and we figured there would be all sorts of land policy challenges to grapple with,” McCarthy says.

In 2007, the Lincoln Institute and Peking University, China’s oldest and most prestigious university, endeavored to open the PLC, a research institute staffed by both organizations. One of the PLC’s early tasks was to help the Chinese government understand how to create a property tax that works as a system of revenue. The PLC organized training events to disseminate international knowledge of property taxation and computer-assisted mass appraisal to China. The PLC invited experts from the International Association of Assessing Officers, International Property Tax Institute (IPTI), Rating and Valuation Department of Hong Kong, ESRI Canada, and others. To better demonstrate how CAMA worked, the PLC launched a pilot demonstration project that established a CAMA system for the financial district of Beijing. The PLC also mobilized international experts to assist Shenzhen and Hangzhou, and funded study tours for technical personnel, in the United States, Canada, and Hong Kong. The impact was enormous.

“The PLC was translating the professional literature on property valuation, and it was the first time we were encountering some of this stuff,”



From the desktop, the system can track a virtual sun across the sky, estimating how much daylight an apartment gets. And it can also model sound—a lower-floor unit facing a busy traffic intersection is disadvantaged compared to a unit facing a peaceful courtyard.

says Dr. Wang Youjie, head of the Shenzhen center’s mass appraisal department. “They also introduced us to CAMA.”

Aided by access to a developed body of knowledge, progress in Shenzhen rapidly accelerated. By 2010, the center had evaluated prices on a per-building basis for 170,000 buildings, and by 2011 had done basic evaluations for 1.5 million residential properties. “After understanding the theory better, 2010 to 2011 was a breakthrough point for us,” says Xia Lei, director of the Shenzhen Assessment Center.

Also important was the Lincoln Institute’s role as a connector, enlisting top foreign experts to host seminars and perform hands-on training and development work. To date, the Lincoln Institute has mobilized more than 20 property tax experts to China. For the assessment center in Shenzhen, no one was more familiar than Michael Lomax.

For 22 years, Lomax worked as property assessor for British Columbia Assessment, a province-wide assessment office in Canada. He was among the first people the Lincoln Institute brought to China in 2007, when he joined a government delegation. He has continued making trips to China even after leaving British Columbia Assessment in 2012 to take a position with ESRI, which specializes in GIS solutions.

“A lot of my work in China was to illustrate, convey, and help them install worldwide best practices,” says Lomax, who also teaches mass appraisal at the University of British Columbia. Around 2011, he began working more directly with the Shenzhen center and an appraisal firm hired by the city of Hangzhou, Zhejiang, a city not far from Shanghai. Like Shenzhen, Hangzhou is also known for its tech industry, including the

headquarters of e-commerce titan Alibaba.

The speed at which these two cities were working was sometimes astonishing. During one trip to Hangzhou, Lomax spent an entire day critiquing the assessment system built by the local department. The next morning, they asked him to look again. “They had their programmers stay up all night at the hotel to fix all the problems I pointed out,” says Lomax, still a bit in awe. “This might take you six months to do in the West, and they did it in hours.”

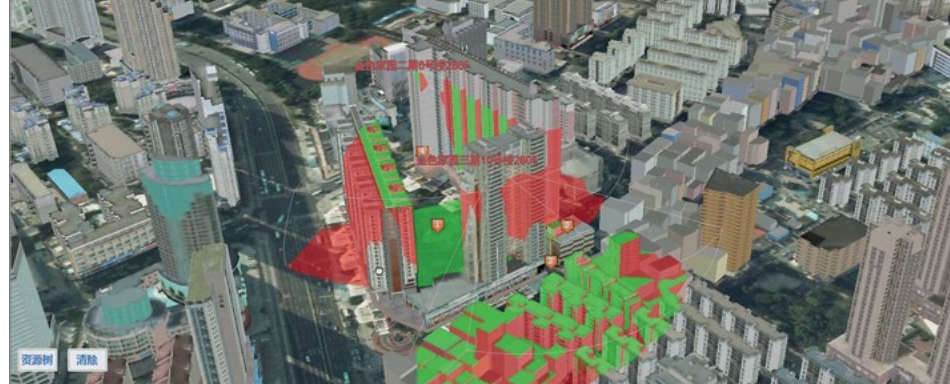
The team in Shenzhen was equally impressive. According to Lomax, they took the computerized evaluation methods to the next level. “They are really advanced in fine-tuning the mathematics,” he says. “Shenzhen is far better at valuing properties dynamically, on the fly, than British Columbia.”

In other words, there was a clear opportunity in Shenzhen to advance the GAMA evolution. “It was Michael that gave us the idea of doing GAMA,” says Wang.

From Follower to Leader

ESRI, a global consulting firm specializing in GIS solutions, is helping to build GAMA models in several municipalities. There is Vancouver, where Lomax works; Maricopa County, Arizona, which encompasses Phoenix; and also Shenzhen. These projects are in varying stages of development, but the Shenzhen system is impressive nonetheless. Sitting in on a demonstration of the system is like inhabiting a painting inside a painting, as if you might spot your virtual self if you peeked in the right window. But what it can do in terms of assessment is even more impressive.

In this screenshot, GAMA is projecting the line of sight from two different apartments (one in the fore, and one in the rear, identified by address); the green indicates areas visible from an apartment, and the red indicates areas blocked from view. Credit: Shenzhen Assessment Center



Of course, it factors in all the indicators accounted for by a traditional CAMA system: location, number of rooms, floor space, recent market prices, and so on. It can also estimate the value of being near a subway station or close to a school. The three-dimensional nature of the system boosts the functionality. Using vectors, it is possible to model the window vantage point of every single unit in a given building. From the desktop, the appraiser can determine if a resident has a sweeping view of beautiful Lianhuashan Park in central Shenzhen (think New York's Central Park, except with palm and banyan trees), or just the boring façade of a neighboring high-rise. The system can also track a virtual sun across the sky, estimating how much daylight an apartment gets. In addition to modeling light, it can also model sound—a lower-floor unit facing a busy traffic intersection, for instance, is disadvantaged compared to a unit facing a peaceful courtyard.

The system alone is marvelous from a technical standpoint, but it is also a testament to the advanced nature of the city as whole. In numerous ways, it is an “only in Shenzhen” achievement.

The system weights all those factors and synthesizes the final valuation of a property. All told, these factors can amount to a 20 percent difference in value between two units in the same building.

The system is also being used to better execute property transaction taxes. Through this smaller trial, the efficacy of the tool is apparent: of the millions of properties valued so far, only

27,106 challenges have been made as of January this year, and of those only 282 assessments had to be readjusted.

The Shenzhen assessment project is not without challenges. First, the market is young, so there is a relative dearth of transaction data. On top of that, transactions are sometimes reported at artificially low prices, to avert transaction taxes. Finally, the housing market is highly heterogeneous, with fairly distinct groups of housing types.

Limited property transaction data can be among the biggest challenges to implementing a system such as this. In this regard, Shenzhen has a distinct advantage over just about any other city in the world in terms of the knowledge of its properties. The whole place is brand new, and this is especially true for the city center where the slick 3-D model is most impressive. That means the data on all the buildings and floor plans is existing, complete, and rendered in digital formats that are, relatively speaking, easy to adapt to the model.

The team in Shenzhen cleverly innovated around this with a system they call the “holistic” approach. Briefly, it treats those distinct groups of housing first as separate “sub-markets.” Then by establishing relationships among those sub-markets, they are better able to estimate prices across the entire market with fewer data points overall.

The system alone is marvelous from a technical standpoint, but it is also a testament to the advanced nature of the city as whole. In numerous ways, it is an “only in Shenzhen” achievement.

Shenzhen is unique in a purely Chinese context as well. Conjured by the pure political willpower that gave life to the Special Economic Zones, Shenzhen is not directly administered by the central government. However, as a prefecture-

level municipality, Shenzhen enjoys closer relationship with the central government than other prefecture-level municipalities. The central government grants more freedom to Shenzhen to try new things.

“In Shenzhen, government agencies, such as the municipal commissions of planning and land, and finance and taxation, are cooperating to share data,” says Director Xia. In a country where interdepartmental data sharing is rare, it is difficult to understate how important this is. “The point is to be creative.”

Geng Jijin, who directed the assessment center before Xia, when development of the model was most intense, puts a more personal spin on it: “Everybody here is from different places in China. We have no choice but to figure out how to get along.”

The Road Ahead

The job of creating the GAMA system in Shenzhen is not yet finished. Partly because Shenzhen grew at such a breakneck pace, a significant portion of buildings from the newly annexed localities are rather poorly documented. According to Director Xia, bringing these properties into the system is a top priority going forward. Given the scale of Shenzhen, it will likely take a few years to work through the challenge.

The implementation of a property tax goes beyond the purview of the Shenzhen Assessment Center. It is a policy problem and the center does not make policy, Wang says, adding “If the policy is put forward, Shenzhen is ready for it.”

It is anyone's guess when that might happen, given the politically sensitive nature of property tax in China. While there have been two pilot taxes in Shanghai and the southwestern city of Chongqing, they have been very limited and undertaken mainly as a signal that property taxes are coming. Pressure is, however, building. In the absence of a property tax, and as the net revenues from land lease sales that local governments rely on have declined, local budgets have become increasingly strained.

In the meantime, the assessment center is already helping to spread knowledge beyond

its very special borders. Delegations have been sent from all around China to view the system, including from across the river in Hong Kong and all the way from Taiwan.

Lincoln Institute President McCarthy, for his part, is ready to see knowledge and experience flow west. Places such as Boston, where there has long been controversy over building near Boston Common due to the shadows it would cause, could use a system that models the sun.

Actually spreading the new GAMA system will likely be difficult, and there is no telling how long it might take. But nobody would have predicted that a fishing village could become a metropolis in three decades flat. □

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THE DRONE



REVOLUTION

UAV-Generated Geodata Drives Policy Innovation

In Brazil alone, officials estimate that 20,000 drones were in operation in 2015, with applications mainly in agriculture, mining, infrastructure inspections, security and border control, and the mapping of environmental areas and cities. Credit: iStock.com/dabidy

By John Wihbey

DRONES ARE REVOLUTIONIZING DATA COLLECTION AND MAPPING, USHERING IN MAJOR SHIFTS AND NEW OPPORTUNITIES IN THE DOMAINS OF LAND MANAGEMENT, POLICY, AND ADVOCACY.

Unmanned aerial vehicles (UAVs) came into wide use globally about a decade ago, as their cost fell rapidly in the consumer market. In the developing world and in rapidly urbanizing areas, drones are quickly becoming an essential tool for securing land rights, updating maps in virtual real-time, and understanding unplanned settlement patterns. From Latin America to South Asia, the drone is being deployed across the geospatial information and land management sectors, by surveyors defining specific urban parcels, appraisers determining land value over a peri-urban field, and corporate and government employees updating territorial information.

The technical capacity of drones—which can carry multispectral small-format aerial cameras and produce images of both the visible environment and the infrared spectrum—provides a substantial complement to traditional aerial photography and even high-resolution satellite imagery. Because UAVs can fly at very low altitude and execute tight, repeating patterns, they can produce fine-grained images of one centimeter resolution or better, enabling production of three-dimensional images.

Their democratic potential is also stirring excitement, as they empower citizens, nongovernment organizations, and other smaller, more informal networks. “Drones are going to make the difference for policy and decision-making processes, as citizens participate in data creation at critical moments,” notes Diego Alfonso Erba, a land surveyor engineer and expert in Latin American land management systems. “Citizens can fly them, take photos of a situation, and share the results with authorities. In rapidly evolving

situations where informal settlement, unsanctioned resource extraction, or conflict is occurring, drones can furnish proof to legal systems.

Latin America’s pioneering use of drones to enrich and improve land policy and management is echoing across the globe. “We are doing the same thing in China,” says Zhi Liu, China program director at the Lincoln Institute and director of Peking University–Lincoln Institute Center for Urban Development and Land Policy (PLC) in Beijing. In East Asia, drones are aiding new high-tech research and experiments to modernize land registries for contemporary uses and to help address other large-scale challenges, including potential implementation of property tax.

Cadastral: Public Land Registries in Latin America

In Latin America and Asia, drones are proving especially useful in the evolution of territorial “cadastral”—public registries that manage information relating to land parcels and that play a critical role in land use decision-making throughout Latin America.

In most of the region, existing territorial cadastral systems derive from an “orthodox”

The democratic potential of drones is stirring excitement, as they empower citizens, nongovernment organizations, and other smaller, more informal networks. “Drones are going to make the difference for policy and decision-making processes, as citizens participate in data creation at critical moments.”

model imported centuries ago from colonial Europe, says Erba, who coauthored *Making Land Legible: Cadastres for Urban Planning and Development in Latin America*, published by the Lincoln Institute in 2016. He is working at the forefront of an effort to upgrade these land registry systems to what are known as “multipurpose cadastres (MPCs),” and drones are playing a key role in this evolution.

Traditional, or “orthodox,” cadastres are maintained as public registries by governmental institutions. They’re inadequate for contemporary urban policy-making because they cover only private parcels and account for limited physical, legal, and economic attributes. Multipurpose cadastres, by contrast, are maintained by volunteer stakeholders in a jurisdiction who commit to providing richer, more inclusive information about a city. MPCs may include alphanumeric data and thematic or domain-specific cadastres pertaining to the environment,

transportation systems, or utility networks, and they may be organized by government and private organizations. The benefits can include better urban planning as well as more equitable taxation, increasing revenues, and a broader tax base.

“The data integration provided by the MPC model is the most direct way to identify and monitor the economic, physical, legal, environmental, and social characteristics of parcels and their occupants,” observe Erba and coauthor Mario Piumetto, a land surveyor who specializes in geographic information systems. “Planners need this information to manage the growth of cities, define strategies for urban financing, reduce informality, and analyze the impact of government interventions” (Erba and Piumetto 2016). By democratizing the tools of geospatial monitoring, drone technology is helping to facilitate this movement toward multi-stakeholder MPCs.

Established Latin American cities with existing cadastres are using drones to tackle challenges associated with informal construction. For example, in Villa 31, one of the most valuable areas of Buenos Aires, some 40,000 people have built informal constructions up to five stories high within a 100-block area, note Erba and Piumetto.

In Villa 31 in Buenos Aires, a government-launched drone survey, in tandem with a street-level laser scanner, created a 3-D model and generated statistics on the occupation of dwellings, streets, and public spaces, creating a more accurate picture of residential development. Credit: Javier Palmieri/Alamy Stock Photo



In 2016, the government launched a drone survey, in tandem with a street-level laser scanner, that created a 3-D model and generated statistics on the occupation of dwellings, streets, and public spaces. With this more accurate picture of residential development, agencies and stakeholders are in a better position to transition informal settlers toward formal property ownership and participation in planning processes.

Ecuador demonstrates how drone-enhanced cadastres can promote resiliency as well. The city of Portoviejo has been using drones to enforce rules against unpermitted occupation of public spaces. By comparing 2010 records with recent drone-produced monitoring imagery, authorities determined that more than 7,000 instances of new construction violated permitting rules. In April 2016, this more accurate real-time record of settlement proved vital when a 7.8-magnitude earthquake wreaked havoc on structures throughout Portoviejo, killing more than 200 people. Photos after the earthquake were compared to recent drone footage, aiding rescue and rebuilding efforts.

GIS-Assisted Mass Appraisal in China

In China, drones may prove most useful in current efforts underway to assess property value (see p. 8). Since 2003, China has been contemplating introduction of a municipal property tax on the private ownership of residential properties—a power that municipal governments have not had for several decades. However, most cities face a huge technical barrier: There is no system of property assessment or database. Researchers hope drones can help facilitate the underlying basis for assessment.

“The question is how we can help so many Chinese cities to quickly develop a cadastre system, which is the basis of a property tax system,” says Liu, noting that the PLC is funding a research project in China to provide innovations in this area. The next stage is for researchers in China to merge property rights data with 3-D representations of parcels produced by drone

technologies. Crucially, researchers must get the full property rights data from the government—such as formal ownership information and the dimensions of units, parcels, and buildings—in order to match up the 3-D imagery in accurate fashion. It is unclear whether these records are fully digitized in many cities, Liu notes. Although drone-generated data cannot provide missing ownership documentation, better parcel data will ultimately accelerate the process of generating an accurate cadastre system.

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Chun Zhang, a professor of city planning from the Beijing Jiaotong University and a leader of the project funded by PLC, says drones are currently using tilt-shift photography—which can make the features below a drone look like a miniature representation—and creating 3-D models through the imagery captured. The project will then provide basic spatial information. Currently, the drone techniques are being applied in small towns such as Jimingyi, Shexian, and Gubeikou. But as the researchers experiment with drones, they are bumping up against technical and regulatory limits. “The survey area cannot be too large,” notes Zhang, given the limits of the drone’s battery. “The biggest difficulty for researchers is flight control in certain [limited] areas—within the 6th ring of Beijing, for example.” But this should not be a problem if the municipal governments decide to use drones to develop a 3-D property database.

Property valuation is beyond the scope of Zhang’s current research project, but it will be a challenge of massive scale in China. Ultimately the work-intensive process might be solved by computational methods aided by drone-generated

data. In the United States, Liu notes, local governments have long used computer-aided mass appraisal (CAMA) techniques to appraise all properties in a certain area. “In China, we work with a few cities that are refining the computer-aided mass appraisal model to incorporate big data, so they can assess property value more accurately,” Liu says. That sort of work might constitute the next phase of research. But the current phase remains focused on seeing how well existing property records can be matched with the drone data.

In the context of land registries, the use of drones is proving crucial in the initial and provisional identification of physical property limits in cities and jurisdictions where there is still no formal land administration system and the land structure is unknown.

Pathways to the Drone Revolution

Drones are now functioning in a crucial capacity across a variety of land policy use cases, fulfilling cultural and legal needs, but their development and use obviously have a wider story. Their evolution toward wider commercial and recreational use—including sharper definition of land policy—is in some ways a classic story of second-order effects of technological innovation. The original development and prototyping of the flight technologies took place largely in the context of military research. But some of the key technical breakthroughs required to make flight-relevant instrumentation available at a reasonable price point resulted from the “smart-phone wars,” wherein various communications technology companies raced to perfect efficient hardware and software for compasses, gyroscopes, altimeters, and more (Anderson 2017).

Still, even as the technology has been ready and the economics right for wide public use, the policy environment for drone use has needed to mature. In the United States, for example, the Federal Aviation Administration has tried to grapple with commercial and consumer demand

while balancing concerns over conflicts with manned aircraft flight paths and potential invasion of privacy and land rights. These types of policy debates have been playing out across the globe, as noted above.

Yet many of the technologies under development are focused on agricultural lands, where competing interests and conflict are minimal. Farming is expected to be the primary zone for commercial use of drone technologies. Because drone instrumentation can be used to measure radiation signatures and the infrared spectrum, drones hold massive potential for improvements in crop yields and farming in general (Wihbey 2015). But the benefits have been unevenly distributed over the past decade, as countries such as Japan and Canada have opened up farming airspace, even as the United States is debating where to open up air space policies for agriculture (Lewis 2017). To scale the technology for farming, much greater latitude will be required for drones flying beyond the sight of ground operators. In any case, the idea of “precision farming” has caught on globally, with potential environmental benefits, such as reduced and more targeted use of pesticides and other chemicals. And surely the advancements achieved for rural farm settings will have applications for monitoring, for example, forest reserves and wildlife populations, and for global efforts to limit sprawling unplanned settlements and ensure ecological sustainability (Paneque-Gálvez et al. 2014).

Policies related to the training, licensing, and certification required for drone operators continue to evolve in many countries, and of course formal land surveying itself has its own professional standards that are integrating these new technologies. Citizen or recreational use and informal monitoring of land and urban space is bound to grow only more complicated, as new observational possibilities and challenges emerge from the use of multiple drones simultaneously and “swarming” techniques, as well as the potential for both greater autonomy, as drones become smarter through software, independent of human operators (*The Economist* 2017).



A drone photographed the Mutianyu section of the Great Wall in Huairou, north of Beijing. Credit: Xinhua/Alamy Stock Photo

Challenges

Drones could prove a crucial tool for managing extensive land use problems expected to emerge over the coming decades as the world rapidly urbanizes, from housing inaffordability to shortages of land for open space (Wihbey 2016). Indeed, drones might facilitate a form of technological “leapfrogging,” similar to that of mobile phone Internet connectivity, which has allowed many individuals and societies across the developing world to connect to the Web without dedicated broadband lines to households.

PLC Director Zhi Liu thinks that multipurpose cadastres would enable solutions, but many Asian cities would need technical advancement, as well as political willingness and public support, to improve and update the cadastres of their rapidly growing cities. Experiments in small cities and towns in China might prove useful to other bigger cities in the region, if not countries around the world.

Regulations throughout South and Central

America are evolving to keep up with the proliferating use of drones as tools to upgrade land policy in the region. In Brazil alone, officials estimate that 20,000 drones were in operation in 2015, with applications mainly in agriculture, mining, infrastructure inspections, security and border control, and the mapping of environmental areas and cities, according to Erba and Piumetto. In May 2017, this growth prompted the Brazilian National Civil Aviation Agency (Agência Nacional de Aviação Civil or ANAC) to issue new safety and operating rules, which cite and specifically follow definitions of other civil aviation authorities such as those found in the United States and the European Union (ANAC 2017).

In Mexico, the Civil Aeronautics General Directorate in Mexico has issued a similar set of rules that aims to prevent accidents and protect third persons and property on land and in flight. In Argentina, flights above 400 feet (122 meters) require authorization, and there are also limitations depending on the weight of the equipment, the areas overflown, and the information collected.



In April 2016 in Portoviejo, Ecuador, drone footage aided rescue and rebuilding efforts after a 7.8-magnitude earthquake wreaked havoc on structures throughout the city. Credit: Andes/César Muñoz/Flickr

New Frontiers for Drones

Many institutions across the world have become interested in leveraging drone technologies to help solve age-old administrative problems, particularly in areas of the world that have suffered under adverse conditions caused by conflict or difficult economic conditions. The World Bank, for example, has highlighted efforts in the post-conflict Balkans, where areas in Kosovo have been left with lingering problems after property owners, mostly male, were killed in the 1990s regional war. The women left in these areas have struggled to reestablish order with regard to property and land policy, given the lack of formal records. The World Bank has noted: “The time, cost, and complexity of conventional land surveying and registration . . . is an obstacle for these women. It often takes years and is too expensive to complete, leaving these women with no information or legal protection of their rights” (World Bank 2016). In partnership with the Kosovo Mapping Authority, drones are therefore being used to execute cadastral mapping activities.

World Bank experts have also noted that drones are proving to be effective weapons in the fight for land rights in underdeveloped areas on the African continent (Totaro 2017). Although nearly 90 percent of Europe is mapped at a local

level, only 3 percent of the African continent has maps at such resolution. As coastal zones are rapidly developed for hotels and commercial/residential use, drones could help communities keep up with development and garner appropriate tax revenue.

Overall, the strength of drones comes from the richly detailed information they can collect at relatively low cost; they can even produce quality 3-D models of streets and properties and expedite data collection. But certain weaknesses must be taken into account. UAVs can only provide limited territorial coverage, given limited speed and autonomy of flight. Adverse weather conditions are also a significant issue.

Drones have so far proven most effective in urban operations, which often require great detail and richness of data. Any decision to deploy drones has to weigh costs and benefits for a given task. High-resolution satellite images (currently down to 30 centimeters, or 1.8 inches, in resolution) may suffice; if the area to be surveyed extends beyond 25 kilometers (about 15.5 miles), satellite image files may be more appropriate and efficient.

Drones might facilitate a form of technological “leapfrogging,” similar to that of mobile phone Internet connectivity, which has allowed many individuals and societies across the developing world to connect to the Web without dedicated broadband lines to households.

Yet drones furnish possibilities that no other aerial surveying technology provides given their mass market deployment. “Drones will democratize geospatial information gathering and analysis,” Erba says. “Everybody will soon have access to the tools that only satellite owners had just a few years ago. Photos could be sent all the time to the cloud.” And this new capability, he notes, could strengthen transparency and accountability of many kinds, and bring efficiencies to government: “Aerial photos of areas being invaded or deforested in real-time could be sent directly to the officer responsible for urban monitoring. This extremely relevant information can be provided at no cost to the state, and it can be used immediately for action.”

Whether such action involves more uniform regulatory enforcement, better tax collection, or richer, more dynamic data for land registries, these new technologies are poised to bring major shifts across numerous aspects of land policy worldwide. □

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SPONGE CITIES & PANDA HABITAT

The Nature Conservancy's
Foray into China

The Nature Conservancy China is working in Sichuan Province to conserve giant panda habitat. Credit: Oktay Ortakcioglu

By James N. Levitt and Emily Myron

PARADOXICALLY, CHINA IS EMERGING AS AN INNOVATIVE GLOBAL LEADER IN GREEN INITIATIVES, JUST AS IT HAS OVERTAKEN THE UNITED STATES AS THE WORLD'S BIGGEST SOURCE OF CARBON DIOXIDE EMISSIONS (Global Carbon Atlas 2016). "After decades of rapid expansion brought smog and contaminated soil," noted the official Xinhua News Agency, "China is steadily shifting from GDP obsession to a balanced growth philosophy that puts more emphasis on the environment" (Xiang 2017).

China generated more solar power in 2016 than any other nation. In January 2017, the government announced plans to invest RMB 2.39 trillion (US\$361 billion) in renewable energy generation by 2020, according to China's National Energy Administration. This September, the government also promised to ban the sale of gasoline- and diesel-powered cars at an unspecified date (Bradsher 2017). And to help meet its commitments to the Paris Climate Accords, China will launch the world's largest carbon "cap and trade" market in November 2017, targeting coal-fired power generation and five other large carbon-emitting industrial sectors (Fialka 2016, Zhu 2017).

Land-based green initiatives include "sponge cities," designed to manage storm water runoff and prevent urban flooding, and conservation efforts to protect water quality and preserve wildlife habitat. The Peking University–Lincoln Institute Center for Urban Development and Land Policy (PLC) is collaborating with The Nature Conservancy's China program (TNC China), providing technical support for a sponge city pilot in Shenzhen and exploring innovative conservation finance mechanisms for China.

The two organizations are complementary in terms of expertise: TNC China has done a lot of ground work to turn sciences and technologies into practice. With the Lincoln Institute providing an international knowledge base, the PLC can

focus on China's conservation strategy, policy, and finance. "The Lincoln Institute has done a lot of research on land conservation in the United States and elsewhere around the world, and the international knowledge developed from this work helps China to address its enormous conservation challenges," says Zhi Liu, director of the PLC and Lincoln's China program.

"For a few years, we have been looking for a way to engage ourselves in China's land conservation. The partnership with TNC China—starting with sponge city development or, more broadly, conservation for cities—provides us a perfect entry point. As one of the partnering institutes in the sponge city pilot project in Shenzhen, we are focusing on strategic and institutional frameworks and long-term finance. We hope that the work in Shenzhen will also help lay a research foundation for national policy making," says Liu.

"China is steadily shifting from GDP obsession to a balanced growth philosophy that puts more emphasis on the environment."

Sponge Cities

China's unprecedented urban growth has taken a hard toll on the landscape. In 1960, it had no metropolitan areas with populations over 10 million. Now it has 15. In 50 years, the urban population multiplied by a factor of six: from 131 million residents or 17.9 percent of total population in 1966, to 781 million or 56.7 percent by 2016 (World Bank 2017). And by 2030, one billion people, or 70 percent of China's total population, are expected to live in cities (Myers 2016). Resulting proliferation of hardscaped roads and building sites have created a vast expansion of

This storm event and other recent floods spurred the Chinese government to develop a series of “sponge cities.” Shenzhen and 29 other cities received instructions and incentives to develop green infrastructure—including bioswales, pervious paving technologies, and rain gardens to absorb storm water into the ground.



impervious surfaces that prevent storm water from seeping into the earth to replenish ground water sources and mitigate the threat of major flooding. In recent years, increasingly severe storms and other surface water running at street level in Chinese cities have presented life-threatening peril to urban residents, such as the 2012 flood in Beijing that killed 79 and caused RMB 11.64 billion (US\$1.76 billion) in damages, according to Xinhua News Agency.

This storm event and other recent floods spurred the Chinese government to announce a national program to develop a series of “sponge cities.” Shenzhen in the Pearl River Delta and 29 other cities, from Wuhan in Central China to Baotou in Inner Mongolia (Leach 2016), received instructions and incentives to develop green infrastructure—including bioswales, pervious

paving technologies, and rain gardens to absorb storm water into the ground. The government will test the results of the pilot projects with the intention of replicating proven-effective practices on a nationwide basis.

By the government’s definition, a city will reach the “sponge” standard when 70 percent of rainfall is absorbed into the ground, relieving strain on traditionally constructed drainage systems and minimizing floods. The goal is that 20 percent of urban built-up areas in pilot cities will reach sponge standard over the course of five years.

TNC China is the key partner and technical adviser to Shenzhen’s sponge city project. TNC invited the PLC and several other institutions to join the effort, providing insight on policy, strategy, and finance. The pilot demonstration project in Shenzhen includes four components: pilot demonstration sub-projects for industrial plants, office buildings, schools, urban neighborhoods, etc.; dissemination and upgrading of past experiments; an education and promotion campaign; and studies of strategy, policy, and financing mechanisms.

“Our work on the sponge city strategy, policy, and finance is currently underway,” says Liu. “We have looked extensively into relevant international experiences from the United States, Germany, the Netherlands, Singapore, and other countries. The sub-projects of the Shenzhen pilot demonstration give us a great sense of which technologies are most feasible, as well as their benefits and costs,” he adds.

The major challenge is how to develop long-term financial mechanisms for sponge city development. Sponge infrastructure is costly, estimated at over RMB 100 million (US\$15.08 million) per square kilometer of built-up urban area. It is a public good in nature. The question is who will pay for it. Today, Shenzhen’s sponge city project is supported by central government subsidies, the municipal budget, and businesses volunteering to build sponge infrastructure facilities, such as rain gardens and rain roofs on their own properties. But the available financial resources are far from adequate to meet the target.

China’s sponge cities will include green infrastructure such as this wetland park in Tianjin, which collects rainwater to irrigate vegetation on the site of a former garbage dump. Credit: Kongjian Yu



“We are investigating other countries’ experiences with financing rainstorm management,” says Liu. “For example, the city of Philadelphia imposes storm water fees based on the amount of impervious surface that a parcel contains. The city also offers several programs to assist nonresidential customers to lower their storm water fees through green projects that reduce the amount of impervious surface on their properties. In the context of China, we believe that the long-term financial solutions will require some careful consideration of fiscal policy reform at the local level,” he says.

Nature Sanctuaries and Land Trust Reserves

TNC China is also active in the conservation of resources beyond China’s cities. In the past several years, TNC China has adapted the American land trust model to local conditions to protect land, biodiversity habitat, and ecosystem services, from air and water purification to flood and drought mitigation. “We’ve been testing this localized land trust model as a way to expand society’s ability to protect and sustainably manage China’s most important lands and waters, while providing green livelihood solutions

for local communities and creating a mechanism to finance long-term reserve management through private contributions. We believe that this new model could become an important supplement to China’s current protected area system,” says Science Director of TNC China, Dr. Jin Tong. Building on this successful experience and taking advantage of access to international knowledge through the International Land Conservation Network (ILCN), a project of the Lincoln Institute, the PLC is exploring land conservation finance for China more broadly.

Land trusts are an American innovation. As charitable organizations, land trusts leverage the power of the private and nonprofit sectors to conserve land by acquiring it outright, and owning title or fee ownership to it; by acquiring conservation easements, also known as conservation restrictions or conservation servitudes; or by serving as the stewards or managers of protected lands owned by others. Indeed, about 56 million U.S. acres (about 23 million hectares) have been protected in the United States by local, regional, and national land trusts as of year-end 2015, according to the 2015 Land Trust Census compiled by the Land Trust Alliance in cooperation with the Lincoln Institute of Land Policy. The United States is believed to be the global leader in private and civic land conserva-

tion, though no comprehensive figures compare nations around the world in terms of private and civic land conservation. Land conserved by NGOs and other private and civic actors complement the 7.9 billion acres (3.2 billion hectares) protected, principally, by governments around the world (UNDP-WCMC 2014).

The world's first regional land trust was established in Massachusetts in 1891. Known today as The Trustees of Reservations, that group continues to protect exceptionally beautiful, naturally important, and historically significant properties in Massachusetts through fee ownership and conservation easements. From that small beginning, more than 1,000 land trust organizations are now spread across the United States. They exist in every state of the union and continue to improve the pace, quality, and permanence of protected lands across the nation, providing multiple public benefits. This work greatly benefits from U.S. federal tax credits for conservation easements to land trusts.

The local government of Sichuan Province's Pingwu County, the Nature Conservancy China, and the Sichuan Nature Conservation Foundation designated a county-level nature reserve, named Laohegou Land Trust Reserve, with over 27,000 acres (about 11,000 hectares) of important giant panda habitat.

The practice of land conservation by private individuals and civic organizations has also spread across the world. Private and civic land conservation groups exist in more than 130 countries and territories in North and South America, Europe, Africa, Asia, and Oceania, according to a recent survey conducted by the ILCN (ILCN 2017). While the legal context and financial incentives for land conservation in the private and civic sectors differ from country to country, the motivation to protect and carefully steward land for the good of present and future generations is a constant across the globe.

Now land trusts, in a new form, may have the

potential to help reshape the way that China approaches the creation and management of protected areas. Currently, more than 15 percent of China's land is designated as a protected area, and more than 2,700 nature reserves have the highest level of legal protection in that nation. However, significant challenges continue to daunt the Chinese network of protected lands. Many protected areas lack adequate financial resources, enforcement and governance mechanisms, and management staff. In order to strengthen and expand the existing network of protected areas, TNC China and its partners are working to develop land trust analogues that work in the Chinese context.

A 2008 Chinese policy that allows private individuals and organizations to assume management rights on collectively owned forest land opened the door for a conversation about land trusts. In 2011, TNC China initiated a collaboration with the local government of Sichuan Province's Pingwu County to explore the establishment of the country's first land trust reserve. In keeping with the local nature of the land trust movement, TNC China then catalyzed the birth of a new local entity—the Sichuan Nature Conservation Foundation (SNCF)—which was later renamed the Paradise Foundation. In 2013, the SNCF signed the nation's first conser-

China's first land trust reserve, The Laohegou Land Trust Reserve, conserves more than 27,000 acres (about 11,000 hectares), strategically connecting existing protected areas for endangered species, such as the Sichuan snub-nosed monkey and the giant panda. Credit: The Nature Conservancy China



The Nature Conservancy China aims to work with partners to create 10 land trust reserves in China by 2020. Credit: The Nature Conservancy China

vation lease, allowing it to manage the parcel for the next 50 years.

The local government, TNC China, and the foundation promptly designated the leased land a county-level nature reserve, named Laohegou Land Trust Reserve, thereby conserving over 27,000 acres (about 11,000 hectares) of important giant panda habitat. This reserve's strategic location connects existing protected areas for endangered species, such as the giant panda and the Sichuan snub-nosed monkey, thereby establishing a large conservation corridor. The interconnected corridor effectively creates a large territory within which anti-poaching regulations can be rigorously enforced. Similarly, within the corridor, local streams that run free can be protected from diversion into hydropower.

The reserve is also important from a research perspective. Scientists have carried out a baseline inventory of wildlife and set up dozens of camera traps to learn more about the numerous important species present. Already, the cameras have captured rare footage of a giant panda eating the remains of a takin (a goat-antelope found in Asian mountain ranges and highlands), reinforcing the relatively new discovery that pandas are omnivores, occasionally consuming meat.

For day-to-day management of the reserve, the foundation sponsored the creation of a local

entity, the Laohegou Nature Conservation Center, which has in turn hired nearby residents to administer and execute management, enforcement, and ecological monitoring workplans.

Several entities supporting and managing the reserve are also piloting mechanisms to increase income in communities bordering the reserves and to fund the reserve's ongoing management. For example, outside Laohegou Reserve, the Paradise Foundation has set up a system in which they sell the community's eco-friendly agricultural products and honey wine to high-end markets. Revenues from these sales augment community income and reduce the pressure from local residents who want to hunt and forage within the reserve. The Paradise Foundation and others are also exploring the potential for limited ecotourism into the reserves, as well as online fundraising for individual projects. Finally, project managers are also optimistic that China's growing philanthropic sector will take interest and support these efforts. It remains to be seen whether these techniques will yield profits that are widely dispersed through the communities near the reserve or provide consistent, long-term funding needed for management activities.

The conservancy's goal is to create 10 land trust reserves in China by 2020 with partners, each employing a slightly different model to

demonstrate the flexibility of this approach, such as leasing land and turning it into a reserve, like in Sichuan Province, or assuming management responsibilities of an existing reserve.

Beyond Laohegou, the Conservancy and its partners are also exploring other models to demonstrate the flexibility of this approach, such as civil societies assuming complete or partial management responsibilities of an existing reserve. To date, four land trust reserves, including Laohegou, have been created around the country in partnership with various local entities, and interest continues to grow.

Borrowing the idea of the Land Trust Alliance in the United States, the Paradise Foundation and TNC China aligned 11 other international and domestic environmental NGOs to launch the China Civic Land Conservation Alliance in 2017, aiming to catalyze the “China land trust movement” by providing a platform for communications, funding, standards, policies, and capacity building. The long-term vision of the Alliance is to collaboratively protect 1 percent of China’s terrestrial land by civic and private organizations and individuals.

“The Conservancy will soon enter its twentieth year in China,” says Jin Tong. “We’ve completed a lot of work on the ground that draws on our science-based approach and international expertise to find viable solutions to China’s most pressing environmental challenges, such as the sponge city pilot project and the land trust reserves. In collaboration with PLC, we could amplify the success of demonstration projects to make larger-scale impacts and create enabling conditions to trigger systematic changes through research on China’s conservation strategies, policy, and finance,” she says. □

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WeChat Pay Shapes Street Life in China

FIRST RELEASED JUST SIX YEARS AGO, THE CHINESE SOCIAL-MEDIA APP WECHAT IS ONE OF THE MOST POPULAR IN THE WORLD, WITH A REPORTED 938 MILLION ACTIVE MONTHLY USERS. It caught on as a messaging service, and has kept adding features. One has become wildly popular in ways that have attracted widespread attention: payments. Visit any Chinese city today and you’ll quickly discover that the option to pay for practically anything by using a smartphone is pretty much inescapable.

The upshot is that WeChat Pay has emerged as a powerful example of a digital-payments ecosystem taking hold through a unique intertwining of mobile technology and the built environment. Along with a rival service called Alipay (offered by e-commerce giant Alibaba), it’s at the center of a digital phenomenon shaped in part by the city context—and one that may, in turn, affect elements of that urban context in the future.

The general notion of digital payment is nothing new. PayPal has been around for years; your credit card details are likely on file at a slew of online retailers; a solid and growing base of users rely on Venmo to make person-to-person payments; Apple Pay has forged deals to enable smartphone payments at a number of major retailers in the United States and beyond. And so on. But while 2016 mobile payments in the United States totaled US\$112 billion (RMB 742.7 billion), the figure in China was a reported US\$5.5 trillion (RMB 36.47 trillion). Beyond the numbers, the sheer ubiquity of WeChat Pay and Alipay has made the smartphone-as-virtual-wallet idea more overtly visible, something woven into the fabric of city life.

Accepting payment via WeChat requires a vendor to do little more than print out a unique QR code—essentially a more advanced form of bar code—and link it to a digital account; to make a payment, a customer can scan that code with a smartphone. Pony Ma, the CEO of WeChat parent Tencent, has called the QR code “a label of

abundant online information attached to the offline world.” For sellers, there’s no need for anything as complicated or expensive as the special devices a vendor typically needs to accept credit-card payments (or, for that matter, Apple Pay); anybody can print a QR code.

That’s one reason WeChat Pay caught on not just with larger established businesses, but also everything from small restaurants to street vendors. “It’s impossible not to use,” says Kate Austermiller, program manager for the China program of the PKU–Lincoln Center in Beijing. Skeptical at first, she now relies on WeChat Pay even for minor transactions like buying water or a piece of fruit from a vendor. “It’s almost faster than fishing through my purse for cash—my phone is always in a pocket,” she says. Even buskers use it to accept “tips” via a QR code, as easily as they might collect coins tossed into a hat.

WeChat Pay has emerged as a powerful example of a digital-payments ecosystem taking hold through a unique intertwining of mobile technology and the built environment.

The Better Than Cash Alliance—a United Nations-based organization focused on financial inclusion, with business, government, and other collaborating members—recently published an extensive case study focused on the rise of digital payments in China, and what that trend could mean globally. “Digital payments are very closely linked to financial inclusion,” observes Camilo Tellez, the head of research and innovation at the alliance. In China, Africa, and elsewhere, he explains, mobile payment systems have given millions of people their first direct link to the formal financial system.

To accept WeChat Pay, vendors like this Beijing grocer print a unique QR code and link it to a digital account; customers simply scan that code with a smartphone to pay. Credit: Tao Jin



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“In China it’s become really obvious that SMEs—small- and medium-sized enterprises—can really reap the benefits,” Tellez says. “Leveraging digital payment systems can actually allow them to access new forms of credit” unavailable to a pure-cash operation, he continues, and that can have a major impact on managing or even growing a business. A payment system folded directly into a social network has other advantages; the Better Than Cash Alliance report tells the story, for instance, of a hair stylist who used WeChat both to expand his customer base, and to avoid carrying too much cash when traveling among client appointments.

Because WeChat made it easy for all sorts of online vendors to use its platform (and even subsidized third-party developers to help them), users can now do anything from book a flight to pay utilities to reimburse a friend for a shared meal, without ever leaving the app. “People responded to it rapidly—it really provided a lot of

convenience,” says Zhi Liu, director of both the China program at the Lincoln Institute of Land Policy and the Peking University–Lincoln Institute Center for Urban Development and Land Policy in Beijing.

In fact, Liu confesses that while he’s not the type to jump onto the latest tech trend, this one made itself irresistible, even offline. He’d start looking around for an ATM to get the cash to, say, split a bill, and his colleagues “would just use a mobile phone and say ‘It’s done!’” Liu laughs. Pretty soon, you just get on board with everyone else. And thus the flip side: any given urban business quickly figures out that if every rival on the block accepts this payment form, it’s time to do the same.

Some country-specific factors have likely contributed to the digital-payment explosion in China. Its Internet ecosystem is distinct in part because familiar entities like Google and Facebook, among others, are essentially locked

out, and a kind of alternative universe of connected innovation has evolved. And in the case of these payment services, at least, Chinese regulators have so far allowed a fair amount of latitude for experimentation. (Current government planning around financial development through 2020 includes the specific encouragement of extending financial services to micro-businesses and low-income groups.)

And in China, digital payments arrived as an option in a fairly cash-based society—certainly compared to the deeply entrenched credit and debit card culture of the United States. (Some observers suggest that a Chinese aversion to debt makes digital payments preferable to the plastic alternative Americans in particular are so fond of.) The leapfrog from cash to digital seems to be happening elsewhere in the developing world, with the rapid rise of mobile as a driving factor. This has been amplified by population shifts toward urban centers, where job opportunities concentrate, that make the ability to stay connected with family or other contacts across physical distances more important.

WeChat isn’t the only digital payment player, or even the first, in China. Alibaba Group’s e-commerce platform dates back to the late 1990s, and evolved from a business-to-business marketplace into a variety of digital-payment

products and services that made the company a global powerhouse. Its Alipay app was early to target brick-and-mortar merchants with an offline, QR code–based payment system. But it is widely acknowledged that when WeChat creator Tencent put its payment feature on the map with a major marketing push a couple of years ago, it was a game-changer.

Cleverly, the campaign played off a tradition of making monetary New Year’s gifts of cash in red envelopes. WeChat offered a digital Red Packets promotion, and an estimated 5 million users participated—learning in an instant to associate the social network with payments. For Tencent, the payment feature isn’t necessarily conceived of as a profit center, but as another attraction keeping WeChat users locked in to a service that profits from games and advertising. The company has subsidized third-party developers to help more businesses adopt WePay, and peer-to-peer transactions are free.

The more WeChat Pay took off, the more Alipay countered with its own competitive moves. Both systems are now widely available in China—and compete with various “cashless society” promotions involving discounts or rebates—and the companies are each diving into markets elsewhere, sometimes in partnership with local players.

As digital payments have become a routine part of city life, they’re already subtly shaping it. Tellez, of the Better Than Cash Alliance, points to the effect on utility cost-recovery and toll collection, particularly in developing-world contexts; and, for even small businesses, the ability to collect and leverage useful transaction data. And as Liu points out, the broader potential of higher-level data collection is tantalizing. Clearly there are privacy-related concerns about how such data is shared and utilized. But in an academic or planning context, it may offer a window on day-to-day economic behavior that can give us a whole new way to, as Liu puts it, “understand the city.” □

A vending machine in Shenzhen accepts WeChat Pay. Credit: Nagarjun Kandukuru/Flickr



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Revitalizing America's Smaller Legacy Cities: Strategies for Postindustrial Success from Gary to Lowell

By Torey Hollingsworth and Alison Goebel



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The cities differ greatly—some benefit from proximity to big cities like Philadelphia and New York, while others are more isolated—but they share much in common. They are grappling with persistent poverty, inequality, and blight, which were compounded by the Great Recession. They seek to attract young professionals and startups to become affordable alternatives to hot market cities, but they also need to nurture their existing populations across all incomes and skill levels. They first rose to prosperity amid a wave of immigration, and many recognize the role of immigrants in their resurgence a century later.

“No two places are alike, but smaller legacy cities can learn from each other as they reposition themselves, whether as a regional service center, a competitor on the national or global stage, or a tourism hub,” the authors said. “They will need to build teams from the public and private sectors who share a spirit of collaboration and the will to lead their communities through a period of great transformation.”

FROM GARY, INDIANA, TO LOWELL, MASSACHUSETTS, SMALLER POSTINDUSTRIAL CITIES ARE TAKING STRATEGIC STEPS TO REGENERATE—with the chance to follow their larger rebounding counterparts like Pittsburgh and Cleveland—by building on downtowns, capitalizing on a unique sense of place, and focusing on workforce development, according to a new report published by the Lincoln Institute of Land Policy in partnership with the Greater Ohio Policy Center.

These smaller cities, with populations of 30,000 to 200,000, are reeling from the same loss of population and manufacturing jobs as Baltimore or Detroit, but they often lack the big universities, hospitals, or philanthropies that have boosted larger cities. They gained national attention when President Trump's message resonated with voters who had long supported Democrats in cities like Scranton, Pennsylvania, hometown of former Vice President Joe Biden. Once powerhouses of the American economy, some now conjure images of abandoned steel

mills and factories, and vacant houses and storefronts.

“The challenges faced by smaller legacy cities loom large in the American imagination,” authors Torey Hollingsworth and Alison Goebel of the Greater Ohio Policy Center write in *Revitalizing America's Smaller Legacy Cities: Strategies for Postindustrial Success from Gary to Lowell*. “It's no coincidence that Billy Joel and Bruce Springsteen chose Allentown, Pennsylvania, and Youngstown, Ohio, respectively, as symbols of the demise of a certain kind of American dream.”

The report makes the case for reinvesting in smaller legacy cities and explores strategies that have shown promise in some places. It examines 24 cities across seven midwestern and northeastern states: Michigan, Indiana, Ohio, Pennsylvania, New York, New Jersey, and Massachusetts. It measures each city's progress from 2000 to 2015 using a range of indicators, from employment to population change, and describes revitalization strategies that have succeeded thus far.

“Smaller legacy cities can learn from each other as they reposition themselves, whether as a regional service center, a competitor on the national or global stage, or a tourism hub. They will need to build teams from the public and private sectors who share a spirit of collaboration and the will to lead their communities through a period of great transformation.”

The report recommends eight strategies for revitalization that have shown promise in some places:

- **Build civic capacity and talent:** Cities like South Bend, Indiana, and Hamilton, Ohio, created fellowships to place talented young workers in management-level positions in the private and public sectors, and Hamilton recruited a city manager from outside the city to change the culture of City Hall.
- **Encourage a shared public- and private-sector vision:** In Lancaster, Pennsylvania, the private sector led the deployment of a plan that reimagined the city as a tourist hub, and in Grand Rapids, Michigan, business leaders created an organization that revitalized the central business district.
- **Expand opportunities for low-income workers:** Lima, Ohio, has created an umbrella organization to coordinate workforce development efforts, and in Syracuse, New York, the regional chamber of commerce tied a redevelopment project to high-paying jobs and skills training.
- **Build on an authentic sense of place:** Bethlehem, Pennsylvania, converted part of a closed steel plant into an arts and cultural campus, and Scranton encouraged former residents who had moved to New York or other large cities to return home, emphasizing quality of life.
- **Focus regional efforts on rebuilding a strong downtown:** Syracuse prioritized downtown revitalization efforts to help create jobs and attract talented workers, and York, Pennsylvania, created a business improvement district to re-create the downtown as a retail center.
- **Engage in community and strategic planning:** Dayton, Ohio, and Flint, Michigan, have engaged residents in tough conversations about future land use after extreme population losses.
- **Stabilize distressed neighborhoods:** Youngstown used data to pinpoint struggling neighborhoods and prioritize funding to triage housing in poor condition.

- **Strategically leverage state policies:** Ohio authorized counties to create local land banks to respond to the vacancy and foreclosure crisis, and Massachusetts is collaborating with a statewide think tank to direct resources to targeted legacy cities.

Revitalizing America's Smaller Legacy Cities is a follow-up to the Lincoln Institute's 2013 report, *Regenerating America's Legacy Cities*, which focuses on larger cities such as Detroit, Baltimore, Cincinnati, and Pittsburgh. It marks the latest step in the Lincoln Institute's ongoing initiative to help build the capacity of legacy cities to thrive in the 21st century, and to ensure that all residents enjoy the benefits of revitalization. □

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