Boundary Issues: The 2016 *Atlas of Urban Expansion* Indicates Global Dedensification

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Abstract

Cities around the world are consuming land at a rate that exceeds population growth, according to the 2016 Atlas of Urban Expansion*—a precise analysis of 200 global urban growth boundaries drawn from satellite images, population figures, and other data. Produced through a partnership among the United Nations Programme for Human Settlements, the New York University Urban Expansion Program, and the Lincoln Institute of Land Policy, the study parses the drivers and effects of sprawl and creates the basis for a science of cities. This article examines some of the critical findings of the* Atlas of Urban Expansion*, such as a general trend of falling density across the world's cities, as well as the identification of a variety of aerial visual signatures of unplanned settlements. Future data collection challenges and implications for land use policy are discussed.*

Introduction

When city growth comes up in public discourse, the conversation nearly invariably focuses on population. We speak of booming cities that have grown from, for example, 2 to 5 million in population in only a few decades or declining cities that are hollowing out and losing residents at a rapid rate.

The common unit of understanding and measurement, in other words, is nearly always the number of people. Measures of land use are often missing from the picture, despite the fact that cities grew much more in land use than in population between 1990 and 2015, according to data (UN-Habitat, 2016a) from the United Nations Programme for Human Settlements (UN-Habitat).

In developed countries, urban population grew 12 percent while urban land use increased 80 percent. In developing countries, population expanded 100 percent and urban land use rose 350 percent.

Land use issues will become more critical as the world population exceeds 9 billion and 2.5 billion persons migrate to cities by 2050, according to United Nations (UN) projections. Configuring urban areas and their available resources to support this massive inflow will be crucial to sustaining human life on the planet (Buhaug and Urdal, 2013; Angel, 2012).

How exactly are these rising urban populations changing global maps? Further, can we observe regular, even predictable, patterns? Are these trend lines, such as they are, sustainable over time?

To date, little scientific understanding exists of broad global patterns related to how city borders, systems, and land use patterns are changing. The online *Atlas of Urban Expansion* (hereafter, the *Atlas*) aims to fill this crucial gap in knowledge (Angel et al., 2016). Produced through a partnership among UN-Habitat, the New York University Urban Expansion Program, and the Lincoln Institute of Land Policy, the new *Atlas* performs precise analysis of satellite imagery, population figures, and other data to study the changing nature of cities from 1990 to the present. The full report and data were unveiled in October 2016 at the Habitat III global cities summit in Quito, Ecuador, as part of the implementation of the UN's *New Urban Agenda*.

The new *Atlas* analyzes 200 cities (up from 120 in the 2012 sample), selected from among the 4,231 cities in the world with populations greater than 100,000 (as of 2010), which constitute a stratified sample of large urban areas. The 200 cities in question contain about 70 percent of the world's urban population (Angel et al., 2016).

The UN statistics division has now accepted and adopted this UN Sample of Cities as a way to conduct ongoing analysis of urbanization trends (UN-Habitat, 2016b). "Cities, how they form, and the effects of urbanization on the quality of human life must now be treated as a science. The unprecedented confluence of climate change, population boom, and the rush to live in cities means that our critical human development will take place in cities" (UN News Centre, 2016).

With unplanned settlement fluidly redefining many urban boundaries, experts and planners say that producing a consistent method for studying cities as contiguous spatial units, not only administrative jurisdictions, is crucial (Angel, 2016). The UN Sample of Cities also enables transition from an urban agenda based on country-level data to one predicated on city-based data collection and analysis.

Studying such a sample enables us to infer some generalizable rules about large urban areas. "The sample accurately represents that universe, so you can actually make statements about that universe given information about the sample. That's the more scientific contribution of this *Atlas*" (Angel, 2016).

Land Consumption and Dedensification

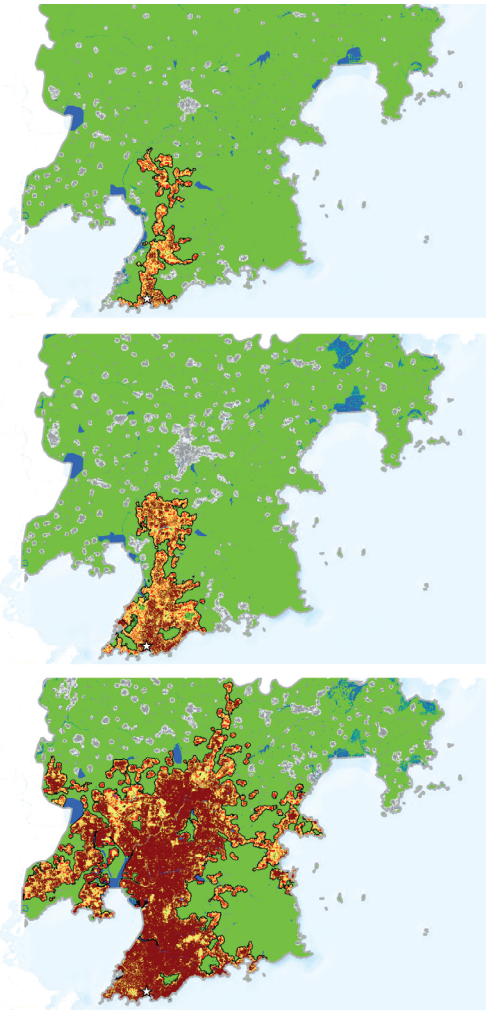
One reliably observed pattern is that cities around the world are stretching out physically and consuming land at a rate that exceeds population growth. This tendency corroborates the findings of the first-edition *Atlas*, which indicates falling density (Angel et al., 2016). In the past, falling density was

termed "sprawl," and some refer to it now as "dedensification." In any case, for a planet increasingly concerned with sustainability, energy efficiency, climate change, and resource scarcity, falling density is a troubling trend. Density generally allows for greener and more sustainable living patterns.

Qingdao, China, had among the fastest rates of population growth and outward urban expansion in the UN Sample of Cities. Population grew at an average annual rate of 7.2 percent per year between 1990 and 2013, rising from 853,000 to 4.5 million, and the built-up area associated Qingdao's urban extents grew even faster, at 11.6 percent per year. Qingdao's expansion areas revealed mostly planned, orderly extensions. Exhibit 1 shows the city in 1990, 2000, and 2013.

Exhibit 1

Urbanization in Qingdao, China, in 1990 (Top), 2000 (Middle), and 2013 (Bottom)



Note: The brown sections are built-up urban areas, red sections are built-up suburban areas, black sections are built-up rural areas, light green sections are urbanized open space, and green sections are rural open space.
Source: New York University, Urban Expansion Program

Angel (2016) noted a kind of rough statistical rule that emerges from the new *Atlas* work—as populations double, land use triples. Many policymakers have been unable, or unwilling, to see this reality unfolding in recent decades.

Chen (2016) observed that the issue of sustainable growth is "very uneven in terms of planning officials' awareness." In many countries, "various orthodoxies are battling it out," and frequently the "cards are stacked against us" in terms of changing norms and official attitudes. "For many, many decades, and in some countries for centuries, there have been incentives [for] building on virgin land." Even where political will for change exists, there are "multiple dimensions of capability to build upward, such as in-ground infrastructure" (Chen, 2016). Wider complex systems must be coordinated from a policy perspective in order to achieve greater density and land conservation.

In any case, the data analysis effort undertaken in the *Atlas*—which at root is intended to help define a new "science of cities"—may serve as a wakeup call. Angel said the *Atlas* can be a "tool for convincing policy makers that the expansion they must prepare for is considerably larger than their own little back-of-the-envelope calculations, or what their planners have in their master plans" (Angel, 2016).

Increasing density again will necessitate sacrifice and modification of existing norms for living standards in many places. It will require people to live in smaller apartments and homes, in multifamily housing, and in higher buildings. It also will frequently require redevelopment of low-density areas in cities.

McCarthy commented that the data are "a little bit chilling," as they reveal a pervasive pattern that signals substantial trouble ahead. "It's something that we have to stop—whether we call it 'sprawl' or 'de-densification' or something else. We can't continue to consume all of our best land with urban development. We still have to feed ourselves. We still need to collect water" (McCarthy, 2016).

McCarthy also noted many ill-fated attempts to build large housing units far outside denser urban areas, leaving millions of units across the world largely empty. These failed attempts have happened in many countries, from Mexico and Brazil to South Africa and China. "Why is it that we continue to build these developments in the middle of nowhere and expect people to live there?" McCarthy (2016) noted. The lesson is that it is vital to link jobs and industrial activity with housing.

More proactive planning clearly is required for growth across the world, according to *Atlas* researchers. That means finding the right ways to channel city growth spatially and to create the infrastructure—transportation, water, sewer, and other necessities—so the new settlements and housing units are serviced appropriately.

Moreover, it is also necessary, *Atlas* researchers say, for many of the big cities around the world—from Lagos, Nigeria, to Mexico City, to Zhengzhou, China—to adopt more next-generation thinking about so-called "polycentric" cities. That will require moving beyond the traditional paradigm of hulking, monocentric cities with a huge urban core and instead creating polycentric networked hubs, whereby a metropolitan area will have many interlinked urban centers.

Signatures of Unplanned Settlement

The satellite imagery analyzed in the *Atlas* also highlights other key patterns that are both drivers and symbols of the overall dedensification trend worldwide.

One granular mark is a lack of four-way intersections, a clear sign that roads are being laid out haphazardly. Such informality and unplanned development have been increasing over time across the world. The pattern, however, is strongly correlated with lower gross domestic product, or GDP, per capita, and therefore is more pronounced in the developing world and global south. Linked to this observed pattern is an increase in urban block size, as shantytowns and unplanned settlements of many kinds grow without regard to transportation needs.

Exhibit 2 shows clear qualitative differences in the layouts of streets and blocks in the expansion areas of Kozhikode, India (top), which were mostly unplanned, and Qingdao (bottom), which were mostly planned. From 1990 to 2014, 28 percent of Qingdao's built-up area was in roads and streets compared with 8 percent in Kozhikode; four-way intersection and average block sizes were 51 square kilometers and 4.7 hectares, respectively, in Qingdao compared with 10 square kilometers and 7.5 hectares, respectively, in Kozhikode. The amount of residential development in formal land subdivisions or housing projects accounted for 76 percent of Qingdao's expansion area compared with 1 percent of Kozhikode's.

Exhibit 2

Layout of Expansion Areas in Kozhikode, India (Top), and Qingdao, China (Bottom)

Source: Bing

The *Atlas* also suggests a pervasive lack of orderly connections to arterial roads, which are key to facilitating transportation to employment and economic networks. Built-up areas within walking distance of wide arterial roads are less frequent than they were in the 1990s, according to data from that decade (Angel, 2012). More generally, there is simply not enough land being allocated for roads.

In many unplanned, rapidly growing cities such as Kozhikode, poor road network connectivity and the low share of land in streets compromises mobility and poses serious economic challenges for residents (exhibit 3). Obtaining city-level estimates for urban layout metrics required analyzing dozens of quasi-randomly located 10-hectare study areas, or locales, distributed throughout a city's entire expansion area.

In addition, low-density tracts and small dwellings are unnecessarily consuming precious urban open space—parks and green spaces that can make dense urban areas more livable.

Angel (2016) noted that planners need to get ahead of the coming wave of urban migration and secure land for transportation, affordable housing, arterial roads, and open space. That kind of planning needs to happen before settlement, after which land prices soar and the logistics of moving populations become trickier. "This can be done at a relatively small cost," said Angel (2016), who suggested that planners begin to "make some minimal preparations for it."

Even in countries where a high degree of central planning occurs, the data contained in the *Atlas* may prove helpful for diverse land management challenges. According to Liu (2016), "Compared to most cities in the developing world, Chinese cities are better managed. The *Atlas* is still useful for China, as it provides accurate, visual urban expansion data and analytics to planners that could strengthen their understanding of the scale and patterns of urban expansion in their cities."

Exhibit 3

Digitization of Road Features in Kozhikode, India (Left), and Qingdao, China (Right)

Source: Google

The *Atlas* Data Challenge

The data collection and analysis that went into producing the *Atlas* highlight future challenges for urban theory and monitoring of global cities, especially in developing nations. Blei (2016) acknowledged that assembling the 200 cities for the stratified sample was difficult, as no universally accepted definition exists for a metropolitan area. Researchers had to account for variables such as regional location, growth rate, and population size in order to ensure the sample was valid, and they had to create a careful and defensible methodology.

The National Aeronautics and Space Administration (NASA) Landsat database, a satellite imagery program running since the 1970s, was the basis for the spatial analysis (NASA, 2017) Although that methodical, scientific data set is of exceedingly high quality, the underlying population data, which were key for establishing migration- and settlement-related patterns, were frequently less than perfect.

"Some countries have very well-established data programs," Blei (2016) noted. In other cases, however, the data are very coarse, and large cities, particularly in the developing world, have only broad census zones. It is therefore difficult, at times, to make fine-grained insights about population changes in connection with land use shifts, because the researchers had to assume equal density over large tracts of the metropolitan area in question.

Scanning the NASA pictures, the researchers analyzed pixels to identify impervious coverage surface or soils. They performed this task with powerful software according to well-established methods, but correlating it with population data was not always smooth. "Unfortunately, there's not very much we can do if the data are not very good, but we did the best we could under the circumstances," Blei (2016) noted.

Evidence suggests the need for less variation in population data collection and synthesis across countries to derive more actionable insights for policymakers in every country. More global consensus is needed around the definition of cities. The U.S. Census Bureau (Wilson et al., 2012) defines them very precisely as "urbanized areas," or "metropolitan statistical areas," but they are frequently defined in more scattered ways by other countries' data collection agencies. Asia and Africa—home of many of the fastest-growing cities, both in terms of population and geographic extent—suffer from a lack of granular city population data that speak to neighborhood-level change.

Global Nuances and Uncertain Futures

The *Atlas* contributes to a long debate in policy and academic circles about how to measure sprawl, both high and low density, and the best models for addressing related issues. The *Atlas* also speaks to a long research literature on the consumption of resources and quality of life in urban contexts.

Silva (2016) said that the *Atlas* research will continue to help advance understanding of government planning and rulemaking and of residential pricing. The 2016 *Atlas* project includes surveys conducted with various stakeholders in cities that might yield insights on planning policies and markets, among other issues.

Silva (2016) noted, "it's definitely an effort that is needed. It's a first-mover type of project. The measure of success will be the extent to which other researchers, whether through critique or support of the initial idea, can improve upon it and contribute to our understanding of how cities are growing, or even contracting."

It will also help ground-level understanding for those studying or making policy in particular cities. Silva (2016) pointed to Buenos Aires, Argentina, which he called a "classic case" where the expansion of territory is occurring faster than the population growth—and where many people are being displaced outward from the denser city core. Silva said that research by Goytia et al. (2015) has shown how lax land use regulation affects settlement patterns. Land markets and their regulations affect affordability, and these dynamics can result in unplanned settlements.

Kudva (2016) praised the "very careful work" performed in the *Atlas* effort. She worries, however, that smaller cities—those with populations of less than 100,000 and therefore excluded from the analysis—may see different dynamics that are subject to more variable patterns and experiences.

In trying to create "one science of cities," she noted, planners and policymakers may miss significant differences between small and big metropolitan areas, limiting the capacity to imagine creative interventions. "The difference between small and big can be the ability to influence political processes, the ability to garner funds, to organize, to intervene. For a person like me who is interested in smaller places, things like the *Atlas* provide important suggestions, important points of reference, important counterpoints, but they are not always useful" (Kudva, 2016).

Kudva also noted that it is possible large-scale, emerging changes related to energy systems, global warming, sea-level rise, and political upheaval may alter worldwide land use patterns compared with those observed in the past. The issue of falling density is potentially reversible, she said. "That trend could change. We need to play a more interventionist role" (Kudva, 2016).

Nonetheless, better data and a more detailed picture of settlement patterns could help substantially address challenges common to cities of many different sizes. Chen (2016) noted that research like the *Atlas* is necessary to combat issues such as unequal access to opportunity. "We need baseline data, and we need to understand the relationship between how we use land and other things."

The issue of global inequality, which McCarthy (2016) called the biggest "unassailable challenge" of cities, looms in all the data. Beyond the layers of the global maps in the *Atlas* are facts and dilemmas that researchers and policymakers are only beginning to understand and address. "The biggest one is the absolute concentration of poverty and geographic isolation of large segments of the population," McCarthy (2016) observed, noting that sometimes 30 to 50 percent of residents in many large cities live in "deplorable conditions."

Decent affordable housing that is meaningfully integrated into the economic network and flow of cities has to be a priority. Many national efforts to date have failed to achieve that goal, however. "That's the thing that I find most vexing," McCarthy (2016) said.

That issue—and many others affecting the world's fast-growing cities—is framed more precisely and powerfully by the new, comprehensive data.

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