Creating a High-Resolution Spatially-Explicit Population Distribution

Presented at: ESRI International Users Conference

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LandScan Global – Historical Developments
High Resolution Population and Social Dynamics Model

LandScan USA


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Multiple Methodologies

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Disaggregation: Top-down

Population counts for a defined control area
Create likelihood surface
Distribute population to cells

Aggregation: Bottom-up

Common data gaps for OCONUS analysis

- Derived lc/lu - census products
  - Resolution, currency, & categorical issues
- Different settlement characteristics
- Different activities/processes

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“Developed Land Cover” Examples
Extraction Process

Divide image into pixel blocks

For each pixel block compute multiscale features

Each pixel block mapped to a multi-dimensional vector

- Histogram of Gradient Statistics
- Pixel block intensity mean and variance (2 features x 5 scales)
- Gray-level Co-occurrence Contrast
- Textons
- SIFT
- Band Ratios

Apply learned linear SVM model
Addis Ababa, Ethiopia

- 2 Xeon Quad core 2.4GHz CPUs + 4 Tesla GPUs + 48GB
- Image analyzed (0.6m)
  - 40,000x40,000 pixels (576 sq. km)
  - RGB bands
- Overall accuracy 93%
  - Settlement class 89%
  - Non-settlement class 94%
- Total processing time
  - 27 seconds
Formal Informal Settlements

Local geospatial neighborhoods are represented using rich feature descriptors composed of edge, texture, lines and spectral attributes.
Formal & Informal Mapping

Current Research: Building Density

How many buildings are there in the settlement?
Example

Apply straight line extraction. Line number has a strong linear relation with building number.
Example Building Estimates
Building Use, Occupancy & Capacity
Population Density Data from Open Source

Retaining Data Provenance is Critical
<table>
<thead>
<tr>
<th>Facility Type</th>
<th>Day-Avg</th>
<th>Day-Min</th>
<th>Day-Max</th>
<th>Night-Avg</th>
<th>Night-Min</th>
<th>Night-Max</th>
<th>Episodic-Avg</th>
<th>Episodic-Min</th>
<th>Episodic-Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>0.740</td>
<td>0.230</td>
<td>1.170</td>
<td>2.802</td>
<td>0.900</td>
<td>4.810</td>
<td>147.724</td>
<td>77.420</td>
<td>238.210</td>
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<tr>
<td>Single Family, Urban or Small Town, Upper and</td>
<td>1.932</td>
<td>1.110</td>
<td>4.470</td>
<td>7.120</td>
<td>3.870</td>
<td>16.660</td>
<td>9.605</td>
<td>4.110</td>
<td>18.510</td>
</tr>
<tr>
<td>Middle Class</td>
<td>1.520</td>
<td>1.030</td>
<td>1.890</td>
<td>6.713</td>
<td>3.870</td>
<td>6.770</td>
<td>1.157</td>
<td>0.670</td>
<td>2.350</td>
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<tr>
<td>Multi-Family Unit (Apartment, Condominium or</td>
<td>1.932</td>
<td>1.110</td>
<td>4.470</td>
<td>7.120</td>
<td>3.870</td>
<td>16.660</td>
<td>9.605</td>
<td>4.110</td>
<td>18.510</td>
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<tr>
<td>Dormitory)</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Institutions/Public Service</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Religious</td>
<td>7.857</td>
<td>3.370</td>
<td>12.200</td>
<td>8.017</td>
<td>0.900</td>
<td>0.440</td>
<td>57.377</td>
<td>8.380</td>
<td>185.010</td>
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<tr>
<td>School (Daycare to grade 12)</td>
<td>9.605</td>
<td>0.440</td>
<td>21.340</td>
<td>1.163</td>
<td>0.100</td>
<td>0.410</td>
<td>178.660</td>
<td>178.660</td>
<td>178.660</td>
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<tr>
<td>College/University</td>
<td>9.605</td>
<td>0.440</td>
<td>21.340</td>
<td>1.163</td>
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<td>0.410</td>
<td>178.660</td>
<td>178.660</td>
<td>178.660</td>
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<tr>
<td>Hospital/Clinic with beds</td>
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<td>0.440</td>
<td>21.340</td>
<td>1.163</td>
<td>0.100</td>
<td>0.410</td>
<td>178.660</td>
<td>178.660</td>
<td>178.660</td>
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<tr>
<td>Conference Centers</td>
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<td>21.340</td>
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<td>0.100</td>
<td>0.410</td>
<td>178.660</td>
<td>178.660</td>
<td>178.660</td>
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<td>Jails, Prisons and Detention Centers</td>
<td>9.605</td>
<td>0.440</td>
<td>21.340</td>
<td>1.163</td>
<td>0.100</td>
<td>0.410</td>
<td>178.660</td>
<td>178.660</td>
<td>178.660</td>
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<td>Retail and Services</td>
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<td>21.340</td>
<td>1.163</td>
<td>0.100</td>
<td>0.410</td>
<td>178.660</td>
<td>178.660</td>
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<td>Outlet</td>
<td>4.005</td>
<td>3.000</td>
<td>4.450</td>
<td>2.450</td>
<td>2.450</td>
<td>2.450</td>
<td>67.350</td>
<td>67.350</td>
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<tr>
<td>Restaurant</td>
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<td>21.340</td>
<td>1.163</td>
<td>0.100</td>
<td>0.410</td>
<td>178.660</td>
<td>178.660</td>
<td>178.660</td>
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<tr>
<td>Hotel/Motel</td>
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<td>0.440</td>
<td>21.340</td>
<td>1.163</td>
<td>0.100</td>
<td>0.410</td>
<td>178.660</td>
<td>178.660</td>
<td>178.660</td>
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<tr>
<td>Commercial</td>
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<td>1.163</td>
<td>0.100</td>
<td>0.410</td>
<td>178.660</td>
<td>178.660</td>
<td>178.660</td>
</tr>
<tr>
<td>Light Manufacturing</td>
<td>9.605</td>
<td>0.440</td>
<td>21.340</td>
<td>1.163</td>
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<td>0.410</td>
<td>178.660</td>
<td>178.660</td>
<td>178.660</td>
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<tr>
<td>Heavy Manufacturing</td>
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<td>0.440</td>
<td>21.340</td>
<td>1.163</td>
<td>0.100</td>
<td>0.410</td>
<td>178.660</td>
<td>178.660</td>
<td>178.660</td>
</tr>
<tr>
<td>Chemical, Refining, Cement</td>
<td>9.605</td>
<td>0.440</td>
<td>21.340</td>
<td>1.163</td>
<td>0.100</td>
<td>0.410</td>
<td>178.660</td>
<td>178.660</td>
<td>178.660</td>
</tr>
<tr>
<td>Recreation/Entertainment</td>
<td>9.605</td>
<td>0.440</td>
<td>21.340</td>
<td>1.163</td>
<td>0.100</td>
<td>0.410</td>
<td>178.660</td>
<td>178.660</td>
<td>178.660</td>
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<tr>
<td>Theater</td>
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<td>0.440</td>
<td>21.340</td>
<td>1.163</td>
<td>0.100</td>
<td>0.410</td>
<td>178.660</td>
<td>178.660</td>
<td>178.660</td>
</tr>
<tr>
<td>Outdoor Intensive (Stadium or Racetrack)</td>
<td>9.605</td>
<td>0.440</td>
<td>21.340</td>
<td>1.163</td>
<td>0.100</td>
<td>0.410</td>
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<td>178.660</td>
<td>178.660</td>
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<tr>
<td>Night Club</td>
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<td>1.163</td>
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<td>0.410</td>
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<td>178.660</td>
<td>178.660</td>
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<td>1.163</td>
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<td>0.410</td>
<td>178.660</td>
<td>178.660</td>
<td>178.660</td>
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<tr>
<td>Indoor</td>
<td>2.240</td>
<td>1.200</td>
<td>3.850</td>
<td>0.117</td>
<td>0.060</td>
<td>0.200</td>
<td>178.660</td>
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<tr>
<td>Outdoor</td>
<td>0.000</td>
<td>0.020</td>
<td>0.020</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>178.660</td>
<td>178.660</td>
<td>178.660</td>
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</tbody>
</table>
Amenity, leisure, and land use data from OSM in Kano, Nigeria
Egypt Wikimapia Results

714,427 Polygon Results in Egypt
83,625 Polygon Results in the Cairo City Districts
Combining Open Source Research

Slum Prevalence in Nigeria: What Role for Architects?

Sunday A. Bobadoyo, Alexander A. Fakere
Department of Architecture, Federal University of Technology, Akure, 304001, Nigeria

Table 1. Slum Prevalence in Nigerian Cities

<table>
<thead>
<tr>
<th>S/No</th>
<th>Nigerian Cities</th>
<th>Slum Areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Lagos</td>
<td>Ajegunle, Makoko, Agege, Bariga, Badia, Ilaje, Ijesha/Edo/Itire, Iwaja, Amukoko</td>
</tr>
<tr>
<td>2</td>
<td>Kano</td>
<td>Kuma Asebe, Sabou gari, Nassarawa,</td>
</tr>
<tr>
<td>3</td>
<td>Ibadan</td>
<td>Beere, Oje, Inalende, Mapo, Oke-Padi, Yemenu, Omiyanin, Agbokojo, Akobo-Ojuinin, <em>Bodija</em>, Ojoo</td>
</tr>
<tr>
<td>4</td>
<td>Akure</td>
<td>Erekere, Obuwa, Isoko, Ijuagba/Ijumokin</td>
</tr>
<tr>
<td>5</td>
<td>Kaduna</td>
<td>Angwar Kurmin Gwari, Television, Nasarawa, Angwar Shana</td>
</tr>
<tr>
<td>6</td>
<td>Jos</td>
<td>Bayan Rogo, Gangare, Katako, Angwan Rukuba</td>
</tr>
<tr>
<td>7</td>
<td>Embo</td>
<td>Akwuwe, Uguwuji, Abakpa, Emene, Akebebeuwu</td>
</tr>
<tr>
<td>8</td>
<td>Port Harcourt</td>
<td>Njemanze, Igbo-etch, Bundu Waterside, Mile 1, Eleme</td>
</tr>
<tr>
<td>9</td>
<td>Aki Ekiti</td>
<td>Oke-Isa, Irona, Oke Illa</td>
</tr>
<tr>
<td>10</td>
<td>Abuja</td>
<td>Dutse Alhaji, Karimu, Gwagwa, Kabusa, Kuchi Bena</td>
</tr>
<tr>
<td>11</td>
<td>Minna</td>
<td>Tudun Fulani, Kpakungu, Angwan Biri, Dutse Kura</td>
</tr>
<tr>
<td>12</td>
<td>Makurdi</td>
<td>Wadata, Agwai Jukun, Idye, Logo</td>
</tr>
<tr>
<td>13</td>
<td>Zaria</td>
<td>Parts of Samaru, Hagan Dogo</td>
</tr>
</tbody>
</table>
Field Observations

- Conducted in 5 cities across Nigeria

<table>
<thead>
<tr>
<th>Hospital</th>
<th>Open Street Map Location</th>
<th>Wikimapia Location</th>
</tr>
</thead>
</table>
Open Source Data Mining: Zoning
LandScan HD Population Modeling

- Beyond the core population and settlement inputs, the availability, completeness, and level of detail of relevant ancillary data determines the model complexity for an area.

- Useful ancillary data increases the spatial or temporal differentiation of population beyond the binary settlement-only model.
Bahrain Day Model

Night Model

Governorate # residents

Minus

Governorate # age 15+

Governorate # age 0-14

Minus

Governorate # students 0-14

Governorate # non-students 0-14

Sum

Governorate # non-mobile

Governorate # non-mobile 15+

Governorate # shoppers

Governorate # workers

Governorate # students

Governorate # students (15+)

Distribution Table

<table>
<thead>
<tr>
<th>NM</th>
<th>Sub-pop</th>
<th>Shop</th>
</tr>
</thead>
<tbody>
<tr>
<td>70%</td>
<td>housewives</td>
<td>30%</td>
</tr>
<tr>
<td>95%</td>
<td>disabled</td>
<td>5%</td>
</tr>
<tr>
<td>80%</td>
<td>retired</td>
<td>20%</td>
</tr>
<tr>
<td>40%</td>
<td>unemployed</td>
<td>60%</td>
</tr>
<tr>
<td>80%</td>
<td>pensioners</td>
<td>20%</td>
</tr>
<tr>
<td>80%</td>
<td>other unob</td>
<td>20%</td>
</tr>
</tbody>
</table>

Labor Force

Bahraini Census

Minus

Governorate # students

Education

School Poly

# Enrollment

Governorate # students

Students

School Poly

# Volume

Governorate # prisoners

Prison Poly

# Volume

Prison Poly

# prisoners

Various Sources

Bahrain # prisoners

Various Sources

Int'l Centre For Prison Studies (ICPS)

Sum

Students +

Prison Poly +

Governorate # residents

Governorate # age 15+

Governorate # age 0-14

Governorate # non-mobile 15+

Governorate # non-mobile

Non-Mobile +

Shoppers +

Workers +

Students +

Prisoners

Day Total

Key:

Boundaries

# Component Population

Boundaries

# Value used in calculation

Coefficient

Component

Operator/Calculation

Data Source

Total Population Raster

Component Population Raster

Day Total
**Key:**
- **Boundaries**
  - # Component Population
  - # Value used in calculation
- **Coefficient Component**
- **Operator/Calculation**
- **Total Population Raster**
- **Component Population Raster**

**Bahrain Night Model**

- **Int'l Centre For Prison Studies (ICPS)**
  - Bahrain # Prisoners
- **Bahraini Census**
  - Governorate # Occupants
- **Various Sources**
  - Coefficient
    - Prison Poly # Volume
  - Settlement
    - Prison Poly # Prisoners
- **Coefficient**
  - Settled Settlement
    - Prison Poly # Prisoners
  - Zoning
    - Governorate # Residents
- **Subtract**
  - Subtract Governorate # Prisoners
- **Sum**
  - Sum Governorate # Residents
- **Prisoners**
- **Residents**
- **Night Total**
LandScan HD - Bahrain

Geographic Information Science and Technology

Ambient
LandScan HD is Spatially Explicit

Cairo, Egypt

LandScan HD
3 arc-second resolution
(~90m)

AfriPop
100m resolution
LandScan HD: Impact on LandScan Global
Questions?

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(865) 574-5430