A discussion on the paper
“Building up or spreading out? Typologies of urban growth across 478 cities of 1 million+”

吕恒
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LETTER

Building up or spreading out? Typologies of urban growth across 478 cities of 1 million+

Richa Mahtta\textsuperscript{1,3}, Anjali Mahendra\textsuperscript{2} and Karen C Seto\textsuperscript{1}

\textsuperscript{1} School of Forestry and Environmental Studies, Yale University, New Haven, CT 06511, United States of America
\textsuperscript{2} World Resources Institute, Ross Center for Sustainable Cities, Washington DC, 20002, United States of America
\textsuperscript{3} Author to whom any correspondence should be addressed.

E-mail: richa.mahtta@yale.edu, anjali.mahendra@wri.org and karen.seto@yale.edu

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Supplementary material for this article is available online
Outline

1. Background on Urban form
2. Datasets and Methods
3. Results and Discussion
4. Summary and Reflection
What is Urban form?

- Spreading out
- Building up
Background

Why Urban Form Matters?

Significance:
- Urban form (2-D/3-D) has significant impacts on environments.

CO2 → GHG → Evaporation ↓

Spreading out & Building up downdraught

Atmospheric boundary layer

Aerosol

TOA

GHG

Q_A

Evaporation

Convection

T_a

Convect
Background

Why Urban Form Matters?

Significance:

☐ Urban form (2-3D) has significant impacts on environments.

☐ Urban form is correlated with energy demand.

☐ Urban form is related to many aspects of sustainability.

Knowledge gap:

➢ Most of studies with remote sensing data (such as, LiDAR and SAR) have been limited in geographic scope to individual city or neighborhood case studies.
What aspects of this paper merit our attention?

- The key trends in upward and outward urban growth across cities of our interest.
- The variables that reflect the upward and outward urban growth are applicable to urban climate effects or not.
- The typologies of urban growth that created is used to distinguish cities for research in different situations or not.
- Implications for urban sustainability.
Datasets and Methods

- The variables that reflect the area and height of urban:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Spatial resolution</th>
<th>Temporal resolution</th>
<th>Study Period</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>GHSL(Percentage urban cover)</td>
<td>38m</td>
<td>Year(1975, 1990, 2000 and 2014)</td>
<td>2000 and 2014</td>
<td>Global Human Settlement Layer (GHSL) dataset</td>
</tr>
<tr>
<td>PR (Power-return-ratio)</td>
<td>4.45km</td>
<td>4-day</td>
<td>2001 and 2009</td>
<td>QuikSCAT SeaWinds microwave backscatter(Ku band,13.4GHz)</td>
</tr>
<tr>
<td>Population</td>
<td>-</td>
<td>-</td>
<td>2000 and 2015</td>
<td>Populated Places dataset(v4.1.0) from Natural Earth</td>
</tr>
</tbody>
</table>

- Calculations:
  
  **Outward growth:** $\Delta_{GHSL}^{(2014-2000)}$
  
  **Upward growth:**
  
  1. $\sigma_{dB}^0$ in dB $\rightarrow 10(\sigma_{dB}^0/10)(PR)$
  2. $\Delta PR^{(2009-2001)}$

- Standardize the spatial resolution: 38m & 4.45km $\rightarrow$ 0.05° grid

- Research objects: cities of 1 million+
Datasets and Methods

For each city: a $11 \times 11$ grid comprised of 121 pixels, and every pixel should

1. Urban cover $\geq 20\%$ in 2014 based on GHSL;
2. Be connected to the largest patch comprising the central pixel of the city;
3. Include non-zero positive change in PR ratio.
Datasets and Methods

Creating five Typologies of Urban growth:

- **GHSL\textsubscript{2000}**
- **PR\textsubscript{2001}**
- **ΔGHSL\textsubscript{(2014-2000)}**
- **Δ PR\textsubscript{(2009-2001)}**

To capture the Initial state

To capture the Change

K-means cluster

Typologies of urban growth:

- Stabilized
- Outward
- Mature upward
- Budding outward
- Upward and outward
Urban growth typology | Initial Horizontal Extent | Initial Vertical Extent | Change in Horizontal Extent | Change in Vertical Extent
---|---|---|---|---
**Stabilized** (1) | Very large | Medium | Very low | Low
**Outward** (2) | Very small | Very small | Very high | Low
**Mature upward** (3) | Very large | Very large | Very low | Moderate
**Budding outward** (4) | Small | Small | Moderate | Very low
**Upward and outward** (5) | Medium | Medium | Moderate | Very high
Results and Discussion

- Distinct urban growth patterns across geographies
- Five urban growth typologies
- Every city is comprised of multiple growth typologies
- Urban growth typologies vary by geography
- Mature upward typology shows highest population density
- Implication for urban sustainability
Distinct urban growth patterns across geographies

<table>
<thead>
<tr>
<th>Geography</th>
<th>Main Urban growth patterns</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>Both upward and outward</td>
</tr>
<tr>
<td>CS America</td>
<td>less upward and outward</td>
</tr>
<tr>
<td>East &amp; SE Asia</td>
<td>upward&gt;outward</td>
</tr>
<tr>
<td>Middle East</td>
<td>upward&gt;outward</td>
</tr>
<tr>
<td>India</td>
<td>upward&lt;outward</td>
</tr>
<tr>
<td>Africa</td>
<td>upward&lt;outward</td>
</tr>
</tbody>
</table>
Five urban growth typologies

- **Budding outward**: 46%
- **Stabilized**: 36%
- **Outward**: 11%
- **Upward and outward**: 6%
- **Mature upward**: 5%
Every city is comprised of multiple growth typologies

- Surat (India)
- Port Harcourt (Nigeria)
- Rome (Italy)
- Dhaka (Bangladesh)
- Osaka (Japan)
- Paris (France)
- Lima (Peru)
- Los Angeles (USA)
- Shenzhen (China)
- Suzhou (China)
Urban growth typologies vary by geography
Mature upward typology shows highest population density

<table>
<thead>
<tr>
<th>No. of pixels</th>
<th>4379</th>
<th>1531</th>
<th>707</th>
<th>6303</th>
<th>834</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean pop density (2000)</td>
<td>4615</td>
<td>1973</td>
<td>6567</td>
<td>1789</td>
<td>3899</td>
</tr>
<tr>
<td>Mean pop density (2015)</td>
<td>5448</td>
<td>2988</td>
<td>7274</td>
<td>2166</td>
<td>5395</td>
</tr>
</tbody>
</table>
Implication for urban sustainability

Results:

- Most of new urban land area is budding outward
- Different areas with a city undergo different types of urban growth
- Higher urban densities to be correlated with lower energy use

Implications:

- Shape future patterns of urbanization
- Differentiated strategies for different parts of a city
- Reduce energy use
Summary and Reflection

- Compare the PR/GHSL with Floor/Area.

(Frolking et al., 2013)
Summary and Reflection

- This paper showed the key trends in upward and outward urban growth across cities of our interest and revealed previously undocumented recent and rapid changes in urban volumetric structure worldwide;

- Besides, cities are worldwide rapidly increasing their built-up infrastructure, with tremendous opportunity to shape emerging urban forms towards more sustainable outcomes;

- The typologies of urban growth that created could be used to distinguish cities for research in different situations.
Thanks for your attention!