



**Upward and Outward Growth:** Managing Urban Expansion for More Equitable Cities in the Global South

#### Anjali Mahendra and Karen C. Seto

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## **EXECUTIVE SUMMARY**

### **Highlights**

- Urban areas are expected to triple in size between 2000 and 2030. Assuming constant annual rates of growth, this would mean that we expect urban areas to increase in size by 80 percent between 2018 and 2030.
- New analysis of the upward and outward growth of 499 cities over time confirms that the challenges of rapid outward expansion are greatest in lower-income cities that have weak planning and land governance and less mature financial markets.
- Unmanaged urban expansion increases the costs of service provision, deepens spatial inequities, and imposes heavy economic and environmental burdens. This paper highlights three key equity challenges linked to rapid outward expansion in cities of the global South: distorted land markets, deficient services in growing areas, and disjointed informal expansion.
- We highlight three strategies to address these challenges: prioritize spatial equity over land speculation through regulations and incentives, incrementally increase the supply of serviced land with partnerships to finance core services, and integrate existing informal settlements while creating affordable density.
- As land-use policy changes play out over long time frames, urgent strategic action led by the public sector is crucial to steer urban growth in a way that enhances equitable access and brings economic and environmental benefits to the whole city.



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## **Growing Cities with Expanding Footprints**

By 2050, 2.5 billion more people will be added to the world's urban areas. Countries in Asia and sub-Saharan Africa are poised to experience the highest rates of urban population and land area growth. Many cities in these regions need more land for housing and infrastructure so they can accommodate new urban residents, but they have limited capacity for governance and tax collection and fewer resources for core urban services.<sup>1</sup> Much empirical evidence exists on how a city's increased spatial extent and decline in its population density increases its per capita costs to provide public services as well as the social costs associated with congestion, pollution, and urban inefficiencies.<sup>2</sup> These land development patterns are difficult to reverse and significantly affect the consumption of resources such as land, energy, and water. Therefore, how cities manage their growth in coming years will determine their overall sustainability.

### The Social, Economic, and Environmental Consequences of Unmanaged Urban Expansion

Residents in areas without access to good quality urban services—such as housing, energy, transportation, water, and sanitation—must rely on alternate, costly, and often unsafe means of service provision. Analysis of spatial indicators of access to services in this paper illustrates severe service provision gaps in peripheral locations of Mexico City and Bangalore. Evidence from Argentina shows that cities with higher expansion rates are more unequal in terms of access to services.<sup>3</sup> Data from Indian and African cities show that access to multiple urban services drops sharply even just five kilometers from the city center.<sup>4</sup> As a result, between 25 and 70 percent of urban populations in the global South rely on informal arrangements to procure core services.<sup>5</sup>

Rapid, unplanned growth imposes heavy burdens on environmental resources and quality. Some of the fastestgrowing urban areas are in low-elevation coastal zones and face limited water availability.<sup>6</sup> Rampant illegal construction on urban flood plains and water bodies is responsible for disastrous flooding from seasonal monsoon rains in many cities of South Asia. Increased greenhouse gas emissions, air pollution, and urban heat effects have all been linked to sprawled growth. Rapid growth in urban land cover is occurring in biodiversity hotspots.<sup>7</sup> Multiple agencies control land and provide services in peripheral locations of fast-growing cities, making governance challenging. As cities expand outward, technical capacity and financial constraints limit the extent to which utilities can expand service networks. Growing peri-urban areas are often located across jurisdictions of multiple local-level agencies (and sometimes regional, state, or rural agencies) that may have functional autonomy but do not coordinate on service provision. Jurisdictions of service-providing agencies do not always match, creating significant governance challenges.

### **About This Paper**

This working paper is part of the World Resources Report (WRR) Towards a More Equal City, which views sustainability as composed of three interrelated issues: equity, the economy, and the environment. The WRR examines whether the equitable provision of urban services to meet the needs of the underserved can improve the other two dimensions of sustainability. This paper examines how urban expansion can be managed in a way that achieves more equitable access to core services for the under-served while bringing wider economic and environmental benefits to cities. It presents new analysis of the growth in urban built-up area over a decade in 499 cities with populations greater than 1 million and develops new metrics to measure changes in their outward and upward growth. The analysis highlights regional trends in urban expansion, differences in urban structure within and between cities, and combines this information with urban population and economic growth projections.8

Based on a review of evidence from multidisciplinary literature and structured consultations with over 20 urban land experts, we discuss key forces driving urban expansion in the global South, three main equity challenges, and high-priority strategies to address these. The strategies discussed are particularly suitable for cities experiencing rapid urban growth with limited financial, technical, and governance capacity—that is, those categorized as *struggling* and *emerging* in the WRR.<sup>9</sup>

This paper argues that while some urban land expansion is inevitable with increasing urbanization, the pace, scale, and nature of this expansion can be managed through a few proven strategies. The strategies proposed are expected to be useful for public sector agencies, private actors, civil society, the development and research community, and other urban change agents working towards more sustainable urban growth patterns.

### Measuring and Analyzing Urban Growth Patterns

Definitions of what is urban are inconsistent, and single spatial measures of urban growth do not capture the heterogeneity that exists in a single city. Urban growth is more accurately characterized when examined in both the horizontal (outward) and vertical (upward) dimensions. The majority of remote sensing studies look only at outward growth, ignoring inner-city redevelopment and densification changes. Problems of spatial equity are even more complex to assess because informal settlements or slums are difficult to characterize accurately through standard satellite-based methods of analysis. Socioeconomic indicators that track people's access to services are not consistently defined or measured, and they are rarely expressed spatially, thus missing under-served locations within the city. On combining remote sensing data with urban demographic and economic indicators, we found that many lower-income cities categorized as struggling and emerging are experiencing significantly more outward growth than upward growth (see Figure ES-1).<sup>10</sup>

#### Figure ES-1 | Upward and outward urban growth for 499 cities



Source: Authors' analysis, using 2000–2014 data from the Global Human Settlement Layer to determine the Outward Growth Index and the power ratio from NASA's SeaWinds microwave scatterometer from 2001 to 2009 to determine the Upward Growth Index. See calculation methodology in Appendix A.

## Key Forces Driving Urban Expansion and Challenges to Equity in the Global South

Multiple drivers are responsible for cities' rapid outward growth, some of which are within a city's control, and some of which are not. Cities grow due to natural population increases, in-migration related to the pursuit of economic opportunities, or because urban administrative boundaries are reclassified to expand their area.<sup>11</sup>

#### A first key challenge is the presence of distorted land markets that offer few returns to public sector stakeholders.

In many cases, government-led investment in residential, industrial, and infrastructure development leads to expansion of land area. Private landowners, real estate developers, and corrupt public officials are often the disproportionate beneficiaries of the land value increases that result from urban development. This motivates a form of exploitative speculation in land values that makes land markets inequitable in many struggling and emerging cities, and occurs due to shortages of land and housing.

#### A second key challenge involves deficient services in

**growing areas.** Housing policies that set ambitious targets for affordable housing units without paying attention to their location have caused large-scale peripheral expansion with limited service provision across Mexico, Brazil, South Africa,<sup>12</sup> and other countries. Weak planning and land governance regimes, coupled with existing land-use regulations, create incentives for expansion.

**Finally, the third important equity challenge pertains to disjointed informal expansion.** Peri-urban areas across much of Asia and sub-Saharan Africa comprise agricultural land, villages, or traditional settlements, often with informal or undocumented property rights. These areas are being rapidly absorbed into cities<sup>13</sup> as either informal settlements with no public services or as privatized developments with largely unaffordable markets for land and services.

### Three Priority Strategies to Manage Urban Expansion for Increased Equity, Productivity, and Environmental Quality

## Strategy 1. Use regulations and incentives to prioritize spatial equity over land speculation

Serviced land that is near employment opportunities and urban amenities is in short supply in many growing cities of the global South. This leads to excessive land value speculation that commodifies land and exacerbates spatial inequalities.<sup>14</sup> Private developers' interest in building more high-end properties than affordable housing is one reflection of this and is a trend observed in many Asian and African cities.<sup>15</sup> Cities can ensure that land-use regulations increase public welfare without creating additional distortions and develop complete land records to facilitate the process.

**Establish incentives to direct development towards specific locations within cities.** Regulations that incentivize the development of land in well-serviced locations or where private developers contribute to the costs of service provision have achieved more equitable outcomes. For example, Brazil and Mexico provide national housing subsidies to developers that build affordable housing in designated zones based on access to core services and employment.<sup>16</sup> In 2013, 80 percent of housing was built in these identified zones in Mexico.<sup>17</sup> In 2003, South Africa passed a law offering tax incentives to developers to build, extend, or improve buildings in specific urban development zones (UDZs). In Johannesburg, the city with the largest UDZ, this was accompanied by the development of publicly available land records in partnership with property owners.<sup>18</sup>

Impose time limits on landholding and tax vacant land and buildings. Cities must enforce time limits on landholding and impose taxes on vacant land to prevent land hoarding or high vacancy rates because land and housing units are often not brought into the market in pursuit of speculative returns.<sup>19</sup> Several Latin American countries, along with China, tax vacant land to reduce speculation, induce development, and bring vacant units into the rental market.<sup>20</sup> As a strategy to limit speculation and discourage land hoarding, some countries (such as Sri Lanka, Malaysia, and Colombia) temporarily freeze land values in locations where major urban development schemes have been announced.<sup>21</sup>

# Strategy 2. Incrementally increase the supply of serviced land by forming partnerships to finance core services

To achieve inclusive urbanization, it is necessary to increase the availability of serviced land for affordable housing in environmentally secure and economically connected locations.<sup>22</sup>

#### Increase the supply of serviced land for affordable development.

Land readjustment approaches allow cities to negotiate and partner with landowners to acquire land for public purposes, including for roads, underlying infrastructure, low-income housing, and open spaces. In Seoul, South Korea, 40 percent of the city has been developed through land readjustment over time, in an approach framed as "build together, benefit together."23 This generated over one-third of the land for roads and public facilities, with a sixfold increase in the value of the remaining serviced land.<sup>24</sup> This also generated financing for the city to extend infrastructure. Another example comes from Ahmedabad, India, which utilizes Town Planning Schemes to generate land for new development and affordable housing with enhanced access to core services.<sup>25</sup> Acquiring land to provide rights of way for future urban services is a strategy being used in Colombia; it has been scaled into a national program to plan for urban expansion.<sup>26</sup>

#### Create partnerships to finance and deliver core services.

Partnerships between cities and service-providing agencies can ensure that new developments are well serviced and inclusive. Brazilian cities feature large-scale projects known as Urban Operations (UOs), which are planned by the public sector. The UOs specify percentages of public-private contributions to costs and revenue sharing, and private developers are incentivized to build within them. The sale of development rights within UOs generates up-front resources for infrastructure provision. In partnership with landowners, land readjustment projects in Colombian cities such as Bogotá and Pereira have been used to generate serviced land specifically for low-income housing projects and community facilities.<sup>27</sup>

## Strategy 3. Integrate existing informal settlements while creating affordable density

Informal settlements provide much-needed affordable housing in growing cities, but they exist in a legal gray space. Integrating existing informal or unregularized settlements within the city's formal jurisdiction and improving them is an important way of maintaining residents' social and economic networks while reducing the need for more urban land.

**Extend core services to informal settlements.** In Medellín, Colombia, the public sector utility company Empresas Públicas de Medellín, which provides electricity, gas, water, sanitation, and telecommunications services, has for decades run a program called Habilitación de Viviendas to extend services to the city's growing informal settlements.<sup>28</sup> Similarly, the Social Urbanizers project in Porto Alegre, Brazil, features engagement between municipalities and private sector informal developers to ensure minimum levels of service provision and better-planned informal subdivisions. This experience has been replicated in Colombia and El Salvador.<sup>29</sup> Regularization programs in Rio de Janeiro and other Brazilian cities have provided legal titles and upgraded services at the same time.<sup>30</sup>

#### Create affordable density through flexible planning standards.

With or without regularization, service provision in existing informal settlements must go hand in hand with flexible minimum planning standards if settlements are to be integrated into the network of core services while remaining affordable and adequately dense. Inclusionary zoning, such as the Zones of Special Social Interest used in Brazilian cities, allows less restrictive densities and building standards and features lower transaction costs for building approvals. Existing informal settlements—such as Khuda-ki-Basti 3 in Karachi (Pakistan), La Candelaria in Medellín (Colombia), and in Windhoek (Namibia)—utilized smaller plot sizes and lower infrastructure standards to increase affordability, with the ability to densify over time. Sites-and-services projects in the Indian cities of Mumbai and Chennai used similar principles to allow for incremental development while allocating space for commercial and social services and facilitating greater density through a hierarchy of streets and open spaces.<sup>31</sup>

### Enabling Conditions that Support Priority Action Areas

The above strategies cannot be considered mutually exclusive; they may be implemented simultaneously or sequentially, on their own or as a package of measures, and require the following common enabling conditions.

**Governance.** Transparent records of land titles and transactions are a prerequisite to developing effective regulations and incentivizing developers. Greater city-level authority to enforce development plans and fiscal incentives from higher levels of government (national, state, and metropolitan) can foster cross-jurisdictional, cross-sectoral coordination for improved service provision. Landrelated policies and plans must prioritize public participation, must be enforceable, and should include mechanisms that prevent these from being challenged or altered by politicians and private players acting in their own short-term interests.

**Urban planning and management.** It is essential to simplify time-consuming and costly administrative processes in order to more effectively enforce land-use plans and regulations and to limit informality. City planning agencies must be proactive and innovative about strategic planning for future growth. The impacts of existing regulations must be monitored regularly to ensure they remain valid under changing development costs and household incomes.<sup>32</sup> Building codes and planning standards for core services must be flexible to match different modes of service delivery and different income levels, and they must be coordinated with available development budgets. Proposals for revised land-use and built-form regulations that respond to growth patterns and new needs must be systematically pilot tested to ensure they are practical for unique circumstances in different types of neighborhoods.

**Finance.** A more transparent property tax system can help discourage speculation, stimulate land development, and increase the provision of urban infrastructure and services. This is the first step towards more sophisticated land value capture instruments. Land value capture tools such as betterment contributions,

development impact fees, and charges and auctions for building and air rights are rarely used in lower-income cities, but have significant potential to generate much needed local revenues.

**Technology and spatial data sharing.** The use of advanced technologies such as satellite imaging and drone surveys, supplemented with community-gathered data on access to core services, has helped shed light on under-served settlements. Spatial data on these indicators are often missing and must be gathered, mapped, combined with other big data, and shared across service-providing agencies to ensure more integrated and inclusive planning.

#### Conclusions

Unmanaged urban expansion creates spatial inequities in accessing core urban services while limiting economic productivity and damaging the environment. The analysis of trends and evidence on key forces driving urban expansion shows that expanding cities in the global South face three important challenges: distorted land markets, deficient services in growing areas, and disjointed informal expansion.

We have identified three priority strategies that cities can implement to address these challenges: use regulations and incentives to prioritize spatial equity over land speculation, incrementally increase the supply of serviced land by forming partnerships to finance core services, and integrate existing informal settlements while creating affordable density. Figure ES-2 highlights the three challenges, strategies to address them, and the enabling conditions needed to achieve them.

These strategies require action by diverse urban change agents. It is only through well-structured partnerships between these actors that urban expansion can be managed in a way that meets the needs of the under-served while bringing economic and environmental benefits to the city as a whole (see Figure ES-3). Given the long time frames over which land-use changes occur, strategic action led by the public sector to actively plan for and manage urban growth in an appropriate manner is both crucial and urgent.

## Figure ES-2 | Challenges and approaches to managing urban expansion in the global south, with necessary enabling conditions



Source: Authors.

## Figure ES-3 | Recommended approaches for managing urban expansion in the global South—benefits for equitable access, the economy, and the environment



Source: Authors.

## **1. EXPANDING CITIES IN A MORE** URBAN WORLD

Cities around the world are exploding in size. More people are attracted to urban areas for their many economic, cultural, and educational opportunities. For the first time in recorded history, a majority of the world's population is now classified as urban. Recent United Nations (UN) forecasts indicate that between 2010 and 2050 the urban population in developing countries is likely to almost double from 3.6 billion to 6.7 billion.<sup>33</sup> About one-third of this growth will occur in just three countries: Nigeria, India, and China, with sub-Saharan Africa and the Indian subcontinent expected to absorb the majority of overall growth.<sup>34</sup> In contrast to earlier urbanization processes in Europe and North America, the current one is occurring in countries with significantly lower levels of income and resources.<sup>35</sup>

Urban expansion itself is not new, but we are currently witnessing rapid physical expansion of cities at rates that are often higher than the rate of population growth. Recent global forecasts based on trends in population density and probabilities of urban expansion project a tripling of urban land area by 2030, when compared with a baseline of 2000.<sup>36</sup> Growing cities need more land to accommodate urban population increases and consumption patterns, given housing and infrastructure needs for new urban migrants and the demands of an emerging middle class. Urban land development patterns have long-term effects that are difficult to reverse. They directly affect people's need for transportation, housing, and other services as well as their consumption of resources such as land, energy, and water.

In prior work, we highlighted the growing urbanization of poverty, which leads to increasing social and spatial exclusion of lower-income groups from the opportunities and services offered by the city.<sup>37</sup> These inequities are common in cities where the scale and pace of growth has overwhelmed the capacity of urban governments to provide core services.<sup>38</sup> With rapidly expanding urban footprints, city governance and management becomes more complicated; land price differentials between central and peripheral areas increase because of greater availability of services and lower commuting costs in central areas.<sup>39</sup> As these locations become more expensive, large segments of the population relocate to the typically underserviced urban periphery in search of affordable housing. Lower-income people who do not relocate often find themselves living in overcrowded informal settlements with inadequate core services.

#### **Abbreviations**

CEPAC	Certificados de potencial adicional de construção (certificate of additional construction potential)			
EPM	Empresas Públicas de Medellín			
GHSL	Global Human Settlement Layer			
GDP	gross domestic product			
GVA	gross value added			
HV	Habilitación de Viviendas			
MTRC	Mass Transit Railway Corporation			
OGI	Outward Growth Index			
PR	power ratio			
SDG	Sustainable Development Goal			
TDR	Transfer of Development Rights			
TPS	Town Planning Scheme			
UGI	Upward Growth Index			
UO	Urban Operation			
UDZ	urban development zone			
WRR	World Resources Report			

Ironically, government programs often displace low-income slum dwellers to peri-urban locations in an effort to improve living conditions. However, if programs give little consideration to the availability of urban services or economic opportunities, new housing on the city's periphery may do little to alleviate poverty or improve well-being. Affluent groups may also locate in the urban periphery by choice, where they can find larger homes at lower prices and can afford the higher travel costs and expense of purchasing private alternatives to public services. The juxtaposition of informal settlements and high-end gated development in peri-urban areas across the global South makes these inequities starkly visible.<sup>40</sup>

As municipal service networks fail to keep pace with increasing urban in-migration, population growth, and urban land expansion, resource-constrained cities tend to react to development trends instead of having land development agencies proactively plan for growth. Increasingly, this leads to the emergence of informal and under-serviced settlements, occupied by an estimated 25 to 70 percent of urban populations in developing cities of Asia, Latin America, sub-Saharan Africa, and the Arab states.<sup>41</sup> It is clear that the lack of municipal services does not deter population growth or new settlements; rather, it spurs informal and costly arrangements to obtain them, negatively affecting household budgets and productivity.<sup>42</sup> Under- or unserviced areas must often wait until their population densities reach a threshold to justify the cost of infrastructure provision.<sup>43</sup> The process can also be political; over time, unauthorized expansion reaches a scale where it acquires electoral strength, prompting elected representatives to consider regularizing such developments and providing public services.<sup>44</sup>

### Unmanaged Expansion Causes Environmental Degradation and Wastes Natural Resources

The adverse environmental impacts that result from unmanaged urban expansion are far-reaching. Increasing urban expansion consumes prime agricultural land and water, which impacts food production, habitats, and biodiversity. Some of the most rapid urban expansion is occurring in low-elevation coastal zones,45 where it exacerbates the challenges of climate mitigation and adaptation. Studies of global urban expansion show that rapid growth in urban land cover is expected in biodiversity hotspots by 2030.46 Increased greenhouse gas emissions, air pollution, and urban heat effects have been linked to sprawled growth. The loss of agricultural land to indiscriminate urban expansion will assume increasing urgency as the global population grows and climate change impacts intensify. Recent estimates show that in mid-latitudinal Africa, urban areas are expected to increase by nearly 20-fold by 2030 compared with a 2000 baseline, with the largest forecasted increase in the vicinity of environmentally protected areas.47

In the expanding areas of Mexico City, São Paulo, Bangalore, and Jakarta, self-provisioned water supply through indiscriminate, unregulated digging of borewells has rapidly depleted groundwater and caused land subsidence, or sinking.<sup>48</sup> Some of the fastest-growing urban areas face limited water availability due to overextraction, saline intrusion, or both.<sup>49</sup> Clandestine connections to the municipal water supply are commonplace and, in the absence of municipal sewer connections, wastewater is frequently released directly into rivers or canals or into poorly constructed septic tanks.<sup>50</sup> Waste collection services may not exist, further contaminating surface water sources, compromising the quality of piped and groundwater, and increasing the incidence of water-borne diseases.<sup>51</sup> Unabated and illegal construction on urban floodplains and water bodies has been causing disastrous flooding from seasonal monsoon rains in many cities in South Asia.  $^{\rm 52}$ 

### Unmanaged Urban Expansion Causes Economic Hardship and Social Exclusion

Unmanaged expansion has economic implications for both households and municipal governments as higher expenditures are required to meet essential needs. In many unplanned or informal peri-urban settlements that lack piped water supplies, reliance on expensive water vendors consumes larger shares of poor households' income.<sup>53</sup> In the absence of adequate public transport connecting employment centers and peripheral urban areas, urban residents increasingly rely on personal cars and two-wheelers or informal commercial vehicles, using multiple modes of transport for a single trip. This adds time and expense to one's trip and hampers economic productivity.<sup>54</sup>

In a study of households living in social housing across secondary cities in Brazil, Colombia, and Mexico, it was found that the location of housing and distance to the city center have a strong impact on households' expenses and access to social networks.<sup>55</sup> Even though households pay on average about 40 percent less than they would for a centrally located unit in a homogenously low-income area, their peripheral location essentially doubles their commute costs and triples their commute time compared with centrally located households.<sup>56</sup> In a rare analysis of social relationships, the study found that 75 percent of residents in central locations are able to visit family members once a month or more, but only one-third of those in peripheral areas are able to do so.<sup>57</sup>

Much empirical evidence shows that the increase in the spatial extent of cities and resulting decline in population densities increases the municipal costs of providing public services as well as the social costs associated with increasing congestion, pollution, and longer commutes.<sup>58</sup> Evidence from Argentina, based on a multidimensional indicator of inequality covering access to multiple core services, shows that cities with higher urban expansion rates are also more unequal in terms of access to services.<sup>59</sup> Evidence from Indian and African cities shows that access to services like paved roads, drainage, and good quality piped water drops off sharply just five kilometers from the city center, with smaller cities facing poor access even in centrally located areas.<sup>60</sup>

### Fragmented Governance Creates Unequal Access to Services

Disaggregated spatial data on indicators of access to services at the city scale are difficult to obtain in a consistent way. However, detailed local-level analyses (see Figures 2 and 3) show that when jurisdictions are expanded, technical capacity or financial constraints limit the extent to which city utilities can expand their service networks. Additionally, areas of new growth, areas of informal growth, or urban villages on a city's periphery often lie within the planning jurisdictions of multiple local-level agencies (and sometimes regional, state, or rural agencies) that may have functional autonomy but do not coordinate on service provision. This creates significant governance challenges. As an example, Figure 1 shows a map of Bangalore, India, and illustrates the spatial mismatch between its local jurisdictions for planning and urban service provision. Only the central areas of the city have overlapping coverage for all services. In 2007 the city's municipal boundary was expanded to incorporate eight urban local bodies with uneven service provision as well as 110 villages on the urban periphery.<sup>61</sup> The city's area more than tripled in 2007 from 225 to 709 square kilometers, significantly increasing the total number of urban under-served through the addition of peripheral urban villages newly classified as urban.<sup>62</sup>

Figures 2 and 3 show spatial disparities in access to key services in two metropolitan regions—Bangalore and Mexico City. The analyses combine spatial and socioeconomic data from national





Source: WRI India, prepared for BBMP Restructuring Committee, 2017.



C. Percentage of households with access to piped water connections, 2011



B. Percentage of households with access to closed drains, 2011



D. Percentage of households with access to piped sewer connections, 2011



Sources: WRI India, based on data from Census of India, 2011; Bangalore Metropolitan Region Development Authority, Bruhat Bengaluru Mahanagara Palike, Bangalore Metro Rail Corporation Limited, Global Land Survey and Landsat (U.S. Geological Survey) images for 1990, 2000, 2010, and 2015.

Figure 2 | Urban expansion and inequitable access to services in Bangalore's metropolitan region





**C. Access to public transportation** 





D. Percentage of households with internet access, 2010



Note: \*The Urban Marginalization Index is a composite of multiple demographic, social, economic, and access to services indicators, for which 2010 data are available from CONAPO (National Population Council) in Mexico.

Sources: WRI Mexico, based on data from Population and Housing Census of 2010; Economic Census of 2014; Marco Geoestadístico Nacional (National Geostatistical Frame) by Instituto Nacional de Estadística y Geografía; CONAPO Urban Marginalization Index for 2010.

censuses at a disaggregated scale. Some researchers have used multiple indicators of access to core urban services to develop a composite spatial Sustainable Development Index or, conversely, an Urban Marginalization Index, as used in Mexico City.<sup>63</sup>

Understanding and addressing the spatial implications of urban expansion is crucial for the well-being of people, economic productivity, and environmental quality in the world's cities.

### Purpose and Approach of This Paper

This working paper addresses a key question: How might growing cities manage their expansions to ensure equitable access to urban services while increasing economic productivity and environmental quality?

Evidence from the global North on approaches to managing urban growth is not always relevant to the urbanizing global South.<sup>64</sup> Although there are various definitions of what a "city" is, there is consensus regarding the large scale of urbanization, its shifting geography towards Asia and Africa, and the rapid rate of urbanization in these locations.<sup>65</sup> Cities in these regions are generally categorized as struggling and emerging in the World Resources Report (WRR) framing paper, *Towards a More Equal City: Framing the Challenges and Opportunities* (see Figure 4).<sup>66</sup>

We explore our key question in the context of these cities, which are typically characterized by low planning capacity, fragmented governance, and limited financial resources, all of which contribute to the challenges of unmanaged urban expansion.

#### Figure 4 | WRR city categories

Income Growth/ Urban Population Growth (2015-2030)

#### **EMERGING CITIES**

**LOW** Income Today **HIGH** Income Growth Relative to Population Growth (2015–2030)

#### STRUGGLING CITIES

**LOW** Income Today **LOW** Income Growth Relative to Population Growth (2015–2030)

#### **STABILIZING CITIES**

**THRIVING CITIES** 

**HIGH** Income Today

**HIGH** Income Today **LOW** Income Growth Relative to Population Growth (2015–2030)

HIGH Income Growth Relative to

Population Growth (2015-2030)

.....

#### Income (GDP/capita) in 2015



Source: Beard et al., 2016, based on data from Oxford Economics, 2016.

#### Box 1 | Densification and Other Common Approaches to Address Urban Expansion

Recently, some approaches for how to accommodate impending urban expansion have become more prominent. They involve realistic projections of urban land needs, feature the extension of municipal boundaries and the acquisition of rights of way that support public transport and other urban infrastructure, and protect open spaces.<sup>a</sup> These types of solutions are reasonable, but they underplay the intractable market failures related to urban land and the politically contested processes of land acquisition in so many countries of the global South.

Other approaches focus on densification as a crucial feature of compact growth, recognizing that highly restrictive regulations that limit densities in growing cities are partially responsible for driving urban expansion.<sup>b</sup> However, these recommendations excessively rely on a single operational measure—population density—without considering important aspects such as built-up area densities or the distribution of density within a city.<sup>c</sup>

Population density is different from the density of the built-up area and neglects differences in land-use mix, spatial configuration, cultural preferences for living standards, and level of access to core urban services.<sup>d</sup> There is value to densifying the built environment, as this shortens distances between locations, which in turn improves accessibility and shortens commutes. Yet population densities vary significantly around the world and must be considered in their sociocultural contexts. For instance, Asian cities are very dense, averaging between 10,000 and 20,000 inhabitants per square kilometer; this is almost double the rates in Latin America. triple those in Europe, and 10 times those in U.S. cities.e

Importantly, a single density value for an entire city provides limited information about the geographic distribution and patterns of density within a city—an issue we explore in detail in the next section. Questions often arise about the optimal level of population density; however, pursuing density alone as a goal is misguided, as the same density levels can have vastly different outcomes in different types of cities. In most cases, it is more important to ensure geographic co-location of densities; for example, employment density with housing density.

Recently, efforts to unpack population density into multiple actionable components-such as building height, floorspace occupancy (an indicator of crowding), and residential coverage-are shedding light on the trade-offs across these factors. Researchers have shown how a city like Kinshasa, which has a lower density than Dhaka or Hong Kong, has almost double the floor-space occupancy (or crowding) of Dhaka and almost four times that of Hong Kong.<sup>f</sup> This highlights the problem with overly simplistic recommendations to "densify" that are often based on increasing building heights without considering the high levels of floor-space occupancy, existing proportion of built-up area, and the inadequacy of existing infrastructure.

Sources: a. Angel et al., 2011; b. Economist, 2015; Brueckner and Sridhar, 2012; Bertaud and Brueckner, 2004; Rode et al., 2014; c. Neuman, 2005; d. Marron Institute of Urban Management at NYU, 2018; e. UN-Habitat, 2010: 62; f. Marron Institute of Urban Management at NYU, 2018.

This paper identifies three particular challenges that confront urban authorities in struggling and emerging cities:

- Challenge 1: distorted and inequitable land markets rife with speculation
- Challenge 2: deficient service provision in growing areas of cities
- Challenge 3: disjointed informal expansion

We discuss key driving forces that create these challenges, along with actionable strategies to address them. Our work is based on a review of evidence from multidisciplinary literature and structured consultations with 20 urban land development experts who have experience across the global South. The analysis and literature review underlying this work has resulted from collaborations between the WRI Ross Center for Sustainable Cities and researchers based at Yale University, the University of Southern California, and the World Bank. The international offices of WRI in India and Mexico supplied valuable local-level spatial data. In assessing the strategies proposed in the paper, we prioritized the potential benefits to the under-served while considering how these actions could also improve economic productivity and environmental quality for the entire city.

The paper argues that while some level of outward urban expansion is inevitable with increasing urbanization, the pace, scale, and nature of this expansion can be managed, and its negative consequences can be mitigated through efforts to carefully steer urban growth. Furthermore, the paper considers how urban expansion can sustainably integrate existing informal settlements into a city's economic and service networks.

Following this introduction to the social, environmental, and economic consequences of unmanaged urban expansion, in Section 2 we analyze growth patterns across different types of cities. To do so, we developed new indices to measure the extent of outward and upward growth of urban built-up area using a new dataset that comprises 499 cities. We draw associations between these spatial growth indices and city-level economic indicators across the WRR city categories. In Section 3, we examine key forces behind unmanaged outward expansion in the global South, focusing on three specific equity challenges linked to this form of growth in struggling and emerging cities. In Section 4, we propose a set of high-priority strategies to address these challenges using examples from cities that have successfully implemented them. In Section 5, we describe key enabling conditions that can facilitate implementation. We expect these strategies to be useful for public sector agencies, private actors, civil society, the development and research community, and other urban change agents working towards more sustainable urban growth. Section 6 presents brief conclusions about this work.

Cities continue to remain centers of productivity, creativity, and innovation. How cities manage their growth in the coming decades will determine whether they continue their historic role as engines of prosperity and opportunity or decline into greater poverty, environmental degradation, social inequity, and unrest.

## 2. A NEW LOOK AT THE GLOBAL PHENOMENON OF URBAN EXPANSION

Measuring and characterizing urban growth is a complex process. The difficulties center around issues of definition (what is a *city* and what constitutes *urban*?), data sources, and interpretation methods. Traditionally, cities have been measured via socioeconomic data, such as the population residing within urban limits, or employment patterns; and spatial extent was recorded on terrestrial maps. Today, the growing use of remote sensing data, obtained from satellite images or radar, along with drone photography, are opening up new ways to measure urban growth. Recent technological improvements that allow higher-resolution imagery<sup>67</sup> have made remote sensing an increasingly useful tool with which to characterize and measure rates and patterns of urban expansion in ways not previously possible. Hundreds of local case studies collectively offer a global perspective on our urbanizing planet and insights into the variations in urban conditions worldwide. A review of 326 peer-reviewed published studies using remote sensing to document urban land expansion between 1970 and 2000 found that rates of increase in urban land area equaled or exceeded population growth rates in all regions, with India, China, and Africa exhibiting the fastest rates of urban expansion—a trend corroborated by recent population data.<sup>68</sup> Another study of a global sample of 200 cities analyzed satellite images and found that the footprint or urban extent of cities in less developed countries increased 3.5 times on average between 1990 and 2015 while their densities declined at an annual rate of 2.1 percent—faster than the 1.5 percent annual decline in more developed countries.<sup>69</sup> The study also projected that in less developed countries urban extents of cities could double and some could even nearly quadruple between 2015 and 2050.70

### The Complexity of Measurement

Urban growth is typically measured in two ways. One is by urban population data that are collected by national governments. In some countries, *urban* is defined using population density thresholds and other built-form characteristics, but in others it is based on a combination of population density and employment characteristics, the level of economic activity, the presence of trunk infrastructure, and the availability of core services.<sup>71</sup> These disparities in definitions make it harder to measure and track goals—such as the cities-focused Sustainable Development Goal (SDG) 11—across countries in a consistent way.

A second commonly used measure of urban growth is derived from satellite data. Satellite data offer one significant advantage over national definitions: they are consistent and uniform regardless of location. However, even with remote sensing, definition-related issues persist. Principally, satellites measure what is considered to be urban based on physical land features: impervious surfaces, mosaics of streets and buildings, vegetation, and so on. Likewise, remote sensing scientists develop algorithms that *infer* how the land is used and which human activities gave rise to these physical features. The same land features in two places may in fact not reflect the same urban uses on the ground, so results are influenced by the methods used to classify and interpret the imagery.<sup>72</sup> The accuracy of satellite-based maps of urban areas therefore depends on the spatial resolution and sensitivity of sensors to measure different surface features on the earth as well as the methods used to classify the imagery.<sup>73</sup>

Since the 1970s, various scholars have attempted to standardize the definition of *urban* in remote sensing data. Recent efforts include those by the European Commission and the World Bank to better understand and compare urban expansion trends measured by satellite data.<sup>74</sup> While the UN reports that 55 percent of the world's population is urban based on aggregating individual country estimates, a recent European Space Agency study that uses a methodology that combines remote sensing and population data finds that 85 percent of the world's population is urban.<sup>75</sup> Using a different approach, the World Bank found that urbanization rates were underestimated in countries of South Asia and sub-Saharan Africa and overestimated in Latin America.<sup>76</sup>

These large variations underscore the challenges of using remote sensing to measure what is urban. It is important to remember that satellite data measure the physical features on the earth, not people or population density. While satellite data provide uniform observations, there is significant variation in the types of human settlements that can be measured from space. Given that satellites measure land features, it is understandable that certain features will be confounded. Buildings constructed of clay and mud bricks are difficult to distinguish from fallow agricultural fields of clay and mud. Even though satellite data provide additional information on land texture and configuration, some types of human settlements are difficult but not impossible—to discern from space.

Likewise, informal settlements, slums, and small settlements with only a few large buildings or roads are difficult to identify with moderate-resolution satellites (greater than 30 meters). Still, whereas satellite data can consistently provide information about urban areas worldwide, census data are expensive to collect, become outdated quickly, and fail to keep pace with proliferating urban land developments, particularly those outside official urban boundaries. Moreover, census data do not typically include information about urban form and infrastructure.

A key measurement problem with remote sensing is that the majority of studies look only at cities' outward growth, ignoring inner-city redevelopment and densification changes. One indicator that attempts to capture these types of changes is the ratio of the rate of urban land consumption to the rate of urban population growth, one of the targets of SDG 11 (11.3.1).<sup>77</sup> A decline in the ratio—which would suggest an increase in urban population density, controlled outward expansion, and perhaps infill development—may be a good thing, but it also brings into question whether the increase in population density is equally or adequately met with urban services.<sup>78</sup>

Moreover, rates of urban land consumption do not indicate anything about the quality of urban conditions. For example, the UN has noted that there are no squatter settlements in Chinese cities despite extremely rapid expansion.<sup>79</sup> Yet there are significant "hidden" undocumented migrant populations in many Chinese cities, including Beijing and Shanghai, who live in underground rental housing characterized by extreme overcrowding and bare-minimum living standards.<sup>80</sup> This occurs within seemingly regular residential buildings that are connected to overburdened core services. For these populations, one incentive to reside in these conditions is to have better access to employment, despite the inadequacy of other services. How the UN indicator can be interpreted and applied to these conditions remains a challenge.

### Outward and Upward Growth: Characterizing Urban Expansion with Remote Sensing

Urban form and built infrastructure are the products of major public and private investments and have important consequences for land values, natural resource consumption, and human well-being. Yet there is a lack of empirical data on built infrastructure for a large sample of cities.<sup>81</sup> The overwhelming majority of urban remote sensing studies use optical data, which differentiate between land cover types and materials and therefore provide information on urban areas' "horizontal," or outward, spatial extent.

However, urban areas vary not only in construction materials but also in their composition in both two and three dimensions. Buildings vary in their volume, height, and width, and streets vary in their layout and patterns. For these reasons, radar remote sensing offers a unique advantage over optical data because it can characterize the three-dimensional structure of the land, such as tree canopies. This in turn allows us to characterize the three-dimensional, or "vertical," structure of built form. Another advantage is that the longer wavelength used in radar remote sensing permits the signal to penetrate most weather conditions, including clouds, haze, and air pollution. A pioneering study by Frolking et al. (2013) was the first to examine changes in urban structure that captured patterns of both outward and upward growth in built form, using a combination of optical and radar data. It was able to produce "fingerprints" of urban form illustrating the relative growth of urban areas in their horizontal and vertical dimensions.<sup>82</sup> The study compared the fingerprints of the world's largest cities between 1999 and 2009 and found that East Asian cities had the greatest increase in built infrastructure. It concluded that Chinese cities exhibited both upward and outward growth, whereas Indian cities grew primarily outward.<sup>83</sup>

## Combining spatial, economic, and demographic data on cities

The analysis in this paper substantially expands the study by Frolking et al. (2013) by combining two sources of satellite data with socioeconomic data. Our study also differs from Frolking et al. because we use built-up area data from the Global Human Settlement Layer (GHSL) instead of the nighttime light data that were used in Frolking et al. The GHSL data are developed by scientists in Europe (see Appendix A for details). In this analysis, we use GHSL data instead of the nighttime light data because there are many cities in low- and middle-income countries with low levels of outdoor lighting, which is what the nighttime light data measure.

Here, we combine radar data and the GHSL with urban demographic and economic indicators from the Oxford Economics Global Cities 2030 database. These indicators were previously analyzed in the World Resources Report to categorize cities as either struggling, emerging, thriving, or stabilizing (see Figure 4).<sup>84</sup>

We adapted these datasets to conduct a new, first-of-its-kind spatial analysis of 499 cities. Our objective was to measure the extent of outward and upward growth in these cities, develop metrics to compare growth trends, and understand how these trends differ across the city categories developed in the WRR.

We conducted the analysis for cities with populations of more than one million, which were then matched with the cities included in the Oxford Economics cities database. We developed a set of "clusters" based on changes in built form that could be applied to the WRR city categories. Five clusters of built-form attributes were developed based on the following parameters:<sup>85</sup>

- ▶ Initial horizontal extent or footprint of the city in 2000
- Initial vertical extent of the city in 2001
- Outward growth observed between 2000 and 2014
- Upward growth observed between 2001 and 2009

We interpreted images of cities in which their urban extents were divided into grids of 11x11 pixels (see Appendix A for the detailed methodology). A pixel is any of the small discrete elements that together constitute an image (as on a television or computer screen).<sup>86</sup> Figure 5 summarizes the five clusters developed for each of our 499 sample cities. The visual schematic shows the *initial extent* urban pixels shaded dark and the *change observed* during the study period in a lighter shade. Changes in each pixel are relative to those observed across all pixels in the 499 city sample.

#### The built-form clusters explained

Cities are composed of many neighborhood tracts and districts, with differences in social and built-up characteristics. One key advantage of the remote sensing analysis is that it permits an understanding of within-city variations that whole-city studies cannot provide. The remote sensing analysis thus allows us to differentiate types of growth and built-up structures in different parts of the city. This is a key innovation of this analysis. Each city has areas represented by pixels distributed across each of the five built-form clusters, so we looked to see which types of clusters predominated.<sup>87</sup> The analysis revealed the structural changes within each city, which is an important step towards understanding how policies to determine built form, including density and land-use regulations, will need to vary within cities according to the nature of built-form changes that have already occurred and those that are desired in the future.

Each built-form cluster is designed to capture a city's initial conditions and the change observed during a given time period. Clusters 2 and 5 exhibit very high urban growth in horizontal and vertical dimensions, respectively, over the study period. Clusters 1 and 3 exhibit very low overall urban growth and incremental upward growth, respectively. Cities falling in clusters 1 and 3 had already gone through a major change in outward and upward growth before 2000. Cluster 4 shows very low structural changes in both upward and outward dimensions. Cities falling in this cluster are in the early stages of their development.

#### Figure 5 | Built-form clusters used to characterize urban growth patterns

	Cluster 1: stable, horizontally expanded	<b>Cluster 2:</b> very high change in horizontal expansion	<b>Cluster 3</b> : stable, vertically expanded	<b>Cluster 4</b> : early stage, no structural change	<b>Cluster 5</b> : vertically expanding cities
Initial Horizontal Extent (GHSL 2000)	Very high	Very low	Very high	Low	Moderate
<b>Initial Vertical</b> <b>Extent</b> (PR 2001)	Moderate	Low	Very high	Low	Moderate
<b>Upward Growth</b> (Change in PR)	Very low	Low	Moderate	Very low	Very high
Outward Growth (Change in GHSL)	Very low	Very high	Very low	Moderate	Moderate
<b>Cluster Description</b>	Very low urban growth	High outward growth	Incremental upward growth	Incremental outward growth	High upward growth

Source: Authors' analysis, using data from the Global Human Settlement Layer (GHSL) for outward (horizontal) growth from 2000 to 2014 and the power ratio (PR) from NASA's SeaWinds microwave scatterometer for upward (vertical) growth from 2001 to 2009.

Some cities show a dominant type of urban growth, but others experience nearly equal amounts of the five clusters of growth. A particularly interesting combination is found in cities that have many pixels in both cluster 5 (rapid upward growth on top of a relatively low vertical extent) and cluster 2 (very high outward growth). These are cities that are growing upward and outward simultaneously. Chinese cities such as Chengdu, Suzhou, and Hangzhou show this trend. Figure A3 and Figures A4 through A7 in Appendix A show this intracity variation in urban structure for cities falling in each of the four WRR city categories. Based on the remote sensing analysis, we then developed an Outward Growth Index (OGI) and Upward Growth Index (UGI) for each city to understand how these indices correlated with a wide range of urban economic indicators (Appendix A presents formulas that describe the metrics).

Figure 6 shows the relative outward and upward growth in cities around the world and indicates interesting regional patterns. Several cities that the WRR identified as struggling primarily display horizontal growth, while emerging cities, particularly those in China, display both characteristics—of high upward and high outward growth.

## Associations between urban growth indices and economic development

The five built-form clusters are based solely on physical urban form and change in structure. In contrast, the WRR's categorization of cities is based on urban population and economic growth expected in the near future (2015–2030) and city-level gross domestic product (GDP) in 2015. Combining the WRR's demographic-economic analysis with the remote sensing cluster analysis yields a joint physical-economic perspective of urban growth across 387 cities (the number of cities that matched across both datasets). This is important because, as we show later, many forces that determine the nature of urban expansion are economic, demographic, and policy based.

We analyzed associations between the new built-form indices for upward and outward growth and the change in city-level economic indicators as well as average household expenditures



Figure 6 | Upward and outward growth in a global sample of cities, with East Asian cities showing both trends

Source: Authors' analysis, using 2000–2014 data from the Global Human Settlement Layer to determine the Outward Growth Index and the power ratio from NASA's SeaWinds microwave scatterometer from 2001 to 2009 to determine the Upward Growth Index. See calculation methodology in Appendix A.

across categories (see Appendix A for more details on results). We found strong correlations between upward growth and the change in total urban GDP and gross value added across the full city sample and across emerging cities, but not so for outward growth.<sup>88</sup> We also found stronger positive correlations between upward growth and the change in average household expenditures on urban services and rent than in the case of outward growth. The relationships between upward growth and the change in household expenditures were most pronounced for emerging cities.<sup>89</sup> Relationships between outward growth and change in household expenditures were modest across the full sample, with the highest correlations seen between outward growth and change in household expenditures on water in emerging cities.<sup>90</sup> Our findings suggest that upward growth in these cities is associated with higher levels of income, and needs more financial investment because it tends to occur in already wellserviced and relatively mature or built-out locations; it therefore also needs well-functioning construction and real estate finance systems. Upward growth may also drive up the costs incurred by households for services and rents because it is often associated with increased land values.

The cities that the WRR defines as struggling and emerging are all at relatively lower income levels today and face constraints to upward growth. Figure 7 shows an illustrative sample of cities in each WRR category and the types of urban built-form growth occurring within each. The figure also shows the co-occurrence of horizontal and vertical growth over time in most cities.

## What Are the Growth Characteristics of WRR City Categories?

Our analysis of combined urban physical and socioeconomic data yields the following findings, observable in Figure 7, which includes examples of cities in each category.

**Struggling cities.** Relative to the global sample, struggling cities showed negligible upward growth before 2000 or during the 2000 through 2009 period; they primarily expanded outward. Since vertical growth is associated with infrastructure development and higher land values, this may indicate that struggling cities have less infrastructure. It also suggests that cities in this category have low financial resources and less mature financial institutions.

**Emerging cities.** Like struggling cities, emerging cities expanded outward prior to 2000 and between 2000 and 2014, with relatively low upward growth. As their economies grow, there is potential for this outward expansion to intensify if current policies and drivers of expansion do not change.

**Thriving cities.** Thriving cities show the highest rates of upward growth, but the high internal city variation is important to keep in mind. These cities either experienced early upward growth or have been expanding upward in recent years (2000–2009).

**Stabilizing cities.** Stabilizing cities predominantly show low overall urban growth or incremental outward growth. Most of these cities had already expanded outward prior to 2000, and very few are still doing so. Cluster 4, which represents incremental outward growth, is present in all types of cities, likely representing new peripheral growth.

Based on our analysis, we see that a single aggregate measure of urban growth—such as change in urban land area—is insufficient to characterize the variation in built form within a single city. Urban growth is more accurately characterized when examined in both the horizontal and vertical dimensions. Builtform trends vary significantly within a single city, and many growing cities exhibit both outward and upward growth.

Our analysis shows that the strategy for managing growth will differ depending on the type of city. To maximize the affordability of well-serviced land where households have access to good quality urban services, it is important for cities to pursue a two-pronged approach—growing upward through infill and redevelopment and growing outward through incremental planned expansion in the urban periphery. However, upward growth requires financial resources and mature financial systems that many struggling and emerging cities lack.<sup>91</sup> Cities that have been rapidly growing outward may need to grow upward in already built-up areas to take advantage of existing infrastructure, with mechanisms to maintain affordability and generate financing from expected increases in land value. Cities that have already achieved relatively higher population, height, and built-up area densities, where upgrading infrastructure and services is difficult and costly, will need to increase the supply of affordable and serviced land for future contiguous outward growth.

### Using Remote Sensing to Identify the Under-served

Although remote sensing as used above is useful for quantifying urban growth and structure, the analysis has some limitations. Contemporary urban expansion and its informality in many cities of the global South leaves large segments of the population under-served. As mentioned, it is difficult, though not impossible, for remote sensing to accurately characterize informal settlements. It is even more difficult to distinguish the informal from the formal using satellite data.

The interpretation of satellite data may need to be validated with local and ground-based knowledge, which the remote sensing community often refers to as "ground-truth" assessments. Some satellite-derived estimates of urban land-use change have achieved accuracies of close to 95 percent, when areas (pixels) identified as new urban growth were verified by ground truthing. <sup>92</sup> However, accuracy assessments of informal settlement mapping are less common, as there are fewer of these types of studies with satellite data. New efforts are currently



Figure 7 | Upward and outward growth in built-up area for a sample of cities across WRR categories

→ Cluster 5–High upward growth

Notes: The x-axis shows outward growth of urban built-up area between 2000 and 2014, and the y-axis shows upward growth between 2001 and 2009. The clusters correspond to the built-form categories. The tail of the arrow shows the initial year of analysis, and the head of the arrow shows the final year. The length of each arrow therefore captures change in built form over time. The arrows represent the pixels analyzed in each city, which were not the same in number, depending on each city's urban area. Each city is composed of areas that fall under different clusters, as the color coding of the arrows shows. For example, Guangzhou is dominated by clusters 3 and 5 but also has some areas that are characterized by clusters 1 and 4. The four WRR city categories of struggling, emerging, thriving, and stabilizing are defined as in Figure 4.

Source: Authors' analysis, combining economic data from Oxford Economics, 2016, with data from the Global Human Settlement Layer (GHSL) to determine outward growth and the power ratio (PR) from NASA's SeaWinds microwave scatterometer to determine upward growth. See an alternate representation of this data in Figure A8 (based on proportion of urban built-up area) in Appendix A.

#### Box 2 | Combining Satellite Imagery with Ground-Truth Assessments to Characterize Informal Settlements

Advances in satellite imagery sensor technology, as well as in algorithm development, have allowed analysts to classify urban land-use patterns at a fine spatial resolution with frequent updates. Particularly promising is the technology's potential to identify informal settlements, which are often omitted from remote sensing analyses and are undersurveyed in ground-based assessments.<sup>a</sup> Census data collected on a decennial basis are insufficient to monitor their growth, and undercounting of this vulnerable population constitutes a significant information gap.<sup>b</sup>

Satellite imagery has the potential to provide a consistent, reliable, and relatively low-cost solution.<sup>c</sup> In general, larger, more homogeneous informal settlement patterns lend themselves to satellite imagery detection, while more isolated dwellings and smaller groupings of buildings that are very heterogeneous may not be easily identified or characterized. However, these are exactly the kind of under-served populations that deserve further attention.

The data generated from satellite images is limited by the remote sensing scientist's knowledge of field conditions. As an example, satellite images generated for Ho Chi Minh City, Vietnam, by three different research groups over the 2000 to 2001 period illustrate the variation, uncertainty, and high degree of interpretation involved in such analysis (see Figure B1).<sup>d</sup> There was agreement among the three studies on the size of the urban core. However, each of the three studies also identified urban areas that the other two did not. Focused on detecting informal settlement construction, one study found areas on the city's southern periphery that were informal settlements at risk for displacement through urban development and flooding and were not captured in the analysis produced by the others.<sup>e</sup> In studies conducted at coarser spatial resolution for national or global scales, the discrepancies were amplified.

It is important to standardize the parameters for capturing these data across cities, particularly where informal settlements are prevalent and growing. Efforts led by organizations like Slum Dwellers International to facilitate community data gathering in informal settlements can supplement satellite imagery to produce more robust and muchneeded information on the location and conditions of informal settlements in cities worldwide. Fine-grained, three- dimensional images produced by drones are also increasingly being used to supplement satellite imagery to identify slums and informal settlements.<sup>f</sup>

#### Figure B1 | Three different interpretations of satellite imagery of Ho Chi Minh City's urban expansion, 2000–2001



Source: Acolin and Kim, 2017.

Sources: a. Miller and Small, 2003; Barry and Rüther, 2005; Carr-Hill, 2013; b. Alkire and Samman, 2014; c. Sethi and Puppim de Oliveira, 2015; Rhinane et al., 2011; Graesser et al., 2012; Kit et al., 2012; Taubenböck and Kraff, 2013; Vatsavai et al., 2014; Antos et al., 2016; d. Acolin and Kim, 2017; e. Acolin and Kim, 2017; f. Wihbey, 2017; World Bank, 2016; Alemany, 2017.

underway to use drones and other high-resolution methods to do this, as will be discussed in Section 6.

The high variability of informal settlement characteristics requires discretion in how satellite imagery is interpreted. Informal structures are typically identified based on the lower quality and reflectivity of building materials, and on spatial patterns and building typologies that differ from formal construction. Identifying the size and location of informal settlements can help local governments identify the underserved and plan for more sustainable and inclusive cities as well as inform a range of other policies, such as siting transport, water, and sanitation networks. Because informal settlements often develop in locations that make them more vulnerable to natural hazards, satellite imagery can also support adaptation plans for resilience to climate change risks, including flooding and heat stress, and resettlement needs.

If the full potential of satellite imagery is to be realized, and not misused—particularly with regard to measuring informal settlements—data interpretation must be informed by local conditions so that policymakers do not undercount or neglect the most needy urban dwellers. It is therefore important to adapt the algorithms and methods to detect informal construction in different contexts. Box 2 describes methods for characterizing informal settlements.

This section highlighted the different urban growth patterns within and across cities and the complexities inherent in measuring and identifying the under-served. The following sections frame the policy challenges of managing urban expansion to ensure equitable access to urban services. From this point forward, we use the term *urban expansion* to refer primarily to the *outward* growth of cities, which we have now seen is the dominant form of expansion in poorer struggling and emerging cities.

## 3. KEY FORCES DRIVING URBAN EXPANSION IN THE GLOBAL SOUTH

Urban expansion is driven by many forces that operate at different spatial and temporal scales but often interact. Cities grow because of natural population increases, in-migration, or the reclassification of urban administrative boundaries.<sup>93</sup> We discuss some of these forces below—including those within and outside the control of city authorities—and the challenges they create.

### Factors Largely outside of City Control

#### Demographic and economic growth

Migration from rural to urban areas has historically been a significant cause of urban population growth and land area expansion in the global South, with a large proportion of new migrants living in informal settlements. Urban population growth creates demand for land (for both residential use and supporting activities), and economic growth tends to encourage wealthier households to consume more land and infrastructure. High subsidies for fuel and decreasing costs of private vehicles contribute to urban expansion by reducing the perceived user costs of transportation over longer distances.<sup>94</sup>

Where economic growth is driven by manufacturing rather than services, the land requirements are higher. A metaanalysis of over 300 case studies showed important regional variations in the factors causing outward urban growth.<sup>95</sup> For example, in Europe, North America, and China, economic growth contributes significantly more to urban expansion than population growth does. In contrast, in India and Africa, population growth contributes more to urban expansion than economic growth does (see Figure 8).<sup>96</sup>

### Factors Largely within City Control

## Infrastructure expansion and perverse land speculation

Urban expansion in the global South is often driven by government-led investments in housing and industrial clusters and by incentivized private development in designated special economic zones in peri-urban areas. While these zones may have been conceived of as production sites, in many cities they have, with significant private investment, transformed into complete urban developments—examples include Saigon South and Hanoi New Town in Vietnam, Shenzhen and Pudong in China, and Navi Mumbai in India.<sup>97</sup>



Figure 8 | Percentage of urban land expansion attributed to urban population or economic growth

Average annual growth rate of urban land area

Note: \*For example, international capital flows, the informal economy, land-use policies, and transportation policies across urban areas Source: Seto et al., 2011.

Municipalities may invest in infrastructure and lead land development in peri-urban areas to generate new sources of revenue.<sup>98</sup> For example, in China, new housing developments and industrial zones in peripheral areas have led to a "polynucleation" of large cities, with a 57 percent increase in the number of industrial parks set up by local governments across the country between 2003 and 2006.<sup>99</sup> In Indian cities, too, government-incentivized development of new industrial corridors and townships is a common cause of rapid urban expansion.<sup>100</sup>

Given the lack of mature financial markets, real estate is a key investment vehicle, involving significant domestic and foreign private investment in discrete infrastructure and real estate projects that are often located in peri-urban areas.<sup>101</sup> Land proximate to these projects, or along transport corridors that provide access to them, is bought up quickly to capitalize on potential increases in its value. Projects are proposed by developers and approved by city authorities either solely based on economic returns—which are attractive because the initial cost of land is so low—or through collusion between public and private actors. This projectized approach is led primarily by economic interests and has resulted in an all-too-common form of speculative and fragmented development in the global South.

In struggling and emerging cities, speculation in land markets is prevalent due to shortages of land and housing and incomplete or asymmetric information between city authorities and land developers. This either results from actual scarcity of land or artificial scarcity caused by regulatory limits and a lack of infrastructure investments. Land value speculation fuels land disputes and dictates where and when land development occurs, undermining the notion of well functioning and equitable markets and the government's capacity to enforce existing regulations.<sup>102</sup> Much speculative investment occurs as transactions within the informal economy and is therefore neither trackable nor taxable; sometimes investments are even controlled by criminal syndicates. For example, in Mumbai—one of the top-four cities in the world in terms of land prices—the mafia plays a key role in the city's land development politics, in collusion with politicians, bureaucrats, and the police.<sup>103</sup>

We must distinguish here between real estate investment that aims to protect financial assets when other investment avenues are limited and exploitative or undesirable speculation.<sup>104</sup> Such speculation commodifies land and exacerbates spatial



#### Figure 9 | Land records and planning regimes by city type







D. Extent to which zoning and land-use plan is respected by government agencies



Sources: Authors' analysis based on data from Oxford Economics, 2016, and the Marron Institute of Urban Management at NYU database of land-use regulations across a global sample of 200 cities, 2016.

inequalities as private developers seek to maximize returns by constructing more high-end properties than affordable housing—a trend observed in many Asian and African cities.<sup>105</sup>

One outcome of this trend is that both private and public sector actors tend to hoard land because it is expected to more significantly appreciate than other assets. In India, Vietnam, and other countries, there are reports of unutilized abandoned land around expanding cities.<sup>106</sup> Farmers cease production and leave land fallow as they wait for urban development opportunities to arise in the city's periphery. Upon realizing the significant gains from land sales, they move their agricultural production farther away.<sup>107</sup> Government-controlled land (for railways, ports, and cantonments) is also rarely brought into the land market due either to limited resources to build or the expectation that it can be sold for larger returns in the future.

This political economy in many struggling and emerging cities has created *distorted land markets* that are inequitable, with few returns from urban development and public investment in infrastructure accruing to public sector stakeholders. This is the first equity challenge we focus on in this paper (see Section 4).

## Weak planning, ineffective land-use regulations, and housing policies

Highly restrictive density regulations are considered partly responsible for outward urban expansion, and examples can be found in many cities around the world.<sup>108</sup> The failure to plan or to enforce existing plans and land-use regulations results in rampant land conversion, and informal land transactions in disconnected peri-urban areas.<sup>109</sup>

#### Weak Planning and Land Governance

We analyzed data from surveys of land ownership and landuse regulations in 200 cities<sup>110</sup> to understand the planning and regulatory regimes that govern urban land markets. We examined the state of land registration records, land-use plans, developer and government agency compliance with zoning and land-use plans, and land ownership characteristics for the four WRR city categories. Figure 9 indicates challenges related to land markets and planning in many struggling and emerging cities, which partly explain their outward growth patterns.

Struggling cities are the worst off, and emerging cities slightly less so, in terms of the existence of land registration records for the urban periphery, established land-use plans, and the extent to which private developers and public agencies respect these plans.<sup>111</sup> The largely outward growth currently underway in these cities is therefore either undocumented or occurring through informal transactions; it is unplanned and occurs in a weak regulatory environment. As illustrated earlier, the jurisdictions of service-providing agencies may not match with land planning agencies in growing areas. Decision-making occurs across multiple siloed agencies, and the lack of local-level finance exacerbates the situation, creating severe gaps in services.

## Existing Land-Use Regulations Create Incentives for Peripheral Development

A unique study compared land-use regulations with requirements for construction of buildings and infrastructure in 600 cities across 150 countries, largely in Asia and Latin America. It found that excessively onerous regulations lead to higher land and housing prices, which may exacerbate informality and urban sprawl.<sup>112</sup> Public officials have been known to use stringent regulations to engage in rent-seeking behavior, offering approvals to builders and real estate developers in exchange for bribes that amount to as much as half of basic building costs.<sup>113</sup> Construction permits were obtained via bribery in only 11 percent of the cases studied in Latin America but in 45 percent of cases in Asia. Asian cities generally have more onerous and costly land-use and building regulations than Latin American cities do, although, as Figure 9 shows, these are not always enforced. In general, poorer countries have higher levels of bureaucracy concerning urban land-use regulations and higher transaction costs for construction permits—factors that spur outward and largely informal expansion.<sup>114</sup>

Building regulations that incentivize denser and infill development—such as those focusing on increasing the floor area ratio, density bonuses, and fiscal incentives in the form of property tax breaks for denser development—are common instruments. But experience now shows that these often serve as a vehicle for private capture of land value, generating largely unaffordable housing in well-serviced locations. This pushes more people into informal settlements.<sup>115</sup>

Although these regulations generate additional revenue for the city (from property taxes or the sale of development or air rights), they disregard the fact that existing population densities are already high and core services (such as roads, electricity, and water networks) may be overburdened and inadequate. The increase in land value is not necessarily used to augment existing urban services and is mostly captured by wealthier landowners or the private sector.

#### **Location-Insensitive Housing Policies**

Social housing programs typically evaluate affordability in terms of income and housing costs; they do not account for travel costs, thus neglecting the importance of location. Many cities' official development plans target locations for expanded urban services, but these locations do not match where growth is actually occurring, thereby creating large numbers of excluded and under-served residents.<sup>116</sup>

In Mexico City, state financing has allowed vast numbers of affordable homes to be built in the urban periphery since 2000. However, such homes are distant and disconnected from the city and lie vacant today.<sup>117</sup> Subsidies for housing construction, including land costs in South Africa, resulted in public housing built in the periphery of cities like Johannesburg. The subsidies did not cover the higher expenses of building at higher densities, deterring housing construction within cities.<sup>118</sup>

Ambitious quantitative targets for social housing that are insensitive to location have thus been another important driver of unserviced urban expansion. Consider targets that required the construction of 1 million affordable homes in Johannesburg between 1996 and 2000, the 2014 commitments made by the Brazilian government to build 2.75 million housing units by the end of its administration, or the 2013 commitment made by the Mexican government to build 1 million housing units. These plans increased the pressure to supply housing within tight time frames and at a scale that could be realized only in the urban periphery.<sup>119</sup>

New social housing complexes built as part of the Minha Casa, Minha Vida program ("My House, My Life") in Brazil between 2010 and 2013 are at a median distance of 25 kilometers from the city center, and in Mexico, new developments are, on average, more than 40 kilometers away from a city's downtown.<sup>120</sup> Across Indian cities, privately built affordable housing is 20 to 25 kilometers from the city center.<sup>121</sup> Evidence shows that the lack of clear regulations regarding housing location leaves private developers free to maximize economic returns rather than consider the proximity to jobs and other amenities, exacerbating spatial inequities in profound ways.<sup>122</sup> As land in peripheral areas is more easily available and affordable, developers are able to achieve significant economies of scale by constructing large housing complexes. Limited development restraints and coordination across the multiple jurisdictions in peripheral areas further facilitates the process.123

Under weak planning and regulatory regimes, certain landuse regulations and housing policies exacerbate the challenge of integrating service provision with land development, most affecting those with the fewest means. A second key equity challenge we therefore discuss in Section 4 is *deficient services in* growing areas.

## Haphazard conversion of peri-urban agricultural land and villages

Worsening urban poverty, the unaffordability of the city, and the struggle to survive in rural areas are making peri-urban land important as "target settlement areas of the poor."<sup>124</sup> Africa's urbanization process, much like that of South Asia, is significantly informal. This implies that despite the limited access to core services, informal peri-urban expansion will continue as long as the majority of urban dwellers in such regions are poor.<sup>125</sup>

There is increasing evidence that farmers are abandoning agriculture because of low productivity and unstable yields (which result in part from climate variation), and this is driving migration to urban areas.<sup>126</sup> Agricultural land on the urban periphery is annexed into the city's jurisdiction, and villages are rapidly absorbed into towns without statutory status.<sup>127</sup> This has led to the creation of unserviced, informal enclaves that sometimes deteriorate into urban slums.<sup>128</sup>

New satellite cities and peri-urban gated communities are being built in response to demand from a growing consumerist middle class that desires what is sometimes called an "escapist urbanism"-urban amenities without the crime, congestion, and pollution experienced in central city areas.<sup>129</sup> Agricultural land is thus highly contested, and conflicts between farmers, real estate developers, and state governments have become common in India, China, and other Asian countries.<sup>130</sup> Reportedly, 2.5 to 3 million farmers in China lose their land (and thus their livelihoods) each year because government agencies seize it for road and other infrastructure development.<sup>131</sup> In other places, such as the Indian city of Gurgaon<sup>132</sup> just outside of New Delhi, land acquisition from adjoining villages has led to hyperdevelopment characterized by gated communities, corporate buildings, and shopping malls. Property owners use private services in the absence of municipal services.133

When unregulated, these dispersed developments either become informal settlements with no public services or create largely privatized and unaffordable markets for land and services. This *disjointed informal expansion* is the third important equity challenge for which we discuss solutions in Section 4.

In summary, as cities experience demographic and economic changes, important forces determine trends of outward and unserviced expansion, resulting in growing numbers of underserved people. Infrastructure expansion and related real estate speculation distort land markets, making them inequitable and disproportionately benefitting private landowners.<sup>134</sup> Existing land-use regulations and location-insensitive housing policies push growth to the urban periphery, where people are disconnected from employment opportunities and core services—a challenge made worse by limited governance capacity. Finally, unregulated conversion of agricultural land and absorption of peripheral villages creates unserviced informal growth outside urban jurisdictions, with detrimental impacts on those who cannot afford alternate services.

These issues are common across many cities of the global South; together they contribute to three key equity challenges that this paper seeks to address: distorted land markets; deficient services in growing areas; and disjointed, largely informal expansion.

## 4. STRATEGIES TO MANAGE URBAN EXPANSION IN THE GLOBAL SOUTH

The previous section highlights some underlying drivers and resulting challenges of unmanaged urban expansion. In this section, we lay out some high-priority approaches to address these challenges. The recommended strategies are based on an evaluation of promising practices in a variety of cities, examples of which are discussed below.

### Challenge 1: Distorted Land Markets

## Strategy 1: Use regulations and incentives to prioritize spatial equity over land speculation

Unbridled land value speculation is a distortion that leads to disproportionate gains for a few, leaving the city unable to leverage increased land values to enhance public services. A strategy for addressing this problem focuses on developing a balance of regulations and incentives that prioritize spatial equity and discourage land speculation.

In many rapidly urbanizing countries, public and private sector actors influence land development decisions and incorporate new areas as *urban*, leveraging information about future development to realize gains from increased land value in specific locations.<sup>135</sup> Recent research in the growing African cities of Kigali and Addis Ababa documents much of the construction as purely speculative, drawing much-needed investment away from affordable housing and towards underand unused high-end properties.<sup>136</sup> Local decision-makers, the private sector, and other influential actors form publicprivate coalitions that act as "growth machines."<sup>137</sup> Their shared vision of urban development is aimed at spurring investment and maximizing economic growth through higher land and property prices while ignoring other environmental and social objectives.<sup>138</sup> Studies have found evidence of this "privatization of urban planning" in cities such as Manila, Mumbai, and Delhi, among others.139

As discussed earlier, strict regulatory limits on building heights and densities in well-serviced locations actually create perverse incentives for urban expansion, adding to the costs incurred by households and the city.<sup>140</sup> In Indian cities, the welfare costs of this phenomenon have been estimated at 3 to 6 percent of household income, measured by an increase in commuting costs for households located in the city's periphery; in Mumbai, it increased housing prices by 15 to 20 percent of income.<sup>141</sup> However, some types of regulations are essential to correct existing distortions and allow land markets to function more equitably and efficiently. Regulations should ensure that land is developed in locations where concurrent service extensions are planned or where private developers will contribute to the costs of service provision. Using incentives (monetary or regulatory) and subsidies to steer development towards specific zones within the city can help cities limit speculative new development while achieving desired social objectives.

Local agencies tasked with enforcing these regulations must accordingly increase their governance capacities so that plans and regulations that disincentivize fragmented land development can be enforced. This is a challenge for many cities in the global South, as they often do not have complete spatial databases of land records (see Figure 9A) and lack the necessary authority to make decisions about land or the political will to tame the private market. Information asymmetries must be reduced to minimize the potential to make vast returns from insider knowledge of future urban investments. We discuss this in more detail under enabling conditions that support these strategies in Section 6.

## Incentives to direct development towards locations within cities

Mexico initiated a major policy turnaround after a decade of subsidizing housing in locations distant from employment centers, often in vulnerable locations such as wetlands or unstable hillsides. A national program that reportedly cost \$100 billion in 2017 resulted in a large proportion of homes lying abandoned and without basic services like running water or electricity.<sup>142</sup> Learning from this debacle, since 2012, the national ministry's housing program only subsidizes housing built within specified "urban containment perimeters."<sup>143</sup> These are defined on the basis of whether basic urban services, infrastructure, and employment opportunities exist. Larger subsidies are available to development projects that are more centrally located. In 2013, 80 percent of housing was built within these perimeters.<sup>144</sup> In other locations, developers must fund and build infrastructure to extend core services (water, sewerage, electricity) and sidewalks to their developments, and municipalities are responsible for operating the services.145

In 2003, South Africa passed a law providing tax incentives to developers to build, extend, or improve buildings located within demarcated Urban Development Zones (UDZs) in selected cities, including Johannesburg. The aim was to encourage economic development and affordable housing in inner-city areas.<sup>146</sup> Johannesburg's UDZ, roughly 18 square kilometers, is the largest in South Africa, and a comprehensive, publicly available property database has been developed for the UDZ in partnership with the South African Property Owners Association.<sup>147</sup>

Brazil has developed new location-based standards for social housing developments as part of its Minha Casa, Minha Vida affordable housing program, which links housing subsidies to specific urban locations. The law discourages communities being built in isolation, highlighting the need to provide public transportation and to prioritize development in areas with existing transportation networks.<sup>148</sup>

## Imposing time limits on landholding and taxing vacant land and buildings

Peripheral land bought at extremely low prices can be held by developers for long periods of time, often a decade or two, in anticipation of city expansion. Land is held either until municipal service provision catches up or large development projects are announced. When construction or land sales begin, the increase in land prices fuels investor demand, leading to real estate bubbles, where property is further leveraged through the financial system.<sup>149</sup> This can lead to surpluses of high-end development, and newly constructed buildings end up lying vacant. This phenomenon is seen in many cities of the global South, which are experiencing rapidly increasing demand for land coupled with high capital inflows into urban real estate.

Property development aimed primarily at meeting speculative demand can be considered one of the biggest risks to builders, financiers, and the economy as a whole; a prominent example is the economic crisis that ensued following the 2007 real estate bubble in the United States.<sup>150</sup> Price speculation in the case of land (and the resultant ills of vacant land and buildings) creates inefficiencies and wastes resources. In China, in 2013, 49 million housing units—or about 22 percent of the total stock—were lying vacant in "ghost towns."<sup>151</sup> The government releases projected urbanization rates each year and developers use this as guidance to acquire and develop land; however, the housing units are sold to investors and those looking for second homes. not to new rural migrants.<sup>152</sup> In 2017, the Chinese government made the stability of the urban housing market—and, with it, the financial markets—its key priority.<sup>153</sup> A similar challenge exists in India, where the 2011 national census showed about 11 million homes lying vacant—about 12 percent of the total urban housing stock—while the country faced a total housing shortage of almost 19 million units.<sup>154</sup> In some Indian cities, more than 20 percent of the built housing stock is vacant.155

An appropriate regulatory framework for real estate development allows land markets to function more efficiently, helping limit speculative demand and the oversupply that it creates.<sup>156</sup> Additional taxes on vacant land and housing and bringing surplus stock into the rental market are measures that have been used to mitigate this situation. In developed cities such as Paris and Vancouver, significantly higher vacant housing taxes were imposed when the vacant properties reached about 7 percent of the city's total housing stock.<sup>157</sup> Several Latin American countries also tax vacant land to reduce speculation and induce development.

Land hoarding is not only practiced by private developers. Large tracts of government-controlled land reserved for public facilities in prime urban locations often lie unused, typically for want of financial resources to develop them. In Mumbai, for example, despite severe shortages in housing, large tracts of land owned by the Mumbai Port Trust, one of the city's largest landowners, have lain vacant for decades but have been partly occupied by slums.<sup>158</sup> Recently, an ambitious plan to develop this land and rehabilitate its slums was announced, but it has not yet been approved.<sup>159</sup> This problem occurs in African cities as well; 40 percent of all zoned residential land in Nairobi lies vacant.<sup>160</sup> Similarly, more than 30 percent of land within five kilometers of the central business district in Harare, Zimbabwe, and Maputo, Mozambique, remains undeveloped, despite relatively high population densities.<sup>161</sup> Cities must consider imposing time limits on landholding by private developers and taxing vacant land to prevent land hoarding and speculation, while bringing public land into the market.<sup>162</sup>

In China, laws are explicitly aimed at limiting the excessive increase in housing prices and ensuring that vacant land is used. For example, laws require housing developers to build on urban land within two years of acquiring it and receiving the land-use right.<sup>163</sup> The legal time limit on holding land prior to its sale in cities such as Nanjing and Wuhan is three years.<sup>164</sup> As a strategy to limit speculation and discourage land hoarding, some countries, such as Sri Lanka, Malaysia, and Colombia, freeze land values in locations where land development or readjustment schemes have been prepared. Such freezes are temporary and are intended to ensure that the land's commercial value does not include increments attributed to the planned project itself, thus limiting land value speculation.<sup>165</sup> Although such regulations are crucial, there is a need to carefully interpret the extent to which urban land must be regulated; such regulations should not create unintended consequences or perverse incentives. Zoning codes were envisioned as a way to balance the benefits of a growing city's increased productivity with the environmental and social costs of its growth. However, in weaker institutional contexts, zoning and other land-use controls have been politicized into mechanisms that perpetuate greater spatial inequity, bringing windfall benefits to those with land ownership and property rights and excluding those without.<sup>166</sup> It is therefore important to find the right balance of regulations that enable consistency but are also flexible enough to support change. Regulations, therefore, cannot be fossilized; they must be adapted to changing conditions, based on ongoing research and monitoring of equity outcomes.

## Challenge 2: Deficient Services in Growing Areas

# Strategy 2: Incrementally increase the supply of serviced land by forming partnerships to finance core services

As Section 2 showed, cities can follow a two-pronged approach when considering where to expand the supply of serviced land. In vacant, under-utilized, or low-density areas that have low upward growth, cities can encourage more upward and compact growth, as these locations are typically close to employment centers and are well connected to services. At the same time, cities that are growing upward in already built-up area but also expanding outward must increase the supply of serviced land in the periphery, balancing the costs of land with the costs of service provision. Spatial and economic development must be integrated so that land and infrastructure planning is combined with the development of employment centers.

In both approaches, cities can encourage more equitable development through participatory land assembly schemes—for example, assembling and redistributing land into a mix of plot sizes, with provisions for affordable housing, and mandating that a percentage of the land be used for public services such as transport networks. Urban planning plays a crucial role because the failure to plan for impending urban growth—particularly growth in the number of low-income residents—often contributes to spatial exclusion.<sup>167</sup>

The challenge is accomplishing this in a regime of mixed private, public, and customary or tribal land ownership, as exists in much of South Asia and Africa. Figure 10 illustrates how land ownership in growing areas is split for a limited sample of cities across the four WRR categories. The struggling cities for which data on land regulations were available have about 60 percent of their land under public, tribal, and customary ownership, and emerging cities have 20 percent owned by the public sector. This



#### Figure 10 | Land ownership in city areas that grew between 1990 and 2014

Sources: Authors' analysis based on data from Oxford Economics, 2016, and the Marron Institute of Urban Management at NYU database of land-use regulations across a global sample of 200 cities, 2016. Struggling, emerging, thriving, and stabilizing cities are as shown in Figure 4. City definitions vary between the NYU and the Oxford Economics datasets. The city data from Oxford Economics are based on city administrative boundaries while the NYU data are based on extent of built-up area (greater than 25 percent built up). highlights the opportunity for struggling and emerging cities to plan better, but no doubt it also contributes to the challenge of ongoing corruption and political involvement in land deals. Divided ownership also necessitates partnership approaches when planning for urban growth. Higher-income cities have 91 to 100 percent of their land under private ownership, which creates other challenges related to privatization and the loss of public space.

## Incrementally increase the supply of land for affordable development

Increasing the availability of land for affordable housing in environmentally secure and economically connected locations is necessary for inclusive urbanization.<sup>168</sup> This is likely to require new regulations and procedures that involve negotiation and collaboration between municipalities, private developers, and communities. It also requires land acquisition processes that are efficient and fair in terms of compensating farmers and other landowners. It involves preparing realistic projections of

#### Box 3 | Secondary Roads as Conduits for Core Services and Infrastructure

The arterial or secondary road system—which is where core urban trunk infrastructure such as water pipelines, sewers, stormwater drains, and public transport is located—is largely undersupplied in sub-Saharan African and Asian cities.<sup>a</sup> The reason is that while primary roads are the responsibility of central or state governments, and tertiary roads within subdivisions are typically planned by developers and have their costs included in the price of land, secondary roads are the responsibility of municipalities. They tend not to get built due to the severe municipal budget constraints of many cities in the global South.<sup>b</sup> Once ad hoc land subdivision and occupation occurs, it is too late and too expensive to acquire the necessary land for secondary roads. Planning a city's expansion in advance allows city governments to get ahead of the informal and unserviced land subdivision that characterizes peripheral development in so many rapidly growing cities. Making well-serviced land incrementally available throughout the urban periphery can increase land values, and therefore property taxes, allowing municipalities to cover the costs of land acquisition while limiting undesirable speculation.<sup>c</sup>

Sources: a. Angel, 2008; b. Beard et al., 2016; c. Angel, 2008.

population growth and identifying areas around a city where the growth can be accommodated, allowing construction of appropriate arterial streets to carry the necessary urban service infrastructure (see Box 3). Finally, it involves altering jurisdictional boundaries and authorizing local government to acquire rights of way and to identify, purchase, and protect public open spaces within the expanded area.<sup>169</sup>

This ambitious strategy takes the standard idea of citywide "master planning" down to specific local plans and actions that make serviced land available for all segments of society in the urban periphery. It has some important prerequisites as well as risks. It requires the existence of functioning land markets facilitated by an effective policy and regulatory framework (see Strategy 1) to ensure alignment of these expansion plans with broader metropolitan goals and regulations. It works best when subdivisions are planned to provide at least a minimum amount of urban services.<sup>170</sup> Strong community engagement, combined with national policies that require fair prices paid to landowners, mechanisms for accountability, and local control can help ensure sustainability.<sup>171</sup> Complementary policies that allow for denser development must be implemented with these urban expansion plans, as newer settlements will eventually become more central.172

Cities in Ethiopia and Colombia have begun implementing projects that follow this approach. Their experiences indicate that large areas of cities can be planned without needing to acquire more than a small proportion of land (6 to 8 percent of the expansion zone) and without disrupting current residents.<sup>173</sup> In Colombia, such efforts are being scaled up into national programs aimed at planning for urban expansion, especially in smaller cities that are likely to see more rapid growth rates and where land may be less contested than in larger cities.<sup>174</sup>

Other countries have adopted similar approaches to allocating land for urban development in accordance with broader development plans that provide for core services and have financing mechanisms built into their designs.<sup>175</sup> In Seoul, South Korea, 40 percent of the city has been developed through a land readjustment approach framed as "build together, benefit together."<sup>176</sup> In Gangnam, which was integrated into Seoul through an expansion of the municipal boundary in the 1970s, land readjustment allowed roughly 37 percent of existing land to be set aside for roads and public facilities, and the value of the remaining 63 percent of serviced land increased 6.5 times.<sup>177</sup> Higher land values initially created challenges with affordability and real estate speculation, but they also increased property taxes, generating the required financing for the city to extend infrastructure. Over time, Seoul's land readjustment program was continually adapted to ensure greater public sector involvement and public benefit and to respond to challenges of affordability. In 2000, the program was integrated into Seoul's Urban Development Act to better serve the needs of a mature city.<sup>178</sup>

In cities in India's state of Gujarat, Town Planning Schemes (TPSs) began to be widely used to proactively plan for urban growth in accessible locations after the state's land policy was amended.<sup>179</sup> Ahmedabad, the capital of the state, utilizes the TPS as a land readjustment mechanism. It allows the city to acquire land from landowners for public purposes, including roads, underlying service infrastructure, low-income housing, and open spaces, in ways that align with the city's development plan. The TPS mechanism has shown most promise in greenfield sites that have no existing development and locations that are close to the urban periphery, where land values have more potential to increase. This approach has helped Ahmedabad generate land for low-income housing that is within the city and equipped with core services. Utilizing a planned and transparent process, it has also generated land to support a dense street network that enhances infrastructure and accessibility overall, which has proved difficult to achieve in many other Indian cities.<sup>180</sup> However, protracted approval processes cause the TPS to face financing challenges and delays in generating buildable land. The TPS also does not address the displacement of tenants and informal occupants of land, nor does it solicit their participation. An in-depth WRR case study on the use of this mechanism in Ahmedabad highlights the importance of having better land records, conducting detailed surveys of existing locations prior to planning, and streamlining approval processes to make the TPS more equitable and effective.<sup>181</sup>

Overall, there are concerns about the ability of struggling and emerging cities to conduct land readjustment at the required scale. Doing so will require cities to engage with both formal and informal land development processes and partner with relevant stakeholders.

#### Partnerships to finance and deliver core services

City development authorities that have partnered with private actors or public utility companies have successfully developed land in locations where it is viable to provide urban services, including to the under-served. For example, in Medellín, Colombia, a partnership between the city development authority and the public sector utility company, Empresas Públicas de Medellín (EPM), which provides electricity, gas, water, sanitation, and telecommunications services, helps foster new development that is well serviced and inclusive.<sup>182</sup> It is owned and managed by the Medellín municipality but run as a commercial enterprise, providing services to a metropolitan area of 5.2 million people.<sup>183</sup> Each year, it contributes 30 percent of all profits to the city's budget for social development projects, which amounted to \$345 million in 2011.<sup>184</sup> EPM also ensures provision of high-quality core services and infrastructure in Medellín's most marginalized neighborhoods. EPM operates as a private company, paying taxes like any other corporate entity in the city. National and international credit-rating agencies have recognized the company for its high performance standards and transparency. The company's contributions to the city's growth and development are linked to its strong connection to the mayor's office; the mayor serves as EPM's president and appoints all of the company's board members.185

In Brazilian cities, private developers are incentivized to develop projects in Urban Operations (UOs) that are planned by the public sector (see Box 4). The sale of development rights within a UO generates resources upfront for infrastructure provision. The UOs are enabled by a national-level city statute as well as by the city's master plans.

Several cities, such as Mumbai in India, use the mechanism known as Transfer of Development Rights (TDR) to grant enhanced development rights to private developers who surrender land in central and accessible locations for public purposes. In exchange for giving up all or part of their land for open space, affordable housing, or public infrastructure, developers are given the right to build and sell additional floor space elsewhere, equivalent to at least twice the area of land surrendered. The policy provides a way for cities with extremely low municipal budgets to acquire land for public purposes while compensating landowners with development rights that may be used or sold to other developers. This has sometimes had unintended consequences with respect to equity and affordability, spurring development in cheaper, under-serviced peripheral areas and encouraging speculation. This problem can be mitigated by clearly regulating where and how TDRs are used. New amendments to Mumbai's TDR policy have now linked TDR utilization to road widths (because they serve as a simple indicator of infrastructure and service availability), with greater permissible built-up area in locations with wider roads. The amendments may mitigate the problem of new development occurring in locations that lack core services.186

#### Box 4 | Public-Private Partnerships for Serviced Urban Operations in Brazil

In Brazil, Urban Operations (UOs) are large schemes aimed at promoting development in new locations, building new public transport infrastructure, improving slums, building affordable housing, and avoiding gentrification, among other objectives.<sup>a</sup> UOs are an important tool for facilitating publicprivate partnerships for urban development and structural transformation in large city areas that require infrastructure and investment in urban services. Funding for these investments is generated from the increase in land value that results from the improvements and zoning changes.

Within the boundary of a UO, an innovative instrument known as a "certificate of additional construction potential" (known in Brazil as *certificados de potencial adicional de construção*, or CEPAC) is used to incentivize private developers to build in accordance with the UO's objectives and the city's statutes. CEPACs are auctioned for use within the perimeter of a UO and entitle the bearer to additional building rights, such as a larger floor area ratio, an altered building footprint, and the ability to change land use. The price a developer pays to the public sector in exchange for new building rights corresponds to the area and location of the plot within the UO where it will be used.<sup>b</sup> Each UO specifies the percentage of publicprivate contributions and how the extra land value generated will be shared between the private developer and the public sector. Faria Lima, one of the first UOs where this mechanism was used in São Paulo, specified 50 percent public sector participation; in Agua Branca, it was 60 percent.° The key advantage of a CEPAC is that it allows the public sector to obtain compensation before the developer begins a project. It thus generates resources to finance the construction of supporting infrastructure and services within the UO without diverting funds from other public purposes or creating a public deficit.<sup>d</sup>

As these large projects are built out and CEPACs are sold in phases, land prices have significantly increased. While this generates value, the success of a UO also leads to gentrification, as homes within it may become unaffordable for lower-income households. In the Faria Lima and Água Espraiada UOs, this issue was mitigated by establishing "zones with special social interest," where the land can be used only for affordable housing. Some UOs in locations with buoyant real estate values may generate more income for cities than is needed to provide core services. In these cases, experts suggest using part of the value generated to develop infrastructure and services where private developers are reluctant to invest, such as in peripheral and low-income areas.

Replicating the success of CEPACs in other countries requires carefully considering the context, which includes determining whether there is a thriving real estate market, a robust financial market, enforceable zoning regulations and city building codes, enabling legislation, and strong local public sector capacity. The public-private partnership model for large urban developments like UOs, supported by a financial instrument such as a CEPAC, requires local public officials to have a high degree of technical capacity, expertise, and authority.<sup>e</sup> Although a CEPAC can be considered a neutral value capture instrument, to promote equity, decision-makers must prioritize social objectives over high auction prices and resulting land values, which could lead to gentrification and displacement.<sup>f</sup>

Sources: a. Sandroni, 2010; b. Sandroni, 2010; c. Sandroni, 2010: 1; d. Biderman et al., 2006; e. Sandroni, 2010; f. Smolka, 2013; 57.

In Johannesburg, South Africa, the 2012 Corridors of Freedom project (later renamed Transit-Oriented Development Corridors) identified high-priority zones for transit-oriented development along the city's new Rea Vaya Bus Rapid Transit system. The scheme was embedded in the city's long-term growth and development strategy for 2040 and was designed to reverse the legacy of spatial inequality since the apartheid era. It also aimed to limit peripheral low-density development by creating denser, mixed-use, and mixed-income developments that are more accessible to all residents.<sup>187</sup> The city created precinct-level Strategic Area Frameworks that included a package of incentives

for private sector investment and partnership. These included preemptive zoning to speed up planning approvals, negotiations over development levies, detailed precinct-level local area plans, and, importantly, commitments to provide infrastructure investments in these zones. Another WRR case study discusses the planning process for the Corridors of Freedom project.<sup>188</sup> Although the results of these decisions are still unfolding, the use of legal and policy frameworks to steer urban growth through partnerships with the private sector is highly instructive for other cities. Projects in Latin America—such as Colombia's Nuevo Usme project (in Bogotá) and Gonzalo Vallejo Restrepo Macro-Project (in Pereira)—have focused on generating serviced land for low-income housing projects and community facilities.<sup>189</sup> Land readjustment was carried out with equitable distribution of costs and benefits across landowners. The municipality acquired the land, captured land value by selling building rights, used the funds to finance the program, and controlled the form and intensity of land use and occupation. Land readjustment has also been done in partnership with informal developers and with community participation in low-income informal settlements, such as in Porto Alegre, Brazil.<sup>190</sup> These are discussed under the next strategy of integrating informal settlements into a city's expansion plans.

As a strategy to generate serviced land, transit-oriented development is well covered in the transportation literature. It is best achieved when cities engage in public-private partnerships, impose regulations on where and when to build, and closely collaborate across land-use and transportation planning agencies.<sup>191</sup> In fact, one implication of weaker land-use controls is that the effects of road and other transportation investments are stronger and more immediate. This makes it crucial for cities to have the capacity to direct the land-use changes that follow transportation investments.<sup>192</sup> Another WRR paper focuses on transportation and equitable access to opportunities to address exactly this issue.<sup>193</sup>

## **Challenge 3: Disjointed Informal Expansion**

## Strategy 3: Integrate existing informal settlements while creating affordable density

This strategy addresses the disjointed and informal expansion that characterizes many growing cities of the global South. An important way to reduce the need for more land is to incorporate existing informal or unregularized settlements within the city's formal jurisdiction and include them in existing urban services networks. Such settlements develop gradually and sometimes exist for decades, gaining services over time but often lacking formal titles.<sup>194</sup> Although informal settlements provide muchneeded affordable housing in growing cities, they exist in a legal gray space; some are unlisted in government records and registries and are outside land-use regulations, with poor or no access to core services. In 2015, about 880 million people lived in slums that lacked access to basic infrastructure and services such as water, sanitation, and electricity.<sup>195</sup>In some cities, informal settlements are home to as much as 70 percent of the population.<sup>196</sup> Given this reality, the manner in which we deal with these informal settlements is "one of the defining policy challenges of our times."<sup>197</sup>

Real estate transactions in many struggling and emerging cities often fall between what is recognized as strictly formal and informal.<sup>198</sup> Studies done in Brazilian *favelas* and Indian slums indicate the prevalence of property transactions that mimic those in the formal sector but are recognized only by the community and are not necessarily legally binding.<sup>199</sup> Self-built homes are bought, sold, and rented, despite the lack of a formal title. There are no clear lines between legal and illegal, and the distinction is irrelevant to the community.<sup>200</sup> Still, regardless of legality, settlement residents represent a crucial electorate and can use political channels to improve public services provision and gain legitimacy. This provides a kind of de facto tenure and, in fact, rights secured through political networks may in time gain proper legal status through subsequent regularization programs.<sup>201</sup>

In technical terms, informal settlements include not only urban slums but also unregulated expansion in peripheral or environmentally vulnerable areas; they also include informal industrial districts that flout zoning, labor, safety, and environmental regulations.<sup>202</sup> Despite a multitude of programs that have increased basic infrastructure coverage (of piped water, sewerage, and streets), the supply of affordable and well-serviced land still lags behind demand, which perpetuates informality.<sup>203</sup>

The first two strategies discussed in this section offer preventive measures to address some of the root causes of informality, including distorted land markets and certain types of regulations, as well as constrained supply of affordable, welllocated, and serviced land. Cities have used strategies such as inclusionary zoning, less restrictive densities and building standards, and reduced transaction costs for building approvals.

However, given the persistence and growth of informal settlements, it is crucial to develop curative measures to address their debilitating gaps in services. Urban expansion approaches in struggling and emerging cities can neither ignore nor easily redevelop swaths of land under such settlements, as has been suggested for cities like Nairobi, based on an argument that informal settlements represent an inefficient use of land.<sup>204</sup> Informal settlements are often part of strong economic networks and are located close to job centers, a key motivation for their existence in these locations. Growing cities can achieve more equitable outcomes by integrating existing low-income, lowrise informal settlements, improving service provision, and supporting residents to add height, introduce open spaces, and improve livability.<sup>205</sup>

#### Extending core services to informal settlements

Much has been written about the positive outcomes of slum upgrading programs, such as in the *kampungs* of Indonesia (via the Kampung Improvement program in Jakarta and Surabaya),<sup>206</sup> the Baan Mankong program in Thailand (which has now been scaled up across many Asian countries), and the *favelas* of Brazil (Favela-Bairro in Rio de Janeiro), among others.<sup>207</sup> These are discussed in detail in a separate WRR paper on ways to generate well-located affordable housing.<sup>208</sup>

Upgrading programs may involve relocating some portion of the population to generate land for urban services, or in cases where informal settlements have developed in environmentally hazardous locations. "Sites-and-services" programs that began in the 1970s were a response to this challenge, and provided spaces for community services and for serviced, affordable home sites where the less affluent could build their own homes.<sup>209</sup> These programs created affordable alternatives to other parts of the city, where land planned to high standards with relatively high specifications for minimum plot sizes and road widths excluded lower-income groups.<sup>210</sup>

As described under Strategy 2, the public sector's ability to secure land is crucial to providing more affordable housing, whether through the use of vacant public land, legal land assembly instruments, or joint efforts with private landowners. Informal settlement dwellers are not always poor, and experience shows they are willing to pay property taxes and fees for services in exchange for legitimate tenure and improved living conditions.<sup>211</sup>

In Colombia, utilities are legally required to cover the costs of infrastructure extension. The utility provider in Medellín (EPM) has for decades run a program called Habilitación de Viviendas (HV, or "Fitting-Out of Dwellings") to work with the municipality to extend utility services to the city's growing informal settlements along with making additional physical improvements.<sup>212</sup> Under the HV program, residents are given long-term, low-interest loans to cover the costs of accessing services. EPM conducts significant capacity building in the neighborhoods that participate in HV programs and holds public meetings to explain the program's costs and benefits. Program evaluations revealed that 95 percent of residents strongly agreed that the HV projects had improved the quality of life in their neighborhoods.<sup>213</sup>

Brazilian cities have made important strides in trying to incorporate favelas into a more formal system.<sup>214</sup> The Social Urbanizers program<sup>215</sup> in cities like Porto Alegre involved engagement between municipalities, private sector informal developers that operated in existing informal settlements, and low-income households. They negotiated and agreed on new rules and procedures to ensure minimum levels of service provision and better-planned informal subdivisions, ensuring urban development in locations where it was cost-effective to provide infrastructure and services.<sup>216</sup> This experience has been replicated in Colombia and El Salvador.<sup>217</sup> It incentivized formal developers to operate in lower-priced markets, and it engaged informal developers to provide formal housing alternatives instead of eliminating them. The result was a win-win situation in which informal developers avoided the risks of clandestine operations and low-income households could purchase legal, serviced lots at similar or lower prices than informal ones.<sup>218</sup>

Some countries have used regularization programs to not only provide legal occupancy rights but also enhance services and environmental conditions within informal settlements. Peru and Colombia have had some success with these programs, but broader experience from Rio de Janeiro and other cities in Brazil shows that title regularization can work only if accompanied by efforts to upgrade and improve urban services.<sup>219</sup> This requires financing and built-in financial recovery mechanisms.

Regularization programs must be designed to feature affordable payments for urban services and contextually appropriate titling schemes that recognize varied forms of land ownership, including customary ownership (common in African cities), long-term leasehold rights, and public or communal land trusts.<sup>220</sup> Regularization programs work best when made financially self-sustainable by collecting property taxes, charging for urban services, and reinvesting increased land values back into public amenities. These programs must be customized to meet particular needs in different contexts. Community involvement, political leadership, and appropriate design and planning standards are
prerequisites for improving services in informal settlements. In Rosario, Argentina, the Rosario Hábitat program, implemented by the city's public housing agency, has helped improve housing, infrastructure, and community services in informal settlements, ensured relocation from flood-prone areas, and provided legal tenure for many families. The program has also focused on employment generation and actively involved local government, civil society representatives, and community residents.<sup>221</sup>

## Affordable density through flexible planning standards

As peripheral urban villages and informal settlements are integrated into cities, past experience with sites-and-services projects and community-led upgrading efforts provides a blueprint for how to upgrade existing settlements while minimizing displacement, maximizing affordability, and ensuring progressive densification as the population grows.

Programs originally meant to generate affordable housing in peripheral areas of the large Indian cities of Mumbai and Chennai have, 20 years later, resulted in thriving communities. They have produced well-planned, well-serviced, mixed-use, and mixed-income neighborhoods that are now well integrated into the city, in highly accessible locations, and almost fully built out.<sup>222</sup> Several factors have contributed to this outcome. These include the introduction of smaller plot sizes, and the allocation of serviced plots in a range of sizes, infrastructure standards, and prices to different income groups. The sites were also planned for progressive densification with a hierarchy of roads and open spaces that fulfilled multiple community functions. Projects were sited in locations with connectivity to employment and transportation, and space was allocated for social services and commercial enterprises operated by community residents.<sup>223</sup>

These features allowed urban services to be more easily upgraded as the settlements' populations grew.<sup>224</sup> The small, affordable serviced plots addressed a key supply gap in formal housing and allowed low-income people the opportunity to enter the housing and land market for the first time. Similar innovations were introduced in the Khuda-ki-Basti 3 development in Karachi, Pakistan, to allow densification on small plots in low-income settlements, as opposed to building high-rise apartments.<sup>225</sup>

In Windhoek, Namibia, the city government worked with the Shack Dwellers Federation of Namibia to reduce the cost of formal (legal) housing plots by changing building codes, reducing minimum plot sizes, and lowering infrastructure standards. This helped lower-income groups afford legal housing plots, on which the city permitted construction of rudimentary housing with upgrades over time.<sup>226</sup> In contrast, the governmentled 20,000 Plots Project in Dar es Salaam, Tanzania, aimed to provide planned and serviced land to stem informality, but the limited availability of small plots and resulting unaffordability excluded low-income people and pushed them further towards informality. Less than 17 percent of the plots were small and affordable, and the priority was to allocate plots to those who could construct homes within two years so that program costs could be recouped.<sup>227</sup> Aside from basic road infrastructure, the plots lacked core services such as water, sanitation, and electricity.<sup>228</sup>

UN-Habitat's Participatory and Inclusive Land Readjustment mechanism adapts traditional land readjustment or landsharing programs to emphasize a participatory process, relying on negotiations between the local authority and all stakeholders, including landowners, informal residents, tenants, and community organizations.<sup>229</sup> It is currently being piloted in La Candelaria, an informal, unplanned settlement in Medellín, Colombia. Located by the river, La Candelaria is primarily occupied by low-income residents. Community members participated in designing the options that would allow them to remain on site yet away from areas at risk of flooding. So far, there have been improvements in housing conditions, public spaces, and community facilities, and the risks from flooding have been reduced. This is accompanied by more dense housing, mixed land uses, equitable distribution of costs and benefits among landowners, and more new housing units for sale in the open market, which helps defray part of the project's costs.<sup>230</sup>

In summary, service provision in existing informal settlements with or without regularization—must go hand in hand with flexible minimum planning standards if informal settlements are to be integrated into the city's network of core services and remain affordable and adequately dense. City officials must closely track the interlinked workings of the informal and formal property markets to develop flexible land development regulations and policies that are better attuned to the pace of urbanization and more responsive to growing cities' informality.<sup>231</sup> Ultimately, cities must strive to bring together, spatially and legally, both planned and self-constructed modes of urban development, using appropriate and flexible legal frameworks, "without eroding the conditions that make them unique."<sup>232</sup>

#### Figure 11 | Enabling conditions for managing urban expansion in the global South



Source: Authors.

# 5. ENABLING CONDITIONS THAT SUPPORT THE THREE STRATEGIES

Reforming land regulations, increasing the supply of serviced land through public-private partnerships, and working with communities to integrate existing informal settlements into the city are high-priority strategies to ensure that core services are available to all residents of rapidly growing cities, and in a sustainable way.<sup>233</sup> This section discusses enabling conditions of urban governance, planning, finance, and technology needed to support implementation of these strategies. Figure 11 summarizes these conditions.

## **Urban Governance**

# Transparent records of land titles, occupancy, and transactions

Good records of land ownership are a prerequisite for drafting effective land regulations and designing incentive schemes. Unjustified private capture of land value can be avoided when complete and up-to-date land records enable local authorities to appropriately assess and tax properties. While the absence of secure tenure and title in informal housing limits public investments in basic services, some cities are paying more attention to existing informal, community-recognized titles and tenure systems.<sup>234</sup> The coexistence of multiple land tenure systems involving public, private, tribal, and customary ownership, particularly in African cities, creates challenges, but increasingly countries like Zambia, Botswana, and Namibia

are recognizing customary land ownership as part of formal tenure systems.<sup>235</sup> As described in Box 2, satellite imagery aimed at identifying informal settlement locations offers a new opportunity to complete land records.

# Incentives for cross-agency coordination with local authority to enforce plans

In many growing peri-urban areas, conflicts are common between rural and urban authorities regarding jurisdiction, policy enforcement, and who pays for service provision.<sup>236</sup> For example, Lagos, Nigeria—one of the fastest-growing sub-Saharan cities—has been described as a "loose federation of diverse localities" whose minimal interaction and lack of coordination has hampered quality of life over the last 20 years.<sup>237</sup> In contrast, evidence from China shows better outcomes in terms of providing housing and services to the urban poor because of the active and entrepreneurial efforts of local governments to negotiate with private developers and other public agencies.<sup>238</sup>

Of central importance are governance processes that give cities authority to enforce development plans and provide incentives from higher levels of government (national, state, or metropolitan) for cross-jurisdictional, cross-sectoral coordination. For example, Brazil's National Law on Urban Mobility, adopted in 2012, required over 3,000 municipalities to adopt urban mobility plans by 2015; and the plans integrated local land use and transport to improve overall accessibility in cities.<sup>239</sup> The law also required cities to ensure public participation in the development and implementation of the mobility plans, spurring innovative ways to share information and engage the public. The Brazilian law was accompanied by a national financing program (PRÓ-MOB) for urban mobility infrastructure, which created an important incentive for cities to coordinate across land-use and transport agencies and other jurisdictions.240

# Participation of the under-served in land readjustment and development schemes

Land-related policies and plans must prioritize public participation, must be enforceable, and should include mechanisms that are unlikely to be challenged or altered by politicians and private players acting in their own shortterm interests. Experience from Jakarta shows how the lack of participatory governance mechanisms has led service extensions to be planned in locations other than informal neighborhoods where new low-income urban migrants live, so as not to legitimize these neighborhoods.<sup>241</sup> Legal frameworks and planning processes for urban development must be flexible and prioritize the social objectives for which they were created, aiming to correct imbalances in political voice by enlisting the participation of communities and civil society.<sup>242</sup>

# **Urban Planning and Management**

## Strategic planning with minimal red tape

Planning agencies must simplify time-consuming and costly administrative processes so they can more effectively enforce land-use plans and regulations while fulfilling their mandate for strategic planning.<sup>243</sup> Land-use plans may take two to three decades to show results, which is precisely why strategic action is crucial. Seoul experienced uncontrolled urban expansion during the early years of its economic growth. A strategy of controlled development that featured both planning and the market were utilized to help the city develop in a more inclusive, transit-oriented, and compact way. Over 40 years of planning based on land readjustment led living space per person to double from 10 to 20 square meters, green space per person to increase by a third, the number of high schools to double, medical facilities to grow by five times, crime rates to be cut in half, and air pollution to be reduced by 60 percent, despite the fact that the number of cars doubled between 1960 and 2000 and the city and metropolitan population quadrupled during the same period.<sup>244</sup> Although many other policies may have contributed to these outcomes, land-use and planning policies have played a crucial role in appropriately directing this form of urbanization.

## Capacity to pilot test new standards and regulations and monitor the impacts of existing ones

In cities of the global South, the public sector can be most effective if it responds to development needs at the same pace as informality proliferates, reinventing programs and policies for greatest impact. Building codes and planning standards for trunk infrastructure such as roads, sewers, water supply and drainage, and electricity must be flexible to match different modes of service delivery and different income levels. These must also be coordinated with available development budgets, lest connectivity to core services remain unaffordable or unprovided. Proposals for revised land-use and built-form regulations that respond to growth patterns and new needs must be systematically tested to ensure they are practical for different types of neighborhoods. The impacts of existing regulations must be monitored regularly to ensure they remain valid under changing development costs and household incomes.<sup>245</sup>

## Finance

The lack of available resources with which public agencies can acquire and survey land and plan for its development is an important cause of unplanned development.<sup>246</sup> Strong local authorities can emerge only if they are allocated the necessary budgetary authority and resources to deliver basic urban services.<sup>247</sup> Fiscal instruments can help make land markets more inclusive and productive and better serve the public interest.<sup>248</sup> A more transparent property tax system can help discourage speculation, stimulate land development, and increase the provision of urban infrastructure and services. This is the first step to more sophisticated land value capture instruments, and it requires well-established records of land ownership and transactions, as discussed under the section on urban governance.

## Land value capture to finance service provision

Land value capture instruments raise revenues for cities in a variety of ways. Such instruments might include betterment contributions, development impact fees, charges and auctions for building rights and air rights, and the sale of land acquired as part of land readjustment schemes.<sup>249</sup> When used in conjunction with concurrent land development and service provision plans, these instruments can help capture the increase in land value for equitable service provision.

Land value capture has been used to finance many transportation-related improvements. For example, in Mumbai, the Mumbai Metropolitan Region Development Authority has used revenues generated from land sales in the Bandra-Kurla commercial complex to support transportation investments throughout the metropolitan region. Similarly, in Brazil, the new satellite city of Águas Claras, located about 20 kilometers outside Brasília's city center, was connected to the city through an underground metro line, 85 percent of which was financed through the sale of developed land plots in Águas Claras.<sup>250</sup>

Leveraging land to finance urban transport in cities with relatively high land values is a strategy that has been proven to work, but certain prerequisites always exist in the successful cases: the land is either owned or bought by public agencies, the original value of the land is low, and the property market is thriving in that location. In the successful cases, the development and sale of land is also managed jointly with the construction of the transport infrastructure, emphasizing yet again how critical it is for cities to coordinate across agencies and adopt an integrated approach to land development and transport improvements.<sup>251</sup> Hong Kong's Mass Transit Railway Corporation (MTRC) is another notable example in which the public transport agency has exclusive rights to long-term (50 to 70 years) government-controlled leases of land around transit and offers land parcels to private sector developers through a competitive bidding process.<sup>252</sup> In partnerships with private developers, the MTRC successfully develops, sells, and rents residential and commercial properties that allow it to fund its operations without public subsidies.<sup>253</sup>

In Bogotá, the betterment levy, or *contribución de valorización*, imposes charges on landowners to defray the costs of improvements to their properties and to provide roads and other upgrading projects distributed around the city. From 1997 through 2007, this mechanism financed 217 public projects in all parts of the city that totaled more than \$1 billion.<sup>254</sup> The innovative law bases the levy on a set of parameters that include land use (commercial and industrial uses cost more than residential), a community's income level and ability to pay, as well as more conventional parameters that pertain to the land parcel's size, location, and level of improvements.<sup>255</sup> Mechanisms for land value capture thus take different forms and must be put to greater use in cities of the global South.

# **Technology and Spatial Data Sharing**

As cities expand their land area by converting rural land to urban uses, or as peripheral areas become classified as urban over time, it is essential to track where these conversions are taking place and the extent to which urban settlements have access to core services. High-quality spatial data from satellite imagery is now increasingly available and should be integrated into institutional processes for planning and managing urban expansion.

In addition, "big data" regarding traffic flows, cell phone communications, internet usage, and financial and other transactions—some of which are available to the public, and some not—are rapidly proliferating. These data sources may be used to identify activity patterns, locations of job growth, and levels of service access in cities that do not have capacity to gather such data on a routine basis. Community-gathered data from thousands of informal settlements across approximately 500 cities are being used to support upgrading efforts under Slum Dwellers International's Know Your City initiative, and nighttime lights data have been used to identify locations of poverty. These data are best made public and, at the very least, shared across government agencies to facilitate greater transparency in decision-making and help citizens innovatively solve urban problems.

### Use of new technologies to gather spatial data

Cities should ensure that satellite imagery interpretations are matched with fieldwork in a sample of locations to understand their accuracy levels. This is crucial for detecting the scope and pattern of urbanization while also offering valuable information about undocumented informal settlements. With increasing use of artificial intelligence, satellite imagery is being used to "train" machine learning algorithms to provide citywide landuse maps, maps of vulnerable environmental sites, and more. This has great potential for cities where technical capacity is severely limited and even basic land-use maps do not exist or are not updated. As this ability is being developed by researchers, there remains the need to verify and appropriately interpret the maps generated through actual ground-level surveys and adapt algorithms accordingly (see Box 2).

Increasingly, in China, India, Tanzania, and some Latin American countries, drones are being used as a low-cost way to tackle the otherwise expensive exercise of land mapping. This has allowed cities to monitor development patterns, complete their land cadasters, enforce land-use regulations, and collect tax revenue.<sup>256</sup> Detailed drone images combined with satellite imagery generated over time can help monitor levels of service provision in existing informal settlements, growth patterns, and the condition of open spaces and environmentally vital areas. As discussed in Section 2, new remote sensing data allow us to better understand cities' outward and upward growth. Most importantly, these technologies should be used to include the under-served rather than exclude them, and support policy making with much needed spatial data.

# Common standards for interagency and public data sharing

The increasing availability of open data and the development of common standards for satellite imagery and other technologies create great potential to share crucial local-level information across multiple actors. Making such data more transparent can help energize public pressure and spark innovation for more sustainable growth. To use the above technologies effectively, agencies must cooperate to share and map data. For example, given the growing use of digitized maps to plan major infrastructure projects, it is technically possible to overlay data on core infrastructure networks (transportation, water, sanitation, electricity) with settlement data, thereby allowing stakeholders to analyze the physical proximity and access of settlements to these core urban services and better understand the need for future investments to expand service provision.

# **6. CONCLUSIONS**

Evidence shows that as long as urban populations and incomes keep increasing, and so long as private transport options remain affordable for the middle and upper classes, urban land area are likely to continue to grow, especially in cities of the global South.<sup>257</sup> However, unmanaged urban expansion creates deep spatial inequities in access to core urban services while limiting economic productivity and damaging the environment. In rapidly growing peripheral locations, new migrants and other lower-income people concentrate in underserved informal settlements, and higher-income groups find ways to self-provide essential services. Evidence from cities like Colombo and Beijing shows how escalating property values and rents in the city cause lower- and middle-class residents to move out to peripheral areas to access housing. At the same time, the poor respond to the lack of affordable housing and land by squatting or living in overcrowded settlements to be close to income sources and to limit transportation costs.<sup>258</sup>

Using new data, this paper has shown that the nature of urban growth across horizontal and vertical dimensions varies within cities, and so should strategies for managing it. Struggling and emerging cities that are currently experiencing low income levels, shortfalls in municipal budgets, and less mature financial markets face constraints to upward growth. Economic and population growth in a context of weak planning, governance, and land regulations; infrastructure expansion in peripheral areas; and rampant conversion of agricultural land cause high rates of largely unmanaged outward growth. This creates trade-offs for households between affordability and access to core services and also has social, environmental, and economic costs for cities. Upward growth uses land efficiently and has important implications for access to core urban infrastructure and services as well as their price and quality. Yet it requires greater financial resources and supporting regulations, and may limit affordability. Strategically planning such growth on underutilized city land through infill and redevelopment policies that direct development towards specific locations, combined with increasing the supply of serviced land in peripheral areas for future growth, provides cities with multiple options to accommodate new urban residents, depending on the type of city and existing growth patterns.

The analysis of trends and evidence on key drivers of urban expansion showed that expanding cities in the global South face three important challenges: distorted land markets, deficient services in growing areas, and disjointed informal expansion. These challenges result from several underlying weaknesses, including unenforced plans and ineffective regulations that have limited ability to utilize land value to finance new development or provide services. Restrictive and inflexible planning standards coupled with high transaction costs to acquire land for urban development actually spur informality. Fragmented urban governance makes it much more difficult to develop coordinated plans and enforce them. When land ownership is largely split across the public and private sectors, as is prevalent in struggling and emerging cities, both sectors have a symbiotic role to play in ensuring that the gains from land development are harnessed for greater public benefit.

Approaches that designate areas fit for urban expansion, coupled with strategies to build more densely while improving living conditions within a city's central areas, can lead to more equitable, productive, and environmentally friendly cities. The development of land and services must proceed concurrently to avoid future gaps in access. Cities that have been rapidly growing outward may need to augment services in peripheral areas and grow upward in already built-up area to take advantage of existing infrastructure, with mechanisms to maintain affordability and generate financing from expected increases in land value. Cities that already have significantly high populations and builtup area densities, where it is difficult and expensive to augment infrastructure and services, will need to make affordable and serviced land available for outward growth.

We have identified the following three strategies that cities should implement to address these challenges and improve access to core urban services for the under-served:

- Use regulations and incentives to prioritize spatial equity over land speculation.
- Incrementally increase the supply of serviced land by forming partnerships to finance core services.
- Integrate existing informal settlements and create affordable density.

These strategies cannot be considered mutually exclusive and require common enabling conditions. They may be implemented simultaneously or sequentially, on their own or as a package of measures. Figure 12 shows how each strategy not only prioritizes equity for the under-served but also has the potential to increase the city's economic productivity and environmental quality.

The social, environmental, and economic impacts of land-use policy changes play out over long time frames of multiple decades. This means that early, strategic action led by the public sector is crucial to steer urban growth in a way that benefits the city as a whole.

# Figure 12 | Recommended approaches for managing urban expansion in the global South—benefits for equitable access, the economy, and the environment



Source: Authors.

# APPENDIX A. METHODOLOGY FOR DETERMINING OUTWARD AND UPWARD GROWTH ACROSS CITIES AND ESTIMATING INDICES

Optical remote sensing sensors observe information in the visible, near-infrared, and shortwave-infrared portions of the electromagnetic spectrum. Different materials reflect and absorb energy differently at various wavelengths. Variations in reflectance across wavelengths permit the ability of remote sensing sensors to differentiate across land surface features such as soils, water, minerals, and vegetation. However, urban areas vary not only in their composite materials (e.g., iron, steel, concrete, brick) but also in their composition in the two and three dimensions. Buildings vary in their volume, height, and width, and streets vary in their layout and patterns.

For these reasons, radar remote sensing offers a different method from optical data to observe urban environments. Radar remote sensing operates in the microwave portion of the electromagnetic spectrum, which is much longer than the near- and mid-infrared. The longer wavelength permits the signal to penetrate most weather conditions, including clouds, haze, and air pollution. Perhaps most important for the purpose of mapping urban areas, radar remote sensing can characterize the three-dimensional structure of surface features. This is especially important for sensing the built environment because there is a lack of empirical data on built-up infrastructure for a large sample of cities.<sup>259</sup> Urban form and built-up infrastructure represent investments in municipal services and have important consequences for land values, natural resource consumption, and human well-being.

A pioneering study by Frolking et al. (2013) was one of the first to examine changes in urban structure that captured patterns of both outward urban expansion and vertical growth in built structure, using a combination of optical nighttime light and radar data. It was able to produce "fingerprints" illustrating the relative growth of urban areas in their outward (horizontal) and upward (vertical) structures.<sup>260</sup> The study compared the fingerprints of the world's largest cities between 1999 and 2009 and found that East Asian cities had the highest increase in vertical, volumetric built-up infrastructure. Chinese cities exhibited both vertical and horizontal growth, whereas Indian cities are growing primarily through outward expansion of urban areas and not upward growth in built-up structure.

# Box A1 | What Are Remote Sensing Pixels and Images?

A pixel is any of the small discrete elements that together constitute an image (as on a television or computer screen).<sup>a</sup> In remote sensing, the pixels that comprise satellite images are organized into scenes (also called images), with each scene containing the same number of pixels. Each pixel is categorized into different land covers—forest, pasture, urban areas, and so on—based on the reflectance of their Earth surface features. Different satellites have different scene and pixel sizes. Some satellite scenes cover an area as small as 25 kilometers on a side of the image, whereas other satellite images cover an area spanning 2,900 kilometers on a side. These are called swaths. Pixel resolution also varies significantly, ranging from submeter pixels to one-kilometer pixels. Finer spatial resolution pixels (e.g., one-meter pixels) capture a lot more detail than coarse resolution pixels (e.g., one-kilometer pixels).

In the analysis undertaken for this paper, interpretation focused only on images of urban areas and their surroundings. The urban extent of each city in the sample, defined as any area that had greater than 20 percent of its area built up, was divided into an 11x11 pixel grid, comprising 121 pixels per city, irrespective of the city's size. This permits a uniform and consistent analysis across the cities. This method is also agnostic to a city's administrative boundaries.

Note: a. As defined by the Merriam-Webster dictionary website, https:// www.merriam-webster.com/. Accessed May 31, 2018.

For this analysis, we used two remotely sensed datasets—mean summer backscatter power ratio (PR) from NASA's SeaWinds microwave scatterometer (Ku-band, 13.4 GHz) and built-up area from the multitemporal Global Human Settlement Layer (GHSL).<sup>261</sup> We reprocessed each dataset to have an equivalent spatial resolution to match the coarsest dataset (0.05°). For all cities with metropolitan populations greater than 1 million people, LandScan<sup>262</sup> data created by the Oak Ridge National Laboratory comprised 499 cities, of which 397 cities matched with those in the Oxford Economics database after standardizing city names. Of the 397 cities, 20 were removed as they showed data anomalies and this led to a merged database of 377 cities.<sup>263</sup>

This large sample size captures the most significant urban areas around the world. We used the latitude and longitude of each urban center as identified by LandScan. We then used a grid size of 11x11 pixel grids (see Box A1), comprising 121 pixels per city, to do the analysis. This grid essentially acts as a cookie cutter for the analysis and is irrespective of the administrative boundaries. In other research by Frolking et al. and in our preliminary analysis, an 11x11 grid was determined sufficient to capture most of the urban areas for most cities. However, for some exceptionally large cities, this "cookie cutter" may not include the entire administrative boundary of the city. Likewise, for smaller cities, the grid may include neighboring towns. Although cities vary in size, the rationale behind using this cookie cutter is to provide a consistent and uniform analysis across the cities. This approach also provides a practical solution to a data gap: there is no dataset of administrative boundaries for cities worldwide. Although each city is defined by an administrative boundary, there is no geographic dataset available for cities. This is something that orld Resources Institute may develop in a future project.

Each pixel size covers 0.05 degrees, which is equivalent to 5.566 kilometers at the equator, with each pixel representing 30.98 square kilometers at the equator. The land area each pixel covers declines as one moves away from the equator. Our analysis centered on first extracting these 11x11 grids for each city with a population greater than 1 million people, identified using the dataset Populated Places from Natural Earth.<sup>264</sup> We then masked out cells that had an urban built-up value of less than 20 percent in 2014 in the GHSL data. To compare urban expansion around the world we aggregated the urban pixels to get a value for outward and upward growth per city. Lastly, we performed

a k-means cluster analysis to classify the urban grid cells into clusters showing similar urban structure and growth patterns. The analysis yielded five classes. In the left graph below, the xand y-axes show GHSL (horizontal extent or footprint of cities in 2000) and PR (vertical extent, similar to height) values in 2001. In the right graph, the x- and y-axes show the change in GHSL values from 2000 to 2014 and change in PR values from 2001 to 2009, respectively.

Each city can have pixels distributed across each of the five builtform clusters. This pixel-level analysis is important because it preserves the variation within each city rather than giving a single value to the entire city. The within-city variation is important to understand how policies that determine built form, including density and land-use regulations, must vary within cities based on the nature of changes in built form in those areas.

The description of the five clusters is shown below in Figure A2 with a visual schematic showing the initial urban pixels in gray and the change observed during the study period in yellow.

Clusters 2 and 5 show pixels with very high growth in horizontal and vertical dimensions, respectively, in the given period of time. On the other hand, clusters 1 and 3 show pixels with very high horizontal and vertical extent in the initial period only. Cities falling in these clusters have already gone through a major

Figure A1 | Clustering of all pixels in global sample based on initial built-form measures and changes in built form over period of study



#### Figure A2 | Built-form clusters used to characterize urban growth patterns

	<b>Cluster 1:</b> stable, horizontally expanded	<b>Cluster 2</b> : very high change in horizontal expansion	<b>Cluster 3</b> : stable, vertically expanded	<b>Cluster 4</b> : early stage, no structural change	<b>Cluster 5</b> : vertically expanding cities
Initial Horizontal Extent (GHSL 2000)	Very high	Very low	Very high	Low	Moderate
Initial Vertical Extent (PR 2001)	Moderate	Low	Very high	Low	Moderate
<b>Upward Growth</b> (Change in PR)	Very low	Low	Moderate	Very low	Very high
Outward Growth (Change in GHSL)	Very low	Very high	Very low	Moderate	Moderate
Cluster Description	Very low urban growth	High outward growth	Incremental upward growth	Incremental outward growth	High upward growth

Source: Authors' analysis, using data from the Global Human Settlement Layer (GHSL) for outward (horizontal) growth from 2000 to 2014 and the power ratio (PR) from NASA's SeaWinds microwave scatterometer for upward (vertical) growth from 2001 to 2009.

change in upward and outward growth before 2000. Cluster 4 comprises pixels from most of the cities from our cities dataset, which shows very low structural changes for both upward and outward growth. Cities falling in this cluster are in early stages of their development.

It is essential to note that *very few* cities exhibit one type (cluster) of growth. A few things are important to underscore. These graphs show individual pixels of each of the cities. The analysis is conducted on 11x11 pixels, and thus each city is composed of 121 pixels. Each city can have pixels distributed across each of the five clusters. The value of the pixel-level analysis is that it preserves the variation within each city, rather than giving a single value to the entire city.

The charts below in Figure A3 show the variation in the distribution of pixels across cities, highlighting the percentage of pixels in each cluster.

## **Key Messages**

There are, therefore, multiple types of urban expansion occurring within a single city and this is a crucial finding. The type of remote sensing analysis done to establish these trends allows us to see the variation within a single city. This analysis show that some cities have high levels of variation of upward and outward growth within the city while other cities shows low levels of variation. Some cities show a *dominant* type of urban expansion, whereas others experience nearly equal amounts of the five

100%

80%

60%

40%

20%

0%



#### Figure A3 | Variation in distribution of built-form clusters within a single city











Low horizontal and vertical extent in 2000-2001, moderate

Wuxi

Shanghai

Nanjing

Changzhou Shenzhen Dubai

Cluster 4

outward growth



Beijing

Sharjah Dongguan Suwon

Chengdu

ncheon

Ningbo

Hangzhou Suzhou



Note: Percentage distribution of clusters in different cities. Here, urban pixels in a city represent pixels with more than 20 percent urban cover in 2000 according to Global Human Settlement Layer data. The total number of pixels in all the cities varies depending on the cities' physical size.

Source: Authors.



CITIES WITH >50% OF URBAN PIXELS IN CLUSTER 5

clusters of growth and cannot be characterized as a single type. For example, Figure A3 above shows that even for cities exhibiting high upward growth, there are other types of urban expansion. One particularly interesting combination is cities that have a lot of pixels in both cluster 5 (growing upward on top of a low vertical base) and cluster 2 (very high outward growth). These are cities that are experiencing simultaneous growing up and growing out.

The categorization of cities into clusters as described above is solely based on physical urban form and structure. In contrast, the city categorization developed as part of the WRR is based on urban population and urban economic growth expected in the near future (2015-2030) and the economic level of cities today. Combining the demographic-economic analysis of the WRR with the remote sensing cluster analysis, therefore, provided a joint economic-structure perspective of urban growth across a large sample of cities. Here it is important to note that the WRR analysis is based on the whole city. That is, each city can fall into only one of the four WRR categories. In contrast, the remote sensing cluster analysis allows a city to have pixels distributed across the five clusters, showing different parts of the city exhibiting different forms of expansion. The value of the remote sensing analysis is to "see through" each city and provide more geographic detail on the variation of vertical and horizontal growth within each city. To combine these two analyses, we took each city in the WRR analysis and graphed the distribution of pixels across the five remote sensing clusters.

City definitions vary between the remote sensing analysis and the Oxford Economics dataset. Whereas the city data from Oxford Economics are based on city administrative boundaries, the remote sensing data are based on the central latitude and longitude of a city and a cookie cutter area of 121 pixels. Pixels that have a built-up area greater than 20 percent are considered urban. That is, one definition is based on governance whereas the other definition is based on land features of built-up infrastructure and an area extent. The analysis additively combines these two datasets and is a spatial overlay of both the administrative area and the built-up area.

# Key Results for WRR City Categories

## **Struggling Cities**

In the WRR struggling category, there are no cities that have pixels in either cluster 3 or 5. This shows that relative to all pixels in the global sample, WRR struggling cities had almost negligible vertical growth before 2000 or during the 2000 through 2009 period. Because vertical growth is a proxy for infrastructure development and land prices, this essentially confirms that WRR struggling cities have relatively lower infrastructure and lower land prices. In short, WRR struggling cities do not exhibit any significant levels of upward growth (Figure A4). The percentages below do not add up to 100 percent because not all pixels within the cookie cutter grid are urbanized.

## **Emerging Cities**

Cities in the WRR emerging category are mainly in clusters 1, 2, and 4 (Figure A5). They have very few pixels in cluster 5, suggesting that large areas in these cities are slow to show structural change. These cities show outward growth prior to 2000.

## **Thriving Cities**

WRR thriving cities are those with the largest share of pixels in clusters 3 and 5 (Figure A6). These cities show the largest amount of upward growth across the sample, although it is important to keep in mind the high internal city variation.

## **Stabilizing Cities**

WRR stabilizing cities are predominantly in clusters 1, 2, and 4, with cluster 1 being dominant (very low urban growth) (Figure A7). In this category, most of the cities have experienced outward growth before 2000 and only some are still expanding outward at a moderate rate. Dubai and Sharjah are the outliers, with a significant proportion of sampled pixels in cluster 5 (high upward growth).

# Key Points from the Remote Sensing/ WRR Analysis

- Struggling cities have no or very limited upward growth (e.g., few new tall buildings).
- Emerging cities experienced outward, horizontal urban growth between 2000 and 2015.
- Thriving cities had upward growth (e.g., new tall buildings) in earlier periods and continue to grow in height (e.g., more new tall buildings).
- Stabilizing cities had already experienced outward urban expansion by 2000.
- Cluster 4, representing no structural change or moderate outward growth, is present in all the WRR categories.

#### Figure A4 | Percentage of pixels within WRR struggling cities in each of five built-form clusters



Note: Brazzaville is a struggling city with nearly equal areas of cluster 1 and cluster 2. In contrast, Fez has no area experiencing cluster 1 growth, only clusters 2 and 4. "Non-urbanized" represents less than 20 percent built-up area in 2000.

Source: Authors.







#### Figure A5 | Percentage of pixels within WRR emerging cities in each of five built-form clusters (continued)







### Figure A5 | Percentage of pixels within WRR emerging cities in each of five built-form clusters (continued)

Note: "Non-urbanized" represents less than 20% built up area in 2000. Source: Authors.

### Figure A6 | Percentage of pixels within WRR thriving cities in each of five built-form clusters









## Figure A6 | Percentage of pixels within WRR thriving cities in each of five built-form clusters (continued)



### Figure A6 | Percentage of pixels within WRR thriving cities in each of five built-form clusters (continued)



#### Figure A6 | Percentage of pixels within WRR thriving cities in each of five built-form clusters (continued)

 $\it Note:$  "Non-urbanized" represents less than 20% built up area in 2000. Source: Authors.

## Figure A7 | Percentage of pixels within WRR stabilizing cities in each of five built-form clusters



*Note:* "Non-urbanized" represents less than 20 percent built-up area in 2000. Source: Authors.





*Note:* "Non-urbanized" represents less than 20 percent built-up area in 2000. *Source:* Authors.

#### Developing a metric for urban growth

The aforementioned analyses use the raw remote sensing data. In order to develop a metric that could be correlated with other indicators, we developed a quantitative metric that captures the vertical and horizontal growth across the city. One challenge with this is that averaging the values would lose the variation within the city. We wanted a metric that captured the variation within a city.

Initially, we developed our indices by using the mean as the statistic to summarize the levels of outward and upward growth in a given city. However, we realized that the mean is insufficient in capturing the growth patterns because it hides variations and is normalized by the total city size or number of observations. Therefore, we examined other statistical measures, such as range, minimum, maximum, variance, and so on. We found that none of these, also when taken in combination, captured the levels of outward and upward growth across cities adequately. From our analysis, we found the sum statistic to be the most appropriate for creating an index to measure and compare levels

of outward and upward growth across cities. This statistic has also been used in quantitative measures of urban expansion derived from satellite imaging, such as nighttime light analysis.

These are the formulas for the metric:

$$UGI_{c} = \sum_{i=1}^{n} \Delta PR_{i} \qquad OGI_{c} = \sum_{i=1}^{n} \Delta GHSL_{i}$$

Where c = city, n = number of urban pixels in each city (c) UGI = Upward Growth Index

OGI = Outward Growth Index

PR = Change in structural backscatter PR (measure of vertical extent, similar but not equal to height), 2001–2009 GHSL = Change in built-up area from the GHSL (measure of footprint or horizontal extent), 2000–2014 We used the Upward Growth Index (UGI) and Outward Growth Index (OGI) to correlate urban spatial growth patterns over time with city-level economic data and household expenditures and conducted the analysis for WRR city categories of interest.

- Correlation analysis suggests that OGI is modestly correlated with economic indicators like the change in gross domestic product (GDP) or gross value added (GVA) for the years that we had spatial data. Across the full sample, the highest statistically significant (p-value ≤ 0.01) correlations were seen between OGI and change in GVA for consumer services (r = 0.50) and change in GVA for industry (r = 0.48),<sup>265</sup> as measured by the Pearson's correlation coefficient. OGI was modestly correlated with the change in total population (r = 0.45) and total GDP (r = 0.48).
- ▶ Relatively stronger correlations were seen between the UGI and city economic indicators. Change in total GDP and GVA were more strongly correlated with UGI (r = 0.68 and 0.69, respectively) as compared to OGI. The highest correlation was again seen between UGI and change in GVA for consumer services (r = 0.68). Correlations between change in GVA for other economic sectors (financial and business services, industry, transport, storage, information and communications services) were moderate (r = 0.41 to 0.56). UGI was more strongly correlated with change in total population than OGI was (r = 0.59).
- ► When considering the different WRR categories, the OGI showed weaker correlations with the economic indicators mentioned above for struggling and emerging cities (r = 0.4 for GDP and GVA of emerging cities and r = 0.24 but statistically insignificant for GDP and GVA of struggling cities), and the UGI showed a strong and statistically significant correlation with the change in total GDP and GVA in emerging cities (r = 0.7 in both cases). GVA of most economic sectors (consumer services, financial and business services, industry, transport, storage and communications services) showed higher correlation values (r = 0.61 to 0.65) with the UGI in

emerging cities. For struggling cities, the correlations of UGI with total GDP and GVA were modest (r = 0.37 to 0.39) and not statistically significant at the test 99 percent level. The highest coefficients were seen for GVA in industry and public services (r = 0.47 and 0.53, respectively) but values were not statistically significant.

- ▶ When analyzing the change in average household expenditures across the full sample of cities, we found low or weak correlations (r = 0.12 to 0.36) that were similar in strength between OGI and changes in different kinds of household expenditures. The UGI had relatively stronger positive correlations with the change in total household expenditures on services (r = 0.52) and some specific categories of expenditures such as housing rent (r = 0.50) and transportation (r = 0.42). Interestingly, expenditures on water and energy were only weakly correlated with the UGI (r = 0.33 for water and 0.21 for energy expenditures).
- ► Across WRR city categories, emerging cities showed strong relationships between the UGI and changes in all types of household expenditures (r = 0.66 to 0.73). This is in contrast with observations for OGI, where all correlations were modest and the correlation of outward growth with change in household expenditures on water was highest (r = 0.43). In comparison, struggling cities showed no relationship between outward growth and changes in household expenditures and only weak relationships between upward growth and changes in household expenditures.

Figure A8 shows an illustrative sample of cities in each WRR category and the type of urban growth occurring across each. It shows the co-occurrence of outward and upward growth over time in most cities. In all city types except struggling cities, locations with more built-up area showed greater upward growth. Less built-up areas showed upward growth only in some emerging and thriving cities, but in struggling cities, all locations showed primarily outward growth.



Figure A8 | Upward and outward growth across cities based on percentage of urban built-up cover in 2000

Notes: The x-axis shows outward growth of urban built-up area based on the Global Human Settlement Layer (GHSL) between 2000 and 2014, and the y-axis shows upward growth based on structural backscatter (power ratio, or PR), between 2001 and 2009 for 16 cities across WRR categories. Arrows represent the pixels analyzed in an 11x11 grid around each city's center; the tail represents the year 2001 for PR and 2000 for GHSL, and the head represents 2009 for PR and 2014 for GHSL. Arrow color corresponds to the percentage of urban cover in 2000; *urban* is defined as having more than or equal to 20 percent built-up area within a pixel in 2014.

Source: Authors' analysis, combining economic data from Oxford Economics, 2016, with data from the GHSL to determine outward growth and the PR from NASA's SeaWinds microwave scatterometer to determine upward growth. See an alternate representation of this data in Figure 7 (showing variation in built form clusters) in the main text.

## **ENDNOTES**

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- 231. Chattaraj, 2016.
- 232. Gouverneur, 2016: 171.
- 233. McGranahan et al., 2016; Lall et al., 2017; Seto et al., 2014.
- 234. Bakker et al., 2008.
- 235. Lall et al., 2017: 29.
- 236. Narain, 2009.
- 237. Gandy, 2006.
- 238. Sanyal, 2016.
- 239. Mahendra, 2018: 235.
- 240. AFD and FMEESDS, 2014.
- 241. Bakker et al., 2008.
- 242. Harpham and Boateng, 1997.
- 243. Gouverneur, 2016.
- 244. Cox, 2011; Kang, 2014.
- 245. Bertaud et al., 1988.
- 246. Kironde, 2006.
- 247. Harpham and Boateng, 1997.

- 248. Smolka and Cesare, 2006.
- 249. Peterson, 2008.
- 250. AFD and FMEESDS, 2014.
- 251. AFD and FMEESDS, 2014.
- 252. Metrolinx, 2013.
- 253. Metrolinx, 2013.
- 254. Peterson, 2008: 63.
- 255. Peterson, 2008; Ochoa, 2011; Borrero, 2011.
- 256. Wihbey, 2017; World Bank, 2016.
- 257. Seto et al., 2012; World Bank Group, 2015; Deuskar and Stewart, 2016; Schneider and Woodcock, 2007; Angel et al., 2011.
- 258. Kim, 2016; Amarawickrama et al., 2015.
- 259. Frolking et al., 2013.
- 260. Frolking et al., 2013.
- 261. The GHSL is an effort of the European Commission, and a multiyear effort supported by the Joint Research Center, the Directorate-General for Regional Development of the European Commission, together with the international partnership GEO Human Planet Initiative. The data are freely available and extensive documentation about the project are described here: https://ghsl.jrc.ec.europa.eu/index.php. The methodology is described here: https://ghsl.jrc.ec.europa.eu/data.php#GHSLBasics. In short, the GHSL involves combining multiyear satellite data with census data to estimate the amount of built-up area and population. The built-up area grid models the proportion of each 38-meter pixel that is covered by a building footprint. The population grids are estimates of populations in a 250-meter resolution pixel. The final GHSL is a combination of these two grids at onekilometer resolution. A key point of the GHSL is that it estimates built-up area regardless of administrative boundaries.
- 262. The LandScan data are developed by the U.S. Department of Energy's Oak Ridge National Lab. It uses a combination of spatial data and satellite imagery to estimate global population distributions at one-kilometer resolution. LandScan data are available starting for the year 2000.
- 263. In the LandScan dataset, 102 cities present are either absent or not sampled in the Oxford dataset, resulting in a reduction in the total number of cities for which combined spatial, economic, and demographic data existed. In the Oxford Economics dataset, certain urban regions are sampled as a combination of two or more cities. For example, Osaka-Kyoto is one urban region but in the LandScan dataset, Osaka and Kyoto are separate cities. In these cases, the match across datasets was made by considering the first city and dropping the other(s), assuming that the first city predominates the urban region. Therefore, in the Oxford Economics data for the Osaka-Kyoto region, and the separate spatial data on Kyoto was dropped from the merged dataset. This matching of datasets would be a problem only if the WRR city categorization (struggling, emerging, thriving, stabilizing) would change based on splitting the cities into Osaka and Kyoto or keeping them combined. This problem was not seen in any of the cases.
- 264. These were identified using the dataset Populated Places from Natural Earth. The Natural Earth website provides raster and vector map data on around 7,000 global cities that are open to the public: http://www.naturalearthdata.com/ downloads/10m-cultural-vectors/10m-populated-places/.
- 265. In the Oxford Economics Global Cities 2030 database, *industry* consists of mining and extraction, manufacturing, utilities, and construction; and *consumer* services comprise wholesaling, retail, hotels and catering, arts, entertainment, recreation, and other services.

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# ABOUT THIS WORLD RESOURCES REPORT

This is the fifth thematic paper in a series of working papers that comprise the World Resources Report (WRR), *Towards a More Equal City*. It will be followed by other working papers on water, sanitation, and transportation. To obtain an electronic copy of this paper, and/or other working papers, and to view supporting materials, please visit www.citiesforall.org.

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# **ABOUT THE AUTHORS**

**Anjali Mahendra** is the Director of Research, WRI Ross Center for Sustainable Cities. She leads the research agenda, guiding the Ross Center's worldwide team in conducting robust, innovative, and policy-relevant interdisciplinary research on urban issues, including WRI's flagship World Resources Report, *Towards a More Equal City*. She has authored several publications on urban transportation, land use, and climate change mitigation policies with a focus on equitable access to core urban infrastructure and services. Her most recent publication (2017) is "Balancing Accessibility with Aspiration—Challenges in Urban Transport Planning in the Global South" *in The Routledge Companion to Planning in the Global South.* 

**Karen C. Seto** is the Frederick C. Hixon Professor of Geography and Urbanization Science at the School of Forestry and Environmental Studies at Yale University. She is an expert in urbanization and global environmental change, urban mitigation of climate change, and satellite remote sensing, and has authored more than 100 scientific articles on contemporary urbanization. She co-led the 2014 United Nations Intergovernmental Panel on Climate Change (IPCC) climate change report's chapter on urban mitigation, and is co-leading the urban mitigation chapter for the IPCC 6th Assessment Report. She is an elected member of the Connecticut Academy of Science and Engineering and the U.S. National Academy of Sciences.

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